Land for Life

SECURING OUR COMMON FUTURE

A JOINT PUBLICATION OF THE GEF AND UNCCD SECRETARIATS

with contributions from GoodPlanet Foundation and the Government of the Republic of Korea

Land is our planet's most precious resource.

The soils that nourish our crops and livestock, the rivers and lakes that give us clean water and fish, the forests that soak up and store greenhouse gases, and a great diversity of plant and animal life, are dependent on land. Sustaining these and many other benefits of land is a global imperative if we are to meet future food and environmental security demands of a world with nine billion people. Since its inception, the Global Environment Facility has invested $438 million and leveraged $2.8 billion to support almost 100 projects on sustainable land management. These projects are delivering on-the ground interventions to improve the livelihoods and economic well-being of local communities, and to preserve or restore ecosystem stability, functions, and services.

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GLOBAL ENVIRONMENT FACILITY
INVESTING IN OUR PLANET

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UNCCD

UN 2010-2020
UNITED NATIONS DECADE FOR DESERTS AND THE FIGHT AGAINST DESERTIFICATION

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Foreword

BY **MONIQUE BARBUT**, CHIEF EXECUTIVE OFFICER (CEO) AND CHAIRPERSON, GLOBAL ENVIRONMENT FACILITY (GEF)

Nearly two decades after the Rio Conventions came into force, the global environment community is still grappling with the challenge of balancing environment and development goals. This is particularly true in the production sectors that depend on land, and where the lives of billions of people are at stake—from the drylands of Africa and Asia to the sub-tropical grasslands of South America.

The threat of land degradation and desertification is very real. Yet, through human ingenuity, amazing transformations in land use are taking place. The stories and images in this book show clearly that well-targeted investments and appropriate policies can respond effectively to the complex problems of land degradation.

As financing mechanism of the Rio Conventions, the Global Environment Facility (GEF) has been a major catalyst of innovations in sustainable land management in the developing world. Since its inception nearly 20 years ago, the GEF has invested $438 million in 94 projects and programmes to combat desertification and deforestation. Through these investments, the GEF has leveraged $2.8 billion in co-financing from multilateral and bilateral agencies, and from governments of beneficiary countries. With the investments covering a wide range of sectors—from crop and livestock production to water resource management—the potential is enormous for achieving the triple-win of increased productivity, enhanced climate resilience, and greenhouse mitigation. In the long term, these investments will not only provide agroecosystem and forest ecosystem services, they will also reduce vulnerability to climate change and other human-induced impacts.

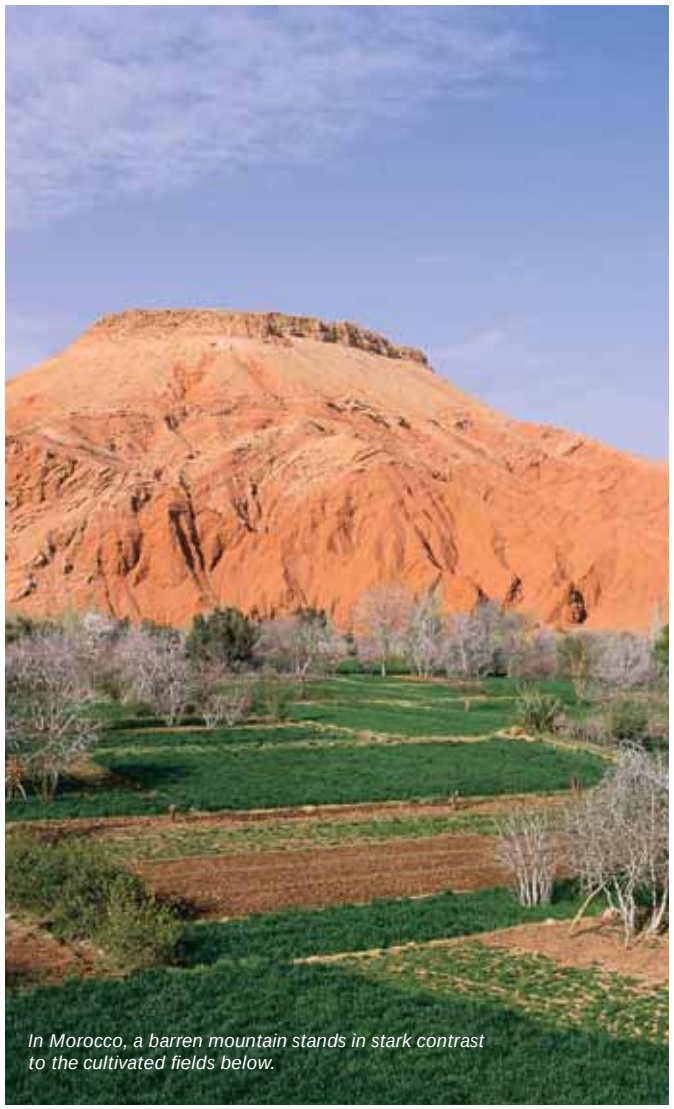
Environmental degradation is one of the greatest risks to local communities that depend on natural resources for their livelihoods. Above all, it is a serious threat to global security. National-level environmental challenges can lead to instability and conflict, and result in migration that threatens the security of neighboring countries.

Our engagement, therefore, is based on two overarching principles: environmental security, and food security for peace in a fragile region. Conservation of the natural environment and diversification of income sources improve the well-being of communities and help reverse migration patterns towards urban areas and abroad. At the same time, improving land management in large areas clearly helps reduce tensions between farmers and pastoralist communities.

The GEF's role and commitment to sustainable land management (SLM) around the world are now well established through the Land Degradation Focal Area. We focus specifically on desertification and deforestation through the removal of economic, policy, knowledge, and institutional barriers to SLM. In this way, GEF investments have established a foundation for improving the livelihood of millions of rural people who rely on agriculture to survive. SLM enables the empowerment of these poor land-users, providing opportunities to voice their concerns at all levels of policy dialogue.

GEF-financed projects on SLM overcome two major barriers:

First, GEF projects recognize that decision-makers at the national and local level often select short-term economic gains (e.g. replacing natural forest ecosystems with forest plantations, farm land, or other more profitable land) over the long-term



In Morocco, a barren mountain stands in stark contrast to the cultivated fields below.

sustainability of forests. GEF-financed SLM projects emphasize a shift from localized and piecemeal efforts to long-term and integrated approaches with potential for scaling-up.

Second, GEF projects acknowledge that institutional (e.g. decentralization), biophysical (e.g. climate change), and economic (e.g. markets) factors are changing constantly, with major implications for the future of land use. Societies need knowledge and technological innovations for sustaining productive land use to cope with these changes or adapt to their impacts. SLM projects financed by the GEF address these concerns by building institutional capacity and knowledge, while helping establish and strengthen land management planning and policies.

Our projects and programmes also foster collaboration within and between countries, which helps government agencies harmonize their support and provides an enabling environment for SLM. As a result, the GEF is now a strategic partner for developing countries to leverage baseline investments and contribute global environmental benefits. Furthermore, we have an excellent track record in facilitating collaborative engagement among multiple stakeholders and across sectors.

In addition to our 10 implementing agencies,[1] the GEF also partners with the scientific community, nongovernmental organizations, private research institutions, bilateral and multinational agencies, and foundations—all to demonstrate innovative practices that could leverage investments. The GEF has helped develop and implement innovative land management practices at local, national, and regional levels. We complement other available financing options to generate global environmental benefits in the control and prevention of land degradation.

Beyond direct alignment with the priorities of national governments and development partners, GEF-funded projects help implement the UNCCD, including its current 10-Year Strategy (2008-2018) that aims *"to forge a global partnership to reverse and prevent desertification/land degradation and to mitigate the effects of drought in affected areas in order to support poverty reduction and environmental sustainability."* Our joint actions are consistent with this goal, directly supporting the efforts of countries while helping reduce poverty in the context of sustainable development.

For all these reasons, we want to shed more light on the considerable achievements and progress of SLM around the world. Undoubtedly, the awareness of what we can accomplish through SLM will eventually overshadow the enormous costs of what we stand to lose from land degradation and desertification.

At the time of publication, the GEF Council approved a $1.8 billion programme for the Sahel and West Africa region to be implemented by the World Bank. The programme will support the Great Green Wall Initiative, a vision of leaders in the region to integrate development and environment through sustainable management of land and water resources. This programme stands to gain immensely from the vast experiences of implementing SLM around the world.

It is my sincere hope that this book offers a glimpse of what's possible through SLM. In the coming decade, as we look back on further progress with SLM, I am certain we will be sharing even more exciting and inspiring stories of transformation.

Foreword

BY **LUC GNACADJA**, EXECUTIVE SECRETARY, UNITED NATIONS CONVENTION TO COMBAT DESERTIFICATION

The most important things in life—friends, love, and family—are invaluable; their loss, a tragedy. The same is true in the environmental realm. The most precious resources in life—the air we breathe, the water we drink, and the land that gives us food—are invaluable. Tragically, humanity has taken these precious, life-supporting assets for granted. It is our generation, the most advanced human civilization to date, which has elicited this threat.

Land for Life, Securing Our Common Future focuses on one of the most essential of these resources for life on Earth. Land is so fundamental to human existence that its governance regimes were among the first to emerge in advanced human society, and remain, perhaps, the most developed. Yet our land use and management have not been the most effective. Thus, largely due to desertification and drought, 120 million hectares of land are degraded every decade—an area about the size of South Africa. Significantly, land degradation is not happening only in the drylands, which are highly vulnerable to climate change and soil mismanagement. The International Fund for Agricultural Development estimates that land degradation affects 1.9 billion hectares of land. This translates into an arable land loss of about 30 to 35 times the historical rate.

The impacts of land degradation on human well-being are far-reaching. Land degradation diminishes soil productivity, forest and vegetation cover, and water availability. These, in turn, affect the conduct and sustenance of economic and social activity, and hasten climate change and biodiversity loss. Land degradation also affects livelihoods. Some 1.5 billion people, including 42 percent of the world's very poor and 32 percent of the moderately poor, depend directly on degrading land. Feeding nine billion people by 2050 without further degrading and polluting the land will be a monumental task. It will not, however, be an insurmountable challenge because land degradation is neither fated nor irreversible.

Degraded land can be restored in all types of ecosystems through timely action and the use of sustainable land management technologies. According to the Global Partnership on Forest Landscape Restoration, for instance, two-fifths of deforested land, which is equivalent to 600 million hectares, and about two-thirds of degraded land, which is equivalent to 900 million hectares, offer restoration opportunities Most of these opportunities are in the semi-arid and dry sub-humid areas, that is, the drylands.

This book, *Land for Life, Securing Our Common Future,* provides a snapshot of the sustainable land management technologies at our disposal to recover and rehabilitate degraded land and to prevent such degradation in the future. It also demonstrates the multiple benefits that we, as a global community, stand to gain as a result. Land degradation begins at a local level, but its impacts reverberate globally and in ways that are now becoming increasingly evident through phenomena such as forced migration and drought-induced food insecurity. Thus, land reclamation through landscape restoration—using these technologies—is an investment opportunity that could generate high returns. In a globalized Green Economy, the business of food security is about preventing and reversing land degradation. And the business of land rehabilitation and recovery is about substantially increasing yields, particularly on small farms.

If these technologies are adopted and scaled-up, we could tackle many of our global policy challenges. But it will take a deliberate choice to design, develop, and implement the policy incentives that will motivate the widespread adoption and dissemination of these technologies. By ratifying the United Nations Convention to Combat Desertification, 194 Parties have expressed their commitment to prevent and reverse land degradation. The time for effective action at all levels is overdue. As this book demonstrates, the technologies needed are available. It is the investment in them that is not sufficient.

Sustainable land use is the cornerstone of a Green Economy, and keeping land degradation and desertification to a minimum, as well as recovering land that is already degraded, are keys to this move. Achieving a zero-net degradation is possible if we can determine optimal land degradation levels and enact the policies that will motivate the recovery of degraded land equivalent to the amount that is degraded every year.

Until we take sustainable land management practices seriously—until we make determined steps to reclaim and rehabilitate the land we have massively degraded—poverty will persist and the threats to food security will recur. We have demonstrated what is possible, highlighted the consequences of our inaction today, and pointed to the policy gaps impeding progress. With a visionary leadership to muster the requisite political will for decisive action, a smooth transition into the Green Economy is within our reach in one generation.

Wind-sculpted mountains provide natural protection for a precious water resource.

Preface

BY **DON KOO LEE, PH.D.**, MINISTER OF KOREA FOREST SERVICE, REPUBLIC OF KOREA

Sustainable land management has been the way of life of the Korean people for centuries. It is intertwined with our history and reflected in traditional practices in ecosystems, from forests to mountains. As host country for the Tenth Conference of Parties (COP) of the United Nations Convention to Combat Desertification (UNCCD), it is a great opportunity for the Republic of Korea (ROK) to share its experiences and achievements in this important publication. The Tenth COP also coincides with the International Year of Forests, which the country has also embraced with great fanfare given our long history with successful management of forest landscapes. The success of greening forest landscapes has been a key factor in ROK's economic growth. In the era of economic crisis in the late 1990s, the forests provided many green jobs for improving forest health and generating multiple benefits.

Until the 1960s, most of ROK's forests were almost denuded due to the over-exploitation of forest resources for wood products, fuelwood production, slash-and-burn farming, and so on. It was unavoidable because of extreme poverty, Japanese occupation and exploitation of natural resources, the Korean War, and population growth. Once exposed, the soils were severely eroded from intensive rainfall in the summer season and from steep slopes of the mountain terrain. At the same time, lowland areas were inundated from excessive flows and sedimentation. During the 1960s and 1970s, ROK took great strides towards remedying the degradation by planting massive amounts of trees on mountain slopes, and by imposing a ban on illegal logging, the exploitation of forest products, and slash-and-burn practices.

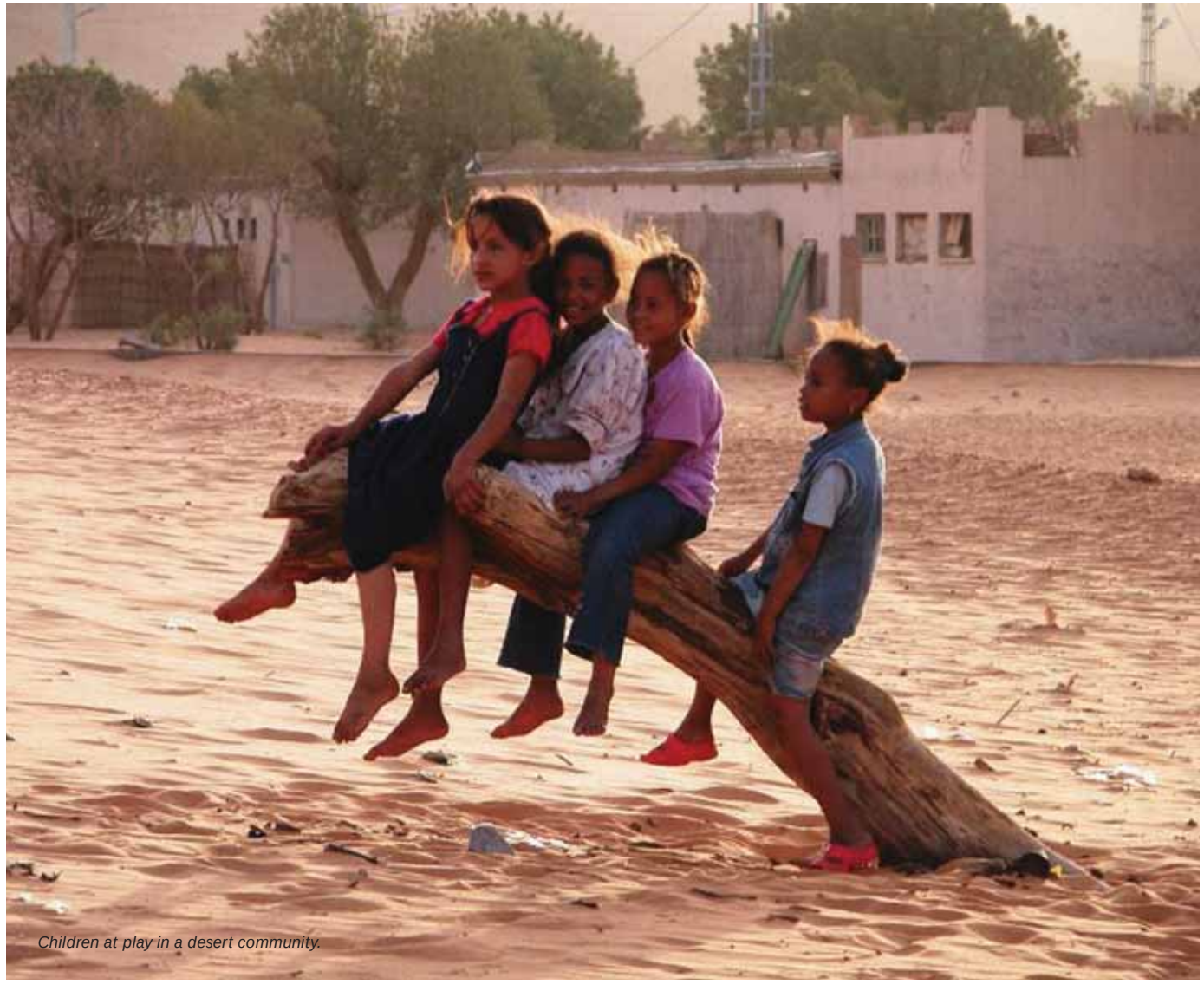
Although rehabilitation of forest landscapes was driven and implemented by the government, success is owed largely to the full participation of people from all sectors of Korean society, and expanded by communities all over the country. As a result, erosion control practices on slopes covered an area of 740,000 hectares. From 1946 to 2000, 1.1 billion trees were planted in an area of about 5 million hectares, accounting for approximately 80 percent of the total forest land. The restored forests reduced soil erosion and disasters, and provided numerous ecosystem services including biodiversity conservation, carbon sequestration, clean water supply, and recreational space. Today, ROK has 65 percent of its territory under forest production, including landscapes that are managed sustainably to safeguard fragile mountain ecosystems.

Baekdu-Daegan is the biggest mountain range and watershed-crest-line which runs through most of the length of ROK, from Mount Baekdusan in the north to Mount Jirisan in the south. The length of Baekdu-Daegan is 1,657 km, which is more than the length of ROK (about 1,000 km). This mountain system constitutes an axis of symmetry with a waterway network, and surrounds the ROK in a systematic way. This is why our ancestors firmly believed that rivers and mountains protected Korea. When the king "Wang Geon" founded the Goryeo Dynasty, this belief made people think that Mount Baekdusan and Jirisan safeguarded him against dangers. The concept of the Baekdu-Daegan was born in this way and the Baekdu-Daegan is both the axis of natural geography and the pillar of the spirit of humanity until now. Also, it serves as the flag for promoting ROK around the world.

The mountain system of Korea is hierarchically organized from large to small mountain ranges. Baekdu-Daegan is considered a backbone mountain range, which has

hierarchical sub-ranges known as *Jeongmaek*. There are 14 *Jeongmaeks* that also have hierarchical sub-ranges. The sub-ranges are divided into increasingly smaller ranges until the level of a village watershed, which is the smallest. This organization ensures that management of the mountain system is strongly linked to land use needs and priorities of the smallest villages. As a result, the sustainability of ecosystem service flows is a major factor in the way land resources are utilized at the village level. This is the basis for the ROK traditional village grove, or *Maeul-Soop*, which denotes that our ancestors located villages where their descendants could live a sustainable life. The practice of *Maeul-Soop* has been included in this publication as one of the stories on sustainable land management.

The aspirations of the Korean people are very much in line with those of the global community for linking healthy ecosystems and human well-being. ROK is therefore committed to working with all the nations of the world to pursue these aspirations. In the Asia Region, we have successful cooperation with China, Mongolia, Myanmar, and Indonesia to mitigate desertification, reverse land degradation, and restore forest landscapes. Through our engagement in the international Conventions, including the UNCCD, we are prepared to extend this cooperation to other regions, including Africa where traditional practices hold great promise for enhancing sustainable land management and economic growth. Through such cooperation, ROK will play its part in supporting the Millennium Development Goals, and in establishing the pathway for achieving Green Growth around the world.



Children at play in a desert community.

Introduction

Land – A Global Lifeline

Land is the foundation for all life-sustaining processes on Earth. Through its physical, chemical, and biological attributes, land underpins a wide range of ecosystem goods and services that humanity depends on for survival. These include *provision* of food and water that we consume; *regulation* of environmental risks such as floods and drought to which we are often vulnerable; *supporting* natural processes such as soil formation and nutrient cycling on which our production systems depend; and *cultural services* such as recreational, spiritual, and other nonmaterial benefits that we enjoy as a society.[2]

Land use in agriculture, livestock production, and forestry plays an important role in global prosperity. All told, land benefits billions of people, including a large proportion that depends entirely on farming and forest products for their livelihood. Agricultural land makes up an estimated 40 percent of the global land surface,[3] and accounts for 95 percent of all animal and plant protein, as well as 99 percent of calories consumed by people. Maintaining sustained and productive use of land is thus a global imperative.

Land Degradation – A Global Challenge

Land degradation is the "*reduction or loss, in arid, semi-arid, and dry sub-humid 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.*"[4]

Globally, land degradation affects 33 percent of the Earth's land surface, with consequences for more than 2.6 billion people in over 100 countries.[5] Since ecosystems are so interconnected, land degradation also triggers destructive processes that can have cascading effects across the entire biosphere. The impacts of land degradation, therefore, extend far beyond local or regional scales.

Although modern agriculture has successfully increased food production, it has also extensively damaged the environment. Increasing fertilizer use, for example, has degraded water quality in many regions. In addition, some irrigated lands have become heavily salinized, causing the worldwide loss of approximately 1.5 million hectares of arable land per year, along with an estimated US$11 billion in lost production.

Indeed, extensive soil degradation has become one of the main symptoms of land degradation. Erosion, salinization, compaction, and nutrient depletion reduce the soil's capacity to produce goods and services, such as sustaining biomass production and biodiversity, and regulating water and nutrient cycling.[6] Ultimately, severely degraded land becomes unable to sustain agriculture, which creates socioeconomic problems in agroecosystems dominated by poor smallholder farmers and pastoralists.

Up to 40 percent of global croplands may also be experiencing soil erosion, reduced fertility, or overgrazing. In addition, the loss of native habitats affects agricultural production by degrading the services of pollinators, especially bees. In short, modern agricultural land-use practices are trading short-term increases in food production for long-term losses in ecosystem services, which include many important to agriculture.

Land degradation also diminishes the quality and quantity of ecosystem services such as hydrological flows, climate and flood management, and soil formation and protection, which all underpin the productivity of agroecosystems. At the same time, land degradation in agroecosystems affects ecosystem services related to air and water quality, disease and pest management, and risk reduction from natural hazards. Loss of vegetative cover and soil degradation in agroecosystems have contributed significantly to increased greenhouse gas emissions from agriculture. The Millennium Ecosystem Assessment noted that, if action is not taken, degradation of ecosystem services will threaten future improvements in human well-being and possibly reverse gains in some regions.[7]

For all these reasons, land degradation is a serious threat to food security, income, and livelihoods of rural populations, especially in developing countries. The loss of goods and services derived from ecosystems is a significant barrier to achievement of the Millennium Development Goals for reducing poverty, hunger, and diseases.

Most natural ecosystems and agroecosystems around the world are facing unprecedented risks of land degradation and loss of biodiversity. A rapidly growing global population is increasing demand for production of food, livestock feed, wood, and fiber. This, in turn, puts added pressure on land resources and encourages unsustainable land use.

Climate change is further accelerating the pace, magnitude, and area of land degradation. It is especially prevalent in drylands, which are inhabited by more than two billion people who depend directly on the land for their livelihoods. Unsustainable natural resource management has led to the demise of distinct civilizations, but for the first time in history, land degradation and natural resource depletion are now challenges on a global scale.

The economic cost of land degradation is estimated at between one and seven percent of Agricultural Domestic Product in selected developing countries.[8] Land degradation, primarily through desertification and deforestation, is therefore a global challenge for sustainable development. Yet it also represents an opportunity to address important drivers of biodiversity loss, sedimentation of freshwater and coastal marine systems, and greenhouse gas emissions in production systems. Various studies under "The Economics of Ecosystems and Biodiversity"[9] initiative show that ignoring these drivers can greatly undermine the value of ecosystem services from nature.

Land for Life—Securing our Common Future

Safeguarding the future of land use is possible through sustainable land management (SLM). Given the complexity of the issues involved, SLM has no universal definition. It has been described *as "a knowledge-based procedure that helps integrate land, water, biodiversity, and environmental management (including input and output externalities) to meet rising food and fiber demands while sustaining ecosystem services and livelihoods."*[10] It is also known as a holistic and integrated approach to land use that maintains ecosystem services while delivering human livelihood benefits.

SLM innovations include measures to increase the productivity of agricultural and forestry lands (e.g. soil quality, vegetative cover), maintain ecosystem services (e.g. carbon sequestration, water availability, erosion and flood control, drought mitigation), and protect genetic resources (e.g. crops, livestock, wildlife).

By harnessing synergies and linkages between components within production landscapes, SLM can generate multiple global environmental and livelihood benefits. On the one hand, it addresses the often conflicting objectives of intensified economic and social development, while maintaining and enhancing ecological and global life-support functions of land resources. On the other, it reconciles environmental issues with economic and social development by improving the policy, planning, and management of lands. As the foundation of sustainable agriculture and land use, SLM clearly plays an important role in poverty alleviation.

Every day, ordinary people are applying local solutions to land degradation through sustainable land management practices. Indeed, SLM is one of the few options left for land users, especially smallholder farmers and pastoralists, to maintain or increase productivity of agroecosystems without destroying land, causing soil erosion, or undermining the ecosystem services.

BOX 1

SLM best practices have been well documented over the last two decades, including these two landmark publications by the partners of the World Overview of Conservation Approaches and Technologies (WOCAT) and *TerrAfrica*. Both publications include well-illustrated examples of various practices around the world. Countries which use SLM in drylands, such as China, have also produced best-practice publications (see story in Chapter 4).

In crop production systems, SLM helps maximize productivity by maintaining healthy soils and reducing erosion, which also increases the system's resilience. In pasture and rangeland systems, SLM enhances the capture, infiltration, and storage of rainwater into soil, which in turn encourages vegetative cover to support livestock grazing needs, improve soil organic matter content, and conserve biodiversity. In forest production landscapes, SLM diversifies livelihood options, and empowers communities to exercise rights over forest and tree resources, reducing the risk of deforestation and degradation.

Throughout the world, land users are applying a myriad of innovative practices to safeguard ecosystem services that underpin productivity and sustainability of production systems. Local successes, however, can only generate environmental and development benefits on a global level through effective integration at appropriate scales and within relevant policy, economic, institutional, and government frameworks.

To that end, practitioners have been synthesizing SLM practices over the past two decades in the context of soil, land, and water management. Two major publications, both involving the World Overview of Conservation Approaches and Technologies (WOCAT), have resulted. The first compiles case studies and analysis of soil and water conservation initiatives around the world.[11] The second, prepared under the *TerrAfrica*[12] Partnership, specifically focuses on SLM best practices in Sub-Saharan Africa, including detailed guidelines for widespread application.[13] Together, these two publications (Box 1) provide a comprehensive knowledge base to apply SLM under a wide range of circumstances to combat land degradation and desertification.

About this Book

This book conveys how SLM practices are helping shape a sustainable future for people and the planet. It does not attempt to replicate the WOCAT and *TerrAfrica* publications, which so succinctly and comprehensively described best practices. Rather, it demonstrates how human ingenuity is largely driving innovations in soil, land, water, and vegetation management around the world. And it describes how harnessing natural, social, and cultural capital is addressing fundamental needs for livelihood and well-being—food, water, energy, and wealth—while delivering global environmental benefits.

The book addresses seven key themes:

1. Food Security—Diversifying farms, maintaining healthy soils, and increasing vegetative cover (*environment benefit*) in production landscapes improves crop and livestock productivity (*development benefit*).

2. Livelihood Assets—Integrating high-value trees in rural landscapes, for example, generates income (*development benefit*) while enhancing ecosystem services (*environment benefit*) in production landscapes.

3. Safeguarding water resources—Reducing sedimentation and sustaining flows in production systems (*environment benefit*) enhance availability of, and access to, water resources for crop and livestock production (*development benefit*).

4. Climate change mitigation—SLM options can harness investment and income opportunities (*development benefit*) while securing carbon stocks and flows (*environmental benefit*) in production landscapes.

5. Climate change adaptation—SLM can increase resilience of vulnerable communities (*development benefit*) and promote sustained productivity of agricultural and rangeland systems (*environmental benefit*).

6. Conservation of biodiversity—Successful conservation of species and habitats through SLM (*environment benefit*) leads to multiple benefits for local populations (*development benefit*).

7. Avoided deforestation—SLM underpins solutions for reducing emissions from deforestation and forest degradation (*environment benefit*) as a means of generating multiple livelihood benefits (*development benefit*) for rural communities.

Each chapter focuses on a particular theme, delivering compelling stories and stunning images that showcase SLM in action in different parts of the world. In so doing, the book highlights SLM achievements for both people and the environment, reinforcing humanity's capacity to harness nature's goods and services, and transform them into sustainable production landscapes. Ultimately, the stories demonstrate that we can arrest or even reverse land degradation if we empower relevant land users to take responsibility. While the stories are organized thematically, they are also cross-cutting, revealing multiple benefits for environment and development.

The stories draw largely on projects and programmes funded by the GEF all around the world in the context of agricultural, rangeland, and forest landscape management (Box 2). While GEF Implementing Agencies have contributed these stories, they represent only a fraction of regional or thematic SLM initiatives funded by the GEF. They do, however, reflect the diversity of approaches on the ground that deliver global environmental benefits and make a difference in the lives of many smallholders. Other stories are either based on country reports to the UNCCD on implementation of the Convention (Box 3), or from well-known cases of how SLM practices have transformed lives and landscapes in different parts of the world.

Overall, the stories cover a wide range of options that include *land resources management* to integrate and preserve components, *sustainable agriculture practices* to improve long-term productivity of crops, and *biophysical measures* to control carbon emissions. They prove that SLM is not just a solution to land degradation, but also an opportunity for achieving land-use transformations that meet current needs and future demands. Each story embodies the common principle that SLM interventions can deliver development benefits (i.e. human well-being and livelihoods) while generating environment benefits (i.e. preserving or restoring the health of ecosystems) that ensure an accompanying flow of goods and services.

SLM holds out great promise on so many levels, yet institutional, knowledge, and policy barriers in many countries prevent its adoption. Knowing the costs and benefits of interventions, for example, enables land users to understand and manage tradeoffs in ecosystem services. Access to knowledge, however, depends on appropriate institutional frameworks at multiple scales, including practical tools that accommodate the needs of all land users. Application of SLM also depends on appropriate policies such as those related to land tenure, rights, and governance. Given these barriers, we hope this book will contribute to a growing body of evidence on the merits of SLM, leading to the lifting of barriers, widespread application, and the scaling-up of successful interventions.

BOX 2: **THE GLOBAL ENVIRONMENT FACILITY—INVESTING IN LAND STEWARDSHIP**

Since its inception, the GEF has invested $438 million in 94 projects and programmes supporting SLM to combat desertification and deforestation. These funds have leveraged $2.8 billion from a wide range of multilateral and bilateral sources, as well as from national governments of recipient countries. The Land Degradation Focal Area, which is the instrument for most of the GEF's investments in SLM, provides guidance on priorities to increase value-added global environmental benefits in country-driven projects that embody SLM practices. The priorities are also linked to UNCCD objectives, enabling countries to deliver on commitments toward implementation of the Convention.

The GEF contribution strengthens national-level processes for SLM such as capacity building, institutional collaboration, knowledge management, and mainstreaming across sectors. GEF projects also deliver on-the-ground interventions to improve livelihoods and economic well-being of local communities, and to preserve or restore ecosystem stability, functions, and services. The GEF investments target three major production practices:

- **Sustainable Agriculture**—GEF investments maintain or improve the productivity of both rainfed and irrigated systems, supporting the integration of environmental health, economic profitability, equity (including gender), and social objectives. On-the-ground, the GEF supports interventions such as crop diversification, crop rotation, Conservation Agriculture, agroforestry, water harvesting, and small-scale irrigation schemes.

- **Rangeland Management—**With nearly three-quarters of global drylands vulnerable to degradation, GEF-funded projects help strengthen viable traditional systems and other measures that improve soil and water conservation. By enabling livestock producers to maintain sustainable livelihoods through effective planning, animal selection, nutrition and reproduction, herd health, and grazing management, GEF projects improve and sustain the economic productivity, as well as environmental sustainability, of rangeland and agropastoral systems. Complementary interventions support mechanisms that generate global environmental benefits such as resolving wildlife-livestock-crop conflicts, conserving indigenous genetic resources (e.g. livestock varieties with naturally adaptive capacity to extreme climatic events and environmental conditions), reducing water and wind erosion, and protecting and/or rehabilitating riparian forest or woodland, as well as the natural vegetation of groundwater recharge areas.

- **Sustainable Forest and Woodland Management**—Rising demands on forest resources have led to loss of biodiversity and degradation of ecosystems, making forest degradation and deforestation a major threat in arid, semi-arid, sub-humid, and humid environments. Indeed, global deforestation and forest degradation account for an estimated 15-17 percent of greenhouse gas emissions. Improved management of forest landscapes and woodlands, however, can both address livelihood needs of rural populations and reduce pressure on threatened ecosystems. The GEF's support for sustainable forest management schemes includes participatory decision-making, tenure and use rights (especially by indigenous communities), sustainable market chains for forest products, payments for ecosystem service schemes, development and implementation of forest management plans, and reforestation.

BOX 3: THE UNITED NATIONS CONVENTION TO COMBAT DESERTIFICATION—FORGING A GLOBAL PARTNERSHIP FOR SUSTAINABLE LAND MANAGEMENT

Established in 1994, the United Nations Convention to Combat Desertification (UNCCD) is the sole legally binding international agreement linking environment, development, and the promotion of healthy soils. The Convention's 194 signatory countries, or Parties, work to alleviate poverty in the drylands, maintain and restore the land's productivity, and mitigate the effects of drought. The Convention has become the cornerstone instrument in the battle for sustainable development. It applies an integrated approach consistent with Agenda 21, while promoting the participation of civil society and the transfer of science and technology and their effective combination with traditional knowledge.

While the Convention focuses primarily on the drylands, its emphasis on prevention—through promoting sustainable land management practices—makes it relevant for all countries. Moreover, the drivers of desertification are the same for land degradation elsewhere. All regions can benefit, then, from cost assessments of soil protection and restoration, as well as from efforts to improve livelihoods and ecosystems in degraded regions.

The Parties to the Convention implement their obligations individually or jointly. Developed-country Parties and affected-country Parties are expected to consult on their respective roles in supporting these programmes. In so doing, they can achieve more holistic, integrated, and participatory management of natural resources in dryland ecosystems. Once Parties have designed a framework programme, international solidarity might facilitate the launch of specific projects and activities in an effective and efficient manner. Since programmes must be adapted to particular regions, specific requirements are described primarily in the five regional implementation annexes for Africa, Asia, Latin America and the Caribbean, the northern Mediterranean, and Central and Eastern Europe.

At their 2007 Conference, the Parties adopted the "Strategy"—a strategic plan and framework of action for implementing the Convention between 2008 and 2018. The Strategy aims to forge a global partnership to reverse and prevent desertification/land degradation and to mitigate the effects of drought in order to help reduce poverty and support environmental sustainability. It heralds the UNCCD's mission as "a *global framework to support the development and implementation of national and regional policies, programmes, and measures to prevent, control, and reverse desertification/land degradation and mitigate the effects of drought through scientific and technological excellence, raising public awareness, standard setting, advocacy, and resource mobilization, thereby contributing to poverty reduction*." The Strategy provides a unique opportunity to address some of the Convention's key challenges, capitalize on its strengths, seize opportunities provided by the new policy and financing environment, and create a new and revitalized common ground for all UNCCD stakeholders.

Four strategic objectives with their own long-term impacts will guide the actions of all UNCCD stakeholders and partners in seeking to achieve the global vision:

1) Improve the living conditions of affected populations;

2) Improve the condition of affected ecosystems;

3) Generate global benefits through effective implementation of the UNCCD; and

4) Mobilize resources to support the implementation of the Convention through building effective partnerships between national and international actors.

A young boy follows in the footsteps of three workers who prepare the terrain.

Food security

Land use for agriculture and livestock production preoccupies more than half of the world's population,

INCLUDING NEARLY 2.5 BILLION IN THE DEVELOPING WORLD WHO DEPEND ALMOST ENTIRELY ON SMALL-SCALE PRACTICES FOR THEIR LIVELIHOOD.

Sustained productivity of land under agriculture and livestock production is, therefore, a major factor in achieving global food security. According to the Food and Agriculture Organization (FAO), an estimated 4.9 billion hectares of the planet's land areas are under agriculture, including 3.4 billion hectares of pastureland and 1.5 billion hectares of cropland (arable land and land under permanent crops). An estimated 5 to 10 million hectares of these production areas are lost annually due largely to the impact of land degradation on productivity. As a result, new land areas are continuously opened up for agriculture land use to sustain productivity, which in turn exacerbates the degradation and destruction of natural habitats.

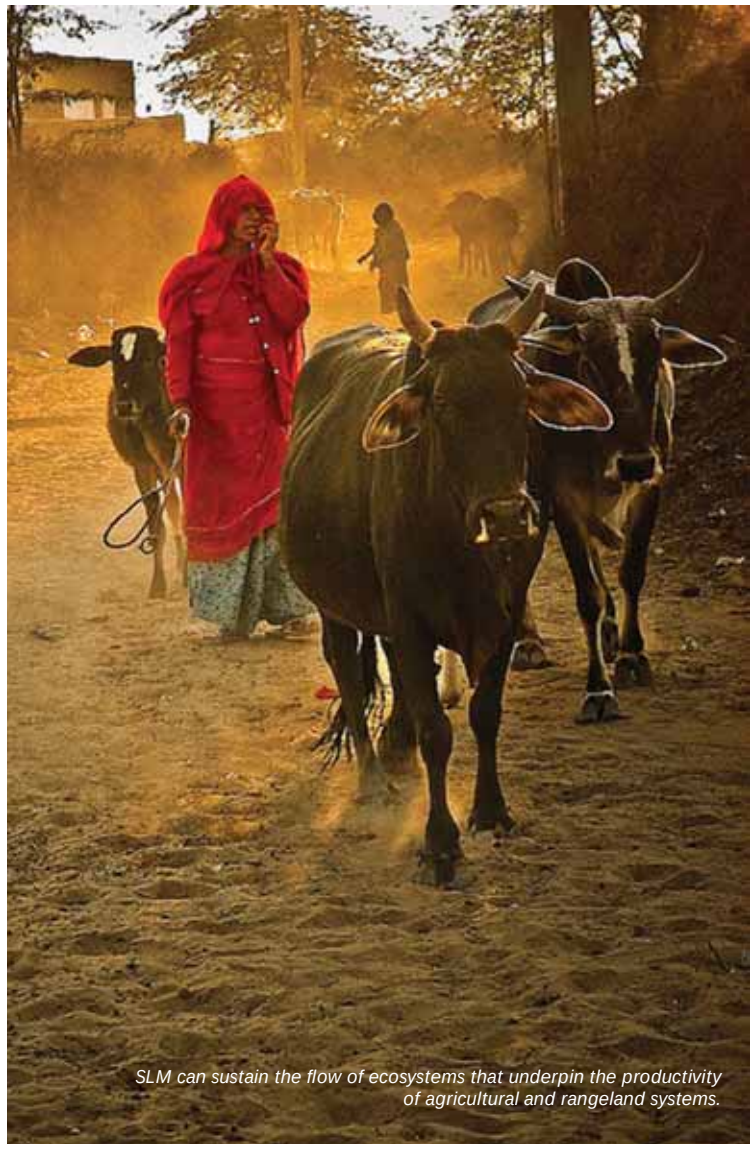
Using a range of scenarios, the Millennium Ecosystem Assessment projections (with a medium- to high-level of certainty) showed that land-use change, primarily associated with the expansion of agriculture, will remain the dominant driver of change in terrestrial ecosystems.[14] According to the FAO, an additional 120 million hectares will be needed by 2030 to support traditional growth in food production. This implies a net increase of 12.6 percent—from 956 million hectares in the base year to 1,076 hectares in 2030. Not surprisingly, the bulk of this projected expansion is expected to take place in Sub-Saharan Africa (60 million hectares), Latin America (41 million hectares), and East Asia, excluding China (14 million hectares). Almost no land expansion is projected in the Near East/North Africa and South Asia regions, while arable land in China is actually expected to decline.

With human population projected to reach nine billion in the next several decades, the pressure to expand cultivated areas for food and feed production will increase.[15] Ultimately, however, land constraints for agriculture and livestock production will be inevitable, especially in the face of competing interests driven by global climate change. In developing countries, as commercial interests in large-scale farms increasingly dominate the agriculture sector, poor communities may be even further marginalized.[16] Using marginal lands for crop and livestock production leaves smallholder farmers increasingly predisposed to malnutrition and "hidden hunger" due to depletion of soil nutrients from overexploitation, leaching, and erosion. Combating land degradation in existing production systems is, therefore, a global imperative for meeting the food security needs of a burgeoning world population.

For millions of smallholder farmers and pastoralists, SLM is the pathway to food security since its practices both increase crop and livestock productivity on existing lands, and diversify lands with options to accommodate multiple livelihood needs. For example, the presence of locally adapted and valuable trees in agropastoral and silvopastoral systems plays an important role in food security by improving soil quality in the production systems. Harnessing the benefits of such trees enables poor farmers both to compensate for lack of access to inorganic inputs (fertilizers) and to cope with risks of climate variability (e.g. droughts) that often predispose their crops to failure. Similarly, in the face of a changing environment and development context, pastoral communities are increasingly adapting traditional grazing regimes to ensure their livestock has sustained access to fodder.

In Africa, farmers are applying a wide range of SLM practices to safeguard the natural capital and ecosystem services that underpin crop and livestock production systems.[17] Cereal production systems, for example, use leguminous trees for their capacity to fix nitrogen.[18] Indeed, the *Faidherbia albida* system is now promoted as a basis for "evergreen agriculture" in Sub-Saharan Africa.[19] Under this

Self-propelled carousels resembling gigantic lily pads draw water up through subsoil layers in Jordan.



SLM can sustain the flow of ecosystems that underpin the productivity of agricultural and rangeland systems.

system, the tree species allows farmers to cultivate crops during the rainy season when the trees shed leaves. In addition to enhancing soil fertility, the trees moderate soil temperatures, reduce erosion, and provide shade for people, livestock, and crops. These benefits help make production systems more resilient, which will become increasingly important due to climate change.

In parts of the world where modern agricultural practices sustain productivity, SLM tackles entirely different challenges. In Europe, Asia, and North and South America, for example, widespread use of inorganic or synthetic fertilizers (especially nitrogen) has helped increase crop production and higher yields to meet demands for food, feed, and fiber. At the same time, it has unintentionally released excess nutrients into the environment through agricultural runoff and sewage. In these high-input systems, SLM practices such as no-till agriculture and more efficient use of crop residue improve soil quality and reduce excessive use of synthetic fertilizers.[20] In addition to enhancing long-term sustainability of production systems, these practices also generate significant environmental and development benefits.

The stories that follow demonstrate how SLM delivers environment and development benefits, especially for the rural poor. SLM innovations are addressing food security by improving soils for crop production (*Senegal*), diversifying landscapes for crop-livestock production (*Tanzania*), and enhancing local fruit-tree diversity in home gardens (*multiple countries*). Through widespread application of such options, SLM can sustain the flow of ecosystem services that underpin the productivity of millions of hectares of agricultural and rangeland systems. In so doing, it can enhance global food security.

Dates dry in a palm grove south of Cairo in the Nile Valley, Egypt.

Aerial view of a village in Niokola-Koba National Park, Senegal.

Improving soil quality for crop production in the Groundnut Basin

Senegal's Groundnut Basin covers nearly 46,367 square kilometers, with a largely rural population of about 4 million. Since the Quaternary era, salt water has intruded into the basin and recurrent droughts have decreased ground water. Areas affected (or Tanns) became gradually bare and uncultivated, leading to impoverishment, food insecurity, and the subsequent migration of land users.

In response, in partnership with UNDP and the GEF, the Government of Senegal launched the Groundnut Basin Soil Management and Regeneration Project (PROGERT) in 2006. The project focused on agronomical and silvopastoral methods of restoration, including improving soil through crops that involved use of the peanut shell (which is rich in calcium ions and enhances infiltration capacity), and the integration of adaptive species into salt-affected areas. Through a participatory process, the project tested peanut shells with two staple food crops—millet and maize production—and showed significantly high yields.

Meanwhile, the introduction of salt-tolerant tree species (*Acacia Senegal, Eucalyptus camaldulensis, Tamarix aphylla, and Melaleuca*) has greatly improved vegetative cover in the area. Recent evaluation suggests that recovered land is more profitable than producing salt. As a result, the project is scaling-up its approach beyond the initial 500 hectares. In addition to significantly raising local incomes and producing more food, the practice is safeguarding productive lands and increasing their resilience in the face of climate change.

Land use for agriculture and livestock production occupies more than half of the world's population.

Harvesting tomatoes in Senegal.

In Kenya, Masai cows cross Lake Amboseli, which is dry 11 months of the year.

Restoration of traditional crop-livestock management system in Shinyanga

The Shinyanga region in Tanzania, located within the miombo and acacia woodlands of Eastern and Southern Africa, is home to the *Sukuma* people, a community of agropastoralists whose livelihood depends largely on livestock and crop production. The woodlands provide fodder for livestock, as well as food and fuel for people. But they are also a reservoir for the tsetse fly, which transmits trypanosomiasis, a parasitic disease that affects livestock and causes sleeping sickness in humans. In the 1920s, colonial authorities began clearing woodlands to eradicate the tsetse fly and create space for cash crops such as cotton. Over several decades, the clearing of vast woodlands led to desert-like conditions throughout the region. At the same time, increase in human and livestock populations put pressure on natural resources for fuelwood, cropland, and fodder. What's more, the government moved families into newly created settlements at the expense of their traditional farmsteads. Consequently, traditional practices and institutional frameworks for natural resource management were abandoned.

In 1986, the Government launched the Shinyanga Soil Conservation Programme or "HASHI" (*Hifadhi Ardhi Shinyanga*). HASHI set out to restore traditional practices such as Ngitili, which uses fodder reserves on farmsteads to enhance sustainability of rangelands for both crops and livestock. Through a variety of approaches, HASHI informed local people about land-use options and encouraged their involvement. Communities also received training on a range of SLM practices, including how to protect Ngitili, which species to plant in their woodlots, and how to improve soil fertility. At its inception, the project documented only 600 hectares of Ngitili; by the late 1990s, Ngitili covered an estimated 78,000 hectares. Widespread application of the practice has since restored up to 500,000 hectares of degraded lands. Increased stability of crop and livestock production goes hand-in-hand with improvements in native biodiversity and carbon sequestration.

A pair of young agropastoralists.

A boy tends his flock in Kenya.

A floating market in Bangkok, Thailand.

Management of local fruit-tree diversity in home gardens

India, Indonesia, Malaysia, and Thailand are home to four genera of tropical fruit trees: *Citrus* (citrus), *Mangifera* (mango), *Nephelium* (rambutan), and *Garcinia* (mangosteen). These tropical fruits, valued for their wide range of nutritional, health, and other benefits, are an important part of Asian culture. The fruit trees are at risk, however, due to an alarming loss of biodiversity caused by three factors: lack of systematic assessment and documentation of local and traditional knowledge; inadequate use of unique and high-value trait differentiation of existing diversity; and the lack of capacity of farmers, user groups, and rural institutions to implement good practices and link to value-chain actors to provide incentives for custodians.

Tropical fruit bounty.

The countries are working together through a UNEP/GEF project, Conservation and Sustainable Use of Cultivated and Wild Tropical Fruit Diversity: Promoting Sustainable Livelihood, Food Security, and Ecosystem Services. The project strengthens the capacity of farmers and institutions to implement community-based management of local fruit-tree diversity in home gardens, and to enhance the *in situ* conservation of their wild relatives in forests. To that end, the project is documenting available diversity and related knowledge, identifying and promoting good practices, enhancing the livelihoods of farmers who conserve genetic resources of tropical fruit trees, and building local, national, and regional capacity for monitoring and policy support. To date, all countries have identified a set of unique and high-value genotypes from farmers' gardens that provide benefits to the custodian farmers. In addition, the project identified 23 good practices from 36 communities to sustain conservation of target biodiversity, and trained 150 participants to strengthen capacity of national frontline staff to implement good practices that promote conservation and enhance livelihood.

Mangos are valued in India for a wide range of benefits.

Farmers at a mango garden in a village north of Calcutta, India.

Livelihood Assets

For the more than one billion people considered poor, SLM is a matter of survival.

FROM WILD SPECIES TO DOMESTICATED CROP AND LIVESTOCK GENETIC RESOURCES, LAND RESOURCES CONSTITUTE IMPORTANT LIVELIHOOD ASSETS. IN ADDITION TO PROVIDING FOOD AND OTHER PRODUCTS FOR CONSUMPTION, THESE ASSETS PROVIDE A WIDE RANGE OF MARKETABLE NATURAL PRODUCTS THAT GENERATE SIGNIFICANT INCOME.

SLM helps mitigate threats that deplete these assets, which farmers, pastoralists, and herders have developed over time for production systems.

Availability and access to productive land greatly influence poor communities' sustained use and management of livelihood assets. In land-based production systems, the integration of trees is one important way for smallholder farmers to secure access to land. Throughout Sub-Saharan Africa, for example, farmers and agropastoralists plant trees around their homesteads and on farms to enhance their livelihoods. By harnessing natural capital in the form of useful trees in productive lands, smallholder farmers can transform working landscapes into assets for alleviating poverty.

According to the International Assessment of Agricultural Knowledge, Science, and Technology for Development[21] (IAASTD), some 1.2 billion people globally grow trees on farms. The practice, otherwise known as agroforestry, currently takes place on an estimated 7.8 million hectares of land: 5.9 million in West and Central Africa, 1.2 million in Asia, and 0.7 million in South and Central America. The agroforestry area is steadily increasing.[22] About half of all agricultural lands in the world now have greater than 10 percent tree cover. In some regions, tree cover on farmlands averages over 30 percent.

Although agroforestry practices are diverse, they basically involve combining trees with crops and/or livestock to improve the production system and, ultimately, create livelihood alternatives. As noted in Chapter 1, SLM with trees on farms helps enhance soil structure and water infiltration, soil organic matter, and the availability of soil nitrogen, and also provides access to useful products for livelihood needs (e.g. timber, fuelwood, fodder). The value of trees as assets for the rural poor represents a major opportunity to transform millions of hectares of production landscapes through SLM.

Smallholder farmers widely use trees with high-value products such as fruits, nuts, and latex in production landscapes to generate income. In West and Central Africa, such high-value trees include the Shea (*Vitellaria paradoxa),* Bush Mango (*Dacroydes edulis*), and Bitter Cola (*Garcinia cola*), all of which are managed and used in production landscapes. The Shea tree, restricted to the drylands, generates raw materials for medicine, as well as $10 million in international trade annually for the cosmetic and chocolate industries. Bush Mango and Bitter Cola are both managed on-farm through domestication, which enables farmers to harness the full range of desirable traits for the two tree species. Tree domestication is widely practiced throughout the developing world, and plays an important role in creating livelihood assets because it involves an iterative process that empowers farmers and leads to long-term sustainability of their farms.[23]

In the humid tropics, complex agroforests are important forms of SLM that involve the cultivation of high-value trees in forest-like vegetation.[24] From the so-called "jungle rubber" in Southeast Asia to the "Chagga home gardens" in East Africa, smallholder farmers manage these complex agroforestry systems intensively to establish assets and secure multiple services for their livelihoods. The trees create multiple strata, generating a range of high-value product for the farmers.

The forest-like structure, covering hundreds of thousands of hectares in Asia and Africa, enhances conservation of native biodiversity. While their inherent structure and diversity offer a unique opportunity for promoting multi-functional

agriculture[25] through SLM, agroforests face increasing threat from large-scale monoculture plantations.

The stories that follow showcase how SLM is helping create assets and generate income opportunities for land users (*development benefit*) while enhancing and safeguarding ecosystem services (*environmental benefit*) in production landscapes, watersheds, and natural habitats. The stories cover a range of natural resources—from tree-based options in agropastoral landscapes (*Burkina Faso*), ornamental plants in drylands (*Namibia*), and farmlands maintained through farmer-managed natural regeneration (*Niger*) to diversification of livelihood assets in fragile watersheds (*Tajikistan*) and in a biologically unique ecosystem (*Brazil*).

Harvest time in Peru.

A "green dam," Hassi Bahbah, Algeria.

School children in Burkina Faso receive saplings.

Tree-based options for livelihood diversification

Burkina Faso has identified land degradation and desertification as the main issues facing the rural economy. In response, the Government has been developing innovative approaches to integrate environment and livelihood needs at scale. Sahel Integrated Lowland Ecosystem Management (SILEM) was designed as a pilot project to demonstrate how communities can improve productive capacity of rural resources (natural, physical, human, and financial) in watersheds over the long term. The project involved 15 rural communes and 158 villages, covering 36 million hectares (13.4 percent of the country) and 662,129 inhabitants.

Building on priorities identified by villages, SILEM facilitated the improvement of existing land-use practices, as well as a variety of innovative soil conservation, crop management, and agroforestry practices. Through SLM, the project helped communities establish important livelihood assets that also generated environmental benefits, including the following: 56.5 kilometers of live fences consisting of high-value trees (e.g. *Jatropha*) planted around fields; 249 hectares of fruit tree plantations; 505 hectares of farmer-managed natural regeneration areas; and 7,500 hectares of native forests delineated for conservation. In addition to the biophysical and environmental interventions for SLM, the integrated ecosystem management (IEM) approach embodied social, institutional, and livelihood dynamics. These were reflected in new land-use rules and regulations (and the translation of these rules into written contracts), physical signs and demarcation posts, and enforcement through local guards and protection groups. This component was central to building community ownership and ensuring the sustainability of livelihood assets in rural landscapes.

In Burkina Faso, students take part in a national tree-planting day.

Children huddle for warmth in the early morning.

Ornamental plants as livelihood assets

In three conservancies in the Kunene region of Namibia—Sorri-Sorris, Doro Nawas, and Huab—livelihood activities revolve around wildlife management and livestock farming. Over the years, the absence of other economic opportunities has increased pressure on natural resources. Under its Country Pilot Partnership (CPP) Programme, the Government of Namibia developed the Ornamental Nurseries Project to support rural economic development by diversifying livelihoods in the three conservancies. This UNDP/GEF project has helped create sustainable enterprises for local communities based on ornamental plants that occur naturally in the area.

Fifteen households established ornamental nurseries, growing mainly indigenous trees and succulent plants (*Acacia, Cammiphora, Moringa, Eiphorbia, Euclea, and Pachypodium*). Since some are protected species, the Ministry of Environment and Tourism granted permits for the nurseries; the National Botanical Research Institute provided training on tree planting and treatment. In 2010, through private-sector markets, the nurseries sold over 3,000 trees for US$5,000. The same year, the National Botanical Society of Namibia awarded the project for promoting the conservation of indigenous trees and sustainable alternative livelihoods. To support continuity and sustainability, the nurseries have been integrated into the conservancies' planning activities and are managed as part of the landscape. Planting the indigenous plants through SLM, and as part of rural economic development, is reducing pressure on the extraction and harvesting of natural resources, while creating livelihood assets.

Namibia promotes the conservation of indigenous plants and trees.

A village near Tahoua, Niger.

Livelihood improvement through farmer-managed natural regeneration

The Republic of Niger, like other Sahelian countries, experienced serious and recurrent droughts during the 1970s and 1980s. These climatic extremes negatively affected production systems, resulting in major food insecurity for both farmers and pastoral communities. In response, the Government of Niger worked with partner countries and institutions on innovative development projects, as well as environmental policy changes. Smallholder farmers, for example, safeguarded soil, water, and vegetative cover to improve crop production and livestock management. The practice, known as farmer-managed natural regeneration (FMNR), involves actively protecting non-planted woody vegetation on farmlands to sustain the ecosystem services that underpin household livelihood needs.

FMNR has succeeded in re-greening most parts of the country and increasing availability of forest and tree resources across vast areas. Recent studies show tree density and diversity on-farm have improved considerably over the past three decades. More than 4.8 million hectares are greener today than 20 years ago in the regions of Zinder and Maradi, for example, primarily because of the “assisted natural regeneration” of trees in densely populated and agriculturally over-exploited areas. The diversification of farmlands has helped create livelihood alternatives for smallholder farmers, which has increased household income. Favorable government policies, institutional innovations at the village level, and successful changes in farmer practices have combined to bring about this dramatic transformation. These positive environmental changes, further substantiated through satellite images, are now continuously monitored by international institutions.

Watching the herd in Mali.

Preparing gardens, Inland Niger Delta, Mali.

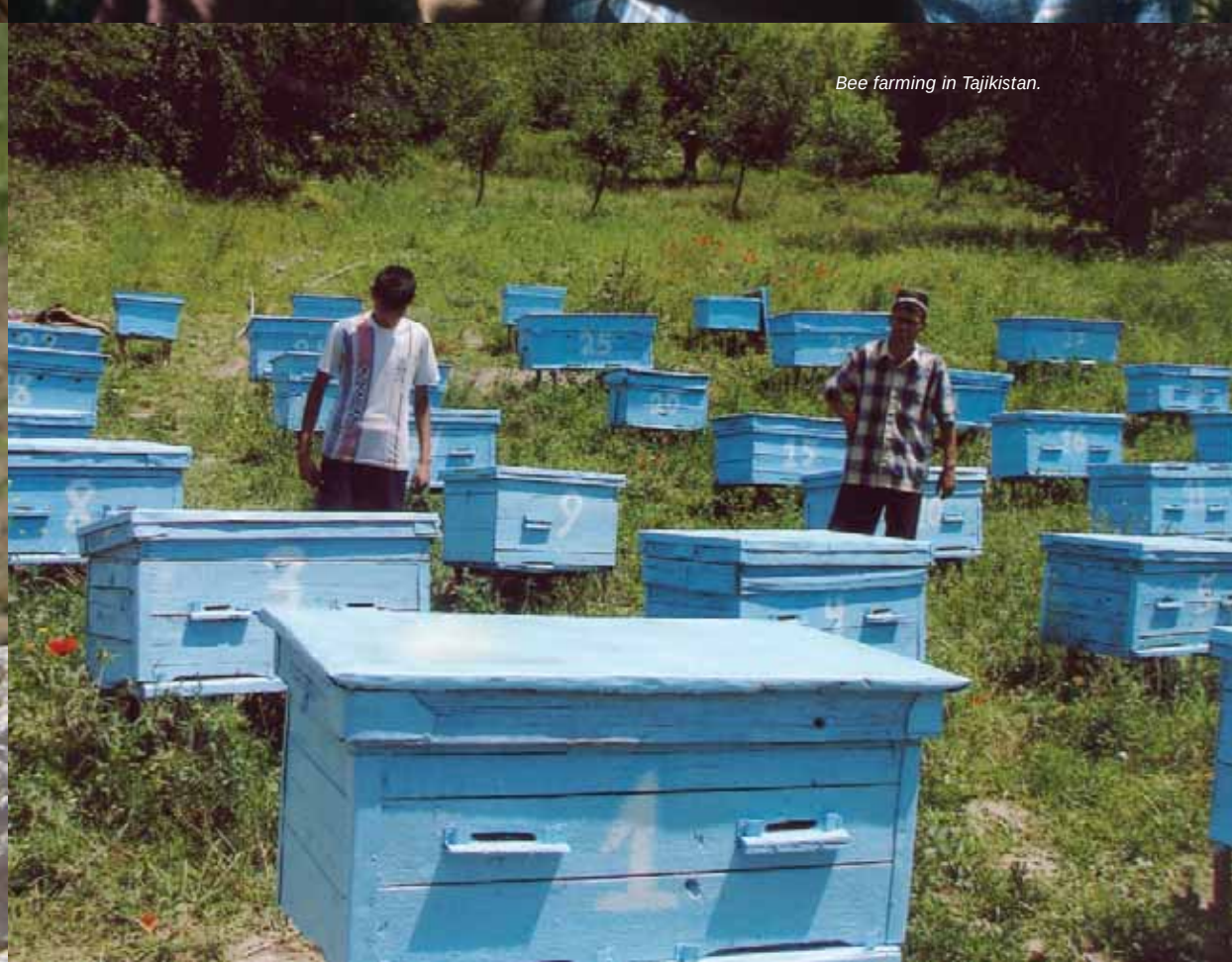
Farmers, young and old, in Tajikistan.

Diversification of livelihood assets and watersheds management

Farmers in Tajikistan's predominantly mountainous landscape face the challenges of land degradation, tenure insecurity, lack of capital financing, limited capacity, and an emphasis on lowland cotton production. This limits the potential of mountain agroecosystems to provide ecosystem services and productive livelihood assets. To address these challenges, the World Bank/GEF-supported Community Agriculture and Watershed Management Project is helping rural communities in four watersheds increase agricultural productivity and household assets in environmentally sustainable ways. Partnerships between government and civil society organizations have helped rural people design and implement about 4,000 small grants for investments in farm productivity, sustainable land management, and rural infrastructure. Popular investments include crop diversification, horticulture, rangeland management, beekeeping, agroprocessing, woodlots, and drinking water supply.

Integrating environmental, economic, and social considerations is critical. Horticulture, for example, which covers more than 2,500 hectares with almost 1 million fruit and nut trees, includes terraced planting, inter-cropping for initial income, soil fertility enhancement, arrangements to secure land-use rights, and measures to share benefits fairly among participants. To date, more than 43,000 households (230,000 people, 40 percent of whom are women) in 402 villages have benefited; many households are receiving annual incremental returns of $100 to $300. Improved land management practices have increased vegetative cover, as well as soil and water conservation, on more than 95,000 hectares. With support from the project, the National Academy of Sciences has also identified and described 425 rare and endangered plant species in the watersheds, which are now being conserved either on farms or *ex-situ.*

Improved land management has enhanced soil and water conservation.



Bee farming in Tajikistan.

A flower farm in Tajikistan.

Deforestation in Amazonia, Mato Grosso, Brazil.

Enhancing livelihood options to safeguard the fragile Caatinga Ecosystem

The Sertão region of north-east Brazil covers an area of almost one million square kilometers, including the Caatinga biome, a biodiversity hotspot with an exceptional level of endemic species. Despite its recognized status as an important habitat for terrestrial biodiversity, the ecosystem is increasingly threatened by land degradation and desertification from a variety of factors: loss of vegetation through charcoal production, poor farming practices, over-grazing, soil erosion, deforestation by smallholder farmers and ranchers, and unsustainable irrigation practices. Desertification has resulted in loss of carbon stocks, disruptions of water flows, and poor quality of water sources. An estimated 20 percent of the region is affected, threatening the livelihoods of about 15 million people.

To address these challenges, the Government of Brazil drew on the experiences of the Sustainable Development Project for Agrarian Reform Settlements in the Semi-Arid North-East—*Dom Hélder Câmara Project (DHCP)*. By adding a cross-cutting environmental dimension, the IFAD/GEF Sustainable Land Management in the Semi-Arid Sertão Project aimed to generate a model for tackling land degradation on the Caatinga ecosystem through SLM. This helped facilitate an integrated approach that has led to the adoption of agroecological practices in crop production and animal husbandry, more efficient irrigation practices, and alternatives to enhance soil fertility. As a result, the Caatinga biome and its ecosystem services, including carbon stocks, are increasingly protected.

A family tends potato fields in northeast Brazil.

SLM helps mitigate threats to the livelihood assets of farmers, herders, and pastoralists.

Mangroves on the Saloum River, Senegal.

Safeguarding water resources

The links between soil, water, and their consequences for people, are both simple and complex.

MORE THAN 1.8 BILLION PEOPLE LIVE IN AREAS PRONE TO LAND DEGRADATION AND WATER SCARCITY, WHERE REDUCED LEVELS OF ECOSYSTEM SERVICES ARE AFFECTING LIVELIHOODS AND FOOD PRODUCTION.

These vulnerable areas have many challenges, including too much or not enough rain, and high temperatures. The most common forms of degradation are groundwater depletion, salinization, soil nutrient depletion, pollution, removal of vegetation cover, and wind erosion. These processes will play out differently depending on soil characteristics, climate, and soil management. Rural poverty and malnutrition are also more acute in these areas.

The growing influence of climatic variations, as well as the impact of a burgeoning population on soil and water resources, can increase the vulnerability of poor farmers. This, in turn, can lead to overexploitation (logging, tree clearing, overgrazing) and further loss of vegetative cover, with long-term consequences at the catchment area. Soil and water management at the catchment area are crucial for reducing erosion on slopes and risk of sediment in lakes, rivers, and wetlands. In numerous cases, however, existing production practices are inappropriate for the soil, the slope, and the type of climate. For example, in several catchment areas of the Lake Victoria Basin, smallholder farmers' land-use practices have contributed significantly to massive soil erosion and subsequent siltation of the lake and wetlands.

Agriculture is actually the single largest user of freshwater[26] and is a major cause of degradation of surface and groundwater resources through erosion and chemical runoff. Irrigation systems are well developed in some humid areas such as Southeast Asia, where SLM plays a crucial role in regulating hydrological flows, including links to forest ecosystems. On the Island of Bali in Indonesia, irrigation does not simply provide water for the plant's roots, it also helps construct a complex, pulsed artificial ecosystem.[27] In this traditional approach to water management known as *Subak*, paddy fields are built around water temples and a priest allocates water.

Small-scale irrigated systems occur in many regions. Individually, these systems may not serve huge numbers of people or help produce vast quantities of food and other crops, but they remain a significant element in the survival of people in dryland areas. Such systems develop along small perennial streams and at oases, or are built where flood and spate irrigation are feasible, as well as around boreholes. While these locations (where water is available) always provide a focal point for socioeconomic activity, livestock owners and farmers are increasingly competing for limited water resources. Since efficient water management will protect land from salinization and waterlogging, SLM aims to reduce water surface, chemical runoff, and erosion in regions where irrigated agriculture dominates. In some regions, where extensive irrigation has depleted groundwater, SLM can help recharge groundwater through innovations that improve infiltration, and reduce runoff and waste, as well as protect aquifers such as wetlands.

More than 90 percent of land-use area for agriculture in developing countries is rainfed. In humid and sub-humid regions, which commonly depend on rain for agriculture, erosion control and agroforestry are important options to enhance soil and water management. In these systems, SLM manages water runoff to avoid sediment flushing, improve rainfall absorption and organic matter storage, and concentrate eventual nutrient inputs for crops. In many ways, successful implementation of SLM practices in rainfed and

A village in Benin with access to safe, clean water.

More than 1.8 billion live in areas prone to water scarcity.

irrigated systems is about being able to connect and conceptualize, through practical applications, techniques that are informed by land use and integrated water resource management options. Various crop practices have been proven to regulate water flow, reduce erosion, and improve yields. Rock dikes, earth bunds, pits, and terraces, for example, continue to improve soil productivity and water management; the height of the stone bunds depends on the availability of stone and depth of the soil.

In arid and semi-arid environments, enhancing soil fertility and controlling erosion are major priorities. In the drylands of Africa, farmers use a wide range of soil and water management techniques to cultivate cereals such as millet and sorghum. Stone lines slow down the rainwater flow, enhance water infiltration, and retain organic fragments and fine soil particles that will increase soil fertility in the long run. Drawing on this same principle, farmers in Burkina Faso and Mali plant pits or basins called “zaï” or “tassa.” Zaï pits, around 20-40 centimeters in diameter, are planted 10-15 centimeters deep to accumulate water, organic matter, and manure. Depending on the cultivated crop, farmers plant 10,000-15,000 zaï pits per hectare. Variations, such as the “half moon” in Niger, are commonly in use throughout the sub-region.

Since rain is a major source of water in Africa’s drylands, water has been harvested for centuries from rain, dew, runoff, or ephemeral streams for agricultural, livestock, or domestic use. Depending on the scale of water harvesting, several options exist to maximize efficiency in agriculture. On the one hand, farmers can use rainwater harvested from small catchments immediately; on the other, they can use or store runoff from macro-catchment systems and flood waters.

The success and sustainability of these options depend on availability of labor, as well as on the often complex realm of land tenure. In agropastoral systems, for example, modern law (rights) coexists with customary practices, leading to conflict between crop farmers and herders. SLM engages and empowers stakeholders to come up with solutions, and also considers local concerns related to land tenure and use rights. Integrated water resource management approaches, which emphasize cross-sector collaboration, also facilitate linkages between upstream and downstream land users at appropriate scales.

The stories that follow demonstrate how SLM innovations can enhance availability and access to water resources (*development benefit*) and also reduce sedimentation, salinization, and waste, while sustaining flows in production systems (*environment benefit*). They include small-scale rainwater harvesting (*Namibia*), wastewater reuse (*Italy*), integrated floodwater management (*Iran*), catchment management to reduce downstream sedimentation (*Turkey*), and protection of mountains as water towers (*Central Asia*).

Rain is a major source of water in Africa's drylands.

Salt deposits on the bank of a lake in Etosha National Park, Namibia.

Rainwater harvesting for improved livelihood practices in drylands

The north-central regions of Namibia (Ohangwena, Omusati, Oshana, and Oshikok), are faced with insufficient availability of water for human and agricultural use. As a result, community members—particularly women—have had to walk several kilometers for water. As part of the Country Partnership Programme with UNDP and the GEF, the Government of Namibia introduced a Climate Change Adaptation (CCA) project that focused on water harvesting. The project distributed 70 water tanks with a combined capacity of 250,000 liters to households, schools, and hospitals in the Omusati region. Rain water, which flows from roof gutters into the tanks, is available for both households and agriculture.

Schools in Namibia have planted vegetable gardens.

In addition to the tanks, the project excavated a multi-purpose earth dam of 6,000 cubic meters from natural ponds to help produce livestock. This water storage system is the only source of water during the drier seasons. Fifty-six farmers are benefiting from the earth dams, and subsequently helping improve the condition of livestock. The harvesting system not only effectively safeguards water, it also helps improve the lives of communities across the region: as part of their curriculum, 15 schools benefiting from this initiative have planted vegetable gardens and established school environmental clubs.

Water retrieved from a borehole near Juba, South Sudan.

Cattle line up at the water trough in Kenya.

Women haul water in Nigeria.

Gathering water in Kenya.

A glacier tongue in the Sary-Jaz Mountains, Kyrgyzstan.

Protecting transboundary water towers in Central Asia

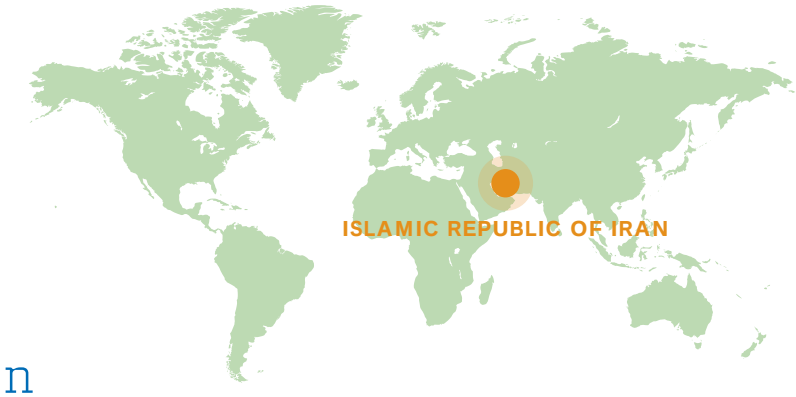
The PALM project, an initiative of the Governments of Tajikistan and Kyrgyzstan with support from UNEP and the GEF, addresses the interlinked problems of land degradation and poverty within one of Central Asia's critical mountain "water towers" and biodiversity hotspots—High Pamir and Pamir-Alai Mountains. By strengthening the technological, institutional, policy, and legislative environments, the project is enabling mountain communities in both countries to take charge of their own resources.

Both countries endorsed a Regional Strategy and Action Plan for SLM based on extensive and participatory consultations. To ensure the strategy's success, the community is assessing resources and land use, and implementing micro-projects at selected hot spots—projects designed to restore and enhance the land's productive and protective roles. Applied research in several fields, including SLM, renewable and bioenergy, and pasture and land management, is providing hands-on advice to communities and governments alike. These lessons, along with training, are developing capacity to apply SLM within the countries' public and private sector agencies, research and advisory service providers, and the mountain communities themselves.

The bottom-up approach, new partnerships, and mainstreaming of SLM are already generating results that may mobilize additional resources for scaling-up in the Pamir-Alai region, as well as in other transboundary mountain environments in Central Asia. Apart from the global environmental benefits for the Pamir-Alai mountains, the project has become a case study that similar environments can replicate to address land degradation.

A yak emerges from Karakul Lake in sight of the Pamir Mountains.

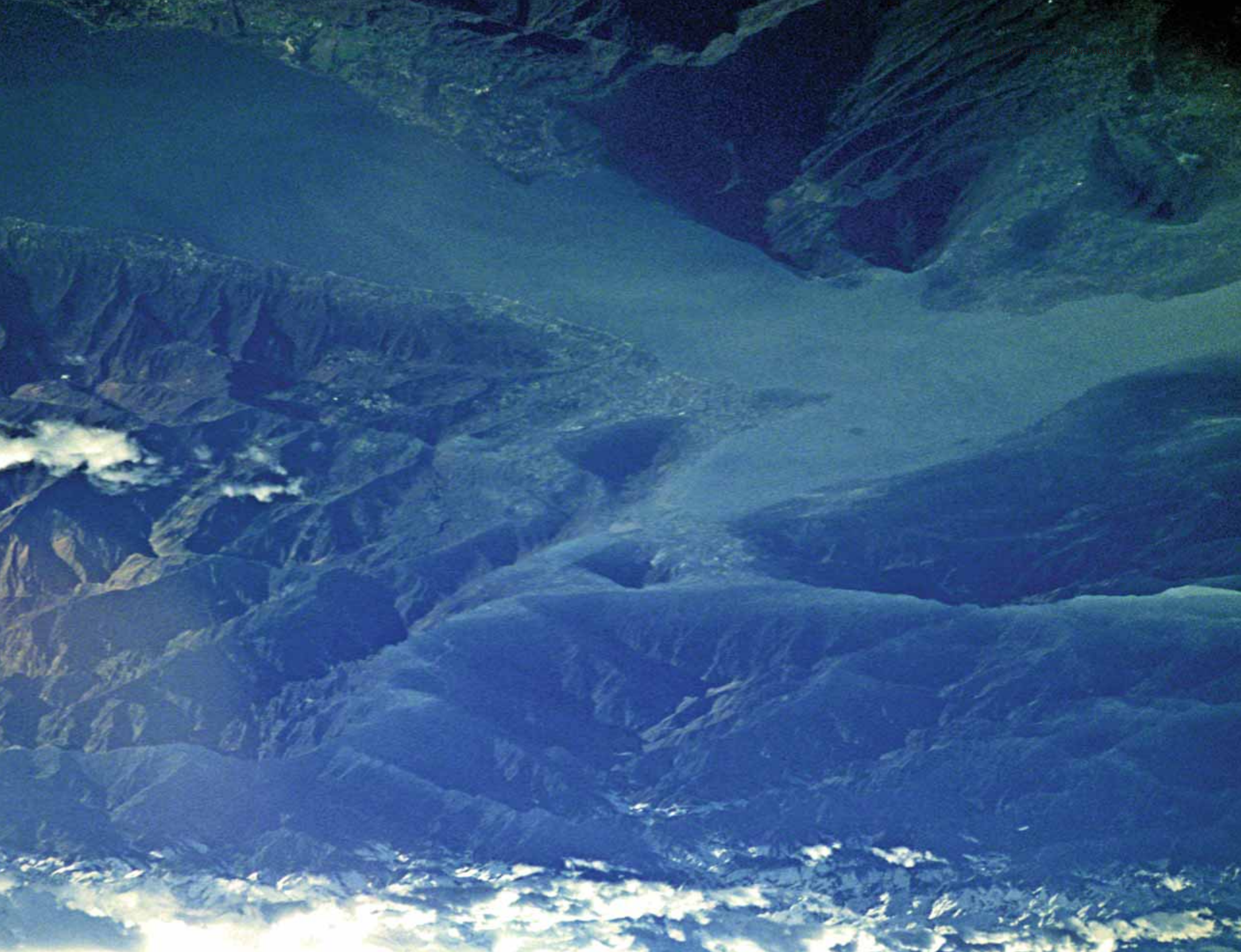
Farmers use cows to thresh wheat in Tajikistan.



Integrated floodwater spreading systems in Gareh Bygone Plain

During the 1930s, nomadic pastoralists were forced to settle in the Gareh Bygone Plain, about 200 kilometers from Shiraz in Southern Iran. This policy led to overgrazing, fuelwood collection, and inappropriate land-use technologies such as plows and pumps, which ultimately degraded 6,000 hectares of scrubland in this arid and fragile ecosystem. Over 12 years, the water table receded 10 meters, leaving it close to the bedrock. Saltwater intrusion into the aquifer compounded the water shortage, and the soil was also damaged from irrigation with saline waters, exacerbating desertification. Some 500 people were now forced by these conditions to leave the Plain as environmental refugees.

In response, the Government of Iran developed a plan for "integrated floodwater spreading systems" to combat desertification in cooperation with The Floodwater Spreading Group of the Research Institute, and the Forests, Range, and Watershed Management Organization of Iran. Drawing on traditions practiced for millennia in different parts of Iran, the project spread floodwaters to increase water in the soil and also artificially recharged groundwater to support agriculture, rangelands, and sustainable natural resources management. As a result, between 1983 and 1987, 1,365 hectares of the Plain were rehabilitated, increasing the irrigated farm area eight-fold. Some 2,500 villagers and 500 nomads now have access to safe water. In addition to irrigating water for 451 hectares of laser-leveled farm fields, the system helped increase soil moisture and groundwater level on abandoned farmlands, making them workable again and thus enhancing agricultural productivity. On rangelands, the average annual forage yield has increased five-fold to 445 kilogram/hectare. The deposit of fine-grained sediments in the systems has converted a loamy sand into sandy loam-loam, suitable for growing small grains.



A range of sleeping giants in Iran.

The rolling hills of Tuscany, Italy.

Reusing wastewaters for production and recreational land use

Ostuni, a city in Italy's southern region of Apulia, has a typically semi-arid Mediterranean climate. While olive trees, vineyards, and arable cropping dominate the economy, tourism is also an important source of income. The land surrounding Ostuni, however, faces many environmental challenges. Water scarcity and drought negatively impact olive trees, wastewater discharge from the city pollutes sea water, groundwater is overexploited, and saline water seeps into coastal aquifers. To tackle these challenges, the Ostuni municipality, in partnership with Apulia Water Association (Acquedotto Pugliese) and funding from the region of Apulia, introduced an innovative technology in 2009 to purify and refine urban wastewater, and then distribute it free to farmers and to 150 hectares of private property for irrigation. The wastewater reuse system has an operational capacity of 6,000 cubic meters per day and a maximum flow of 100 liters per second with the storage tank alone containing up to 1,000 cubic meters of purified and refined wastewater—the equivalent of about half an Olympic-size swimming pool.

The City of Ostuni is purifying urban wastewater.

The technology, which has also become an alternative to private well-water outflows for irrigation, has served several objectives concurrently. At the system level, under the city's watchful eye, it has improved efficiency in wastewater reuse for agriculture. It has also preserved olive trees in public places, which, in turn, has enhanced the city's beauty and biodiversity, along with its value for tourists; the olive trees are also producing more. An increase in irrigation-based crop production has improved farmers' incomes, while the availability of more reclaimed wastewater for irrigation has motivated some farmers to venture into horticulture. The salinization of groundwater has declined, while the elimination of urban wastewater discharge has restored nearby coastal waters for swimming. In short, local and household economies, land health, and biodiversity have all benefited.

An olive grove by the sea.

A meadow overlooks Santa Maria di Leuca, Italy.

In the Anatolian Highlands of Turkey, between Ankara and Hattousa.

Catchment rehabilitation in the Anatolian Highlands

Deforestation to meet increasing timber, fuel, and fodder demands, together with overgrazing of rangeland, farming of steep slopes, and the lack of effective soil conservation practices on agricultural land, have resulted in widespread degradation of land and water resources. Only 6.6 percent of the land in Turkey does not suffer from erosion. Land degradation has significantly reduced the carrying capacity of rangeland and the fertility of agricultural land in the upper catchment areas, negatively affecting farming households' livelihoods in the upland regions, with resulting higher poverty rates in these areas. Reduced vegetative cover has led to marked reductions in soil moisture content, making agricultural lands significantly more vulnerable to drought. Land degradation has also led to unstable and increasingly torrential river flows with more flooding and growing sedimentation problems. Landslides have also become a cause for concern.

Building on successful community-based and integrated approaches to natural resource management, the World Bank/GEF Anatolia Watershed Rehabilitation project is working with 28 communities to develop and implement an integrated natural resource management plan (micro-catchment plans) in the Upper Watershed Areas. Communities chose from a menu of technical options to rehabilitate and to use degraded forest, range, and agricultural lands more sustainably. As a result, the project has rehabilitated more than 80 square kilometers of the degraded micro-catchments. SLM practices, such as application of organic manure and compost to the farmed soils, have directly enhanced production of crops like chickpeas, which have increased by 45 percent. Improved yields also increased overall household income by as much as 14 percent since the project's inception. These results, along with extensive training courses, have led one-third of all farmers in the micro-catchments to adopt environmentally friendly, organic farming practices. The results have also been central in the formulation of a draft "Code of Good Agricultural Practices"—a vital first step in moving towards a legal framework consistent with the EU Nitrate Directive for good agricultural practices based on on-farm trials, demonstrations, and training sessions.

Only 6.6 percent of land in Turkey does not suffer from erosion.

Farmers tending crops in Turkey

Farming in the Plain of Adana, a fertile region in Turkey.

A young alfalfa farmer in Turkey.

Women working the fields in Turkey.

Deforestation and overgrazing have degraded both land and water resources in Turkey.

Haystacks cluster in a pastoral valley of the Anatolian plateau.

Sand dunes, like this one covering a road in the Nile Valley, encompass nearly one-third of the Sahara Desert.

Climate change mitigation

According to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC), land use accounts for 30 percent of all greenhouse gas (GHG) emissions.

Of this amount, 10-12 percent of emissions come from energy, fertilizers, and tillage, while deforestation accounts for some 15-17 percent of land emissions—some 8 gigatons of carbon in 2000.[28] The Report also notes that managing cropland and grazing land, alongside restoration of degraded and cultivated organic soils, are the most promising strategies for reducing carbon. At the same time, livestock and rice field management have the greatest potential for reducing nitrous oxide. Further, soil carbon sequestration could reduce close to 90 percent of these GHG emissions.

Drylands account for 36 percent of the total carbon stock of terrestrial ecosystems.[29] Plant biomass per unit area is low in drylands—60 tons per hectare compared to 100-180 tons per hectare in other terrestrial systems. Still, given the drylands' large surface area and high levels of soil degradation, much potential exists for soil carbon sequestration. In fact, the IPCC's Third Assessment Report observed that a carbon-depleted ecosystem may accumulate carbon at much higher rates than a comparable ecosystem that has maintained carbon stocks. The restoration of degraded and eroded dryland soils demands an increase of soil carbon, which would lead to the sequestration of 0.4-0.6 gigatons of carbon per year.

SLM helps mitigate climate change through carbon sequestration both above and below ground, as well as by reducing emissions from maintaining and enhancing carbon stocks in agroecosystems. Introducing SLM practices in areas vulnerable to climate change helps build resilience and stabilize ecosystem services. Directing such practices at erosion control can also increase capacity for carbon sequestration in soils. In addition, reducing land degradation in agroecosystems can alleviate anthropogenic pressures on natural forests, protect existing carbon stocks, and increase overall resilience of the ecosystem. Finally, increasing resilience to climate change through SLM can improve both ecosystem health and the supply of ecosystem services in production systems.

The potential for climate change mitigation in the agricultural sector includes: (a) improved crop and grazing land management to increase soil carbon storage; (b) restoration of cultivated peaty soils and degraded lands; (c) improved techniques for rice cultivation, as well as for livestock and manure management, to reduce methane emissions; (d) improved techniques for nitrogen fertilizer application to reduce nitrous oxide emissions; (e) dedicated energy crops to replace fossil fuel use; and (f) improved energy efficiency. The economic potential of these mitigation options has been projected to reach 2.3–6.4 gigatons carbon-dioxide equivalent (CO_2-eq)/year in 2030, and at a price of US$100/ton CO_2-eq. This is higher than the estimate for the forestry sector, which varies between 1.3 to 4.2 gigatons CO_2-eq/year at the same price.[30]

Conservation Agriculture, an important SLM option that offers environment and development benefits to mitigate climate change, is based on three key principles that contribute to carbon storage: minimum mechanical disturbance of the soil, permanent organic cover of the soil surface, and a diversified sequence or association of crops. Although its adoption in regions such as Sub-Saharan Africa

A tree plantation in Tunisia.

has been slow,[31] Conservation Agriculture can still be viewed as a base for National Action Plans for Adaptation, and its practices can reduce GHG emissions by 0.5–1 ton/ CO_2-eq per year and hectare. On the approximately 100 million hectares of Conservation Agriculture currently practiced worldwide, this works out to about 1 gigaton of reduced emissions until 2030—more than the 10 percent required to meet the scenario of reducing emissions to 450 parts-per-million (ppm) CO_2-eq.[32]

Generally, measurement, reporting, and verification (MRV) of climate change mitigation have been a key constraint to adopting soil carbon sequestration in global policy initiatives. Recent scientific advances, however, have made soil carbon sequestration easier to measure, and there is also growing awareness of the potential of global soil organic carbon: these shifts in the landscape have raised hopes for tangible mitigation benefits from SLM. Furthermore, the potential for engaging local populations in mitigation activities and the relatively vast land surface that could be harnessed for soil carbon sequestration have fuelled interest in this issue, and its untapped market. In this context, it will be important to create carbon finance opportunities for climate-friendly projects in the drylands. Linking private buyers of carbon emission reductions with local SLM initiatives will enable the private sector to support environmentally and socially responsible projects.

The stories that follow demonstrate the potential of SLM options for harnessing investment and income opportunities for communities (*development benefit*) while securing carbon stocks and flows (*environmental benefit*) in production landscapes. They include practices that contribute to carbon sequestration at scale, such as Conservation Agriculture (*Eritrea*), integrated ecosystem management (*China*), pasture and rangeland management (*Kazakhstan*), afforestation (*Romania*), village grove (*Korea*), and use of organic matter (*Spain*). As knowledge of MRV tools becomes widely applicable, the opportunities for scaling-up carbon mitigation in agriculture and livestock production will become invaluable in the fight against rural poverty and land degradation.

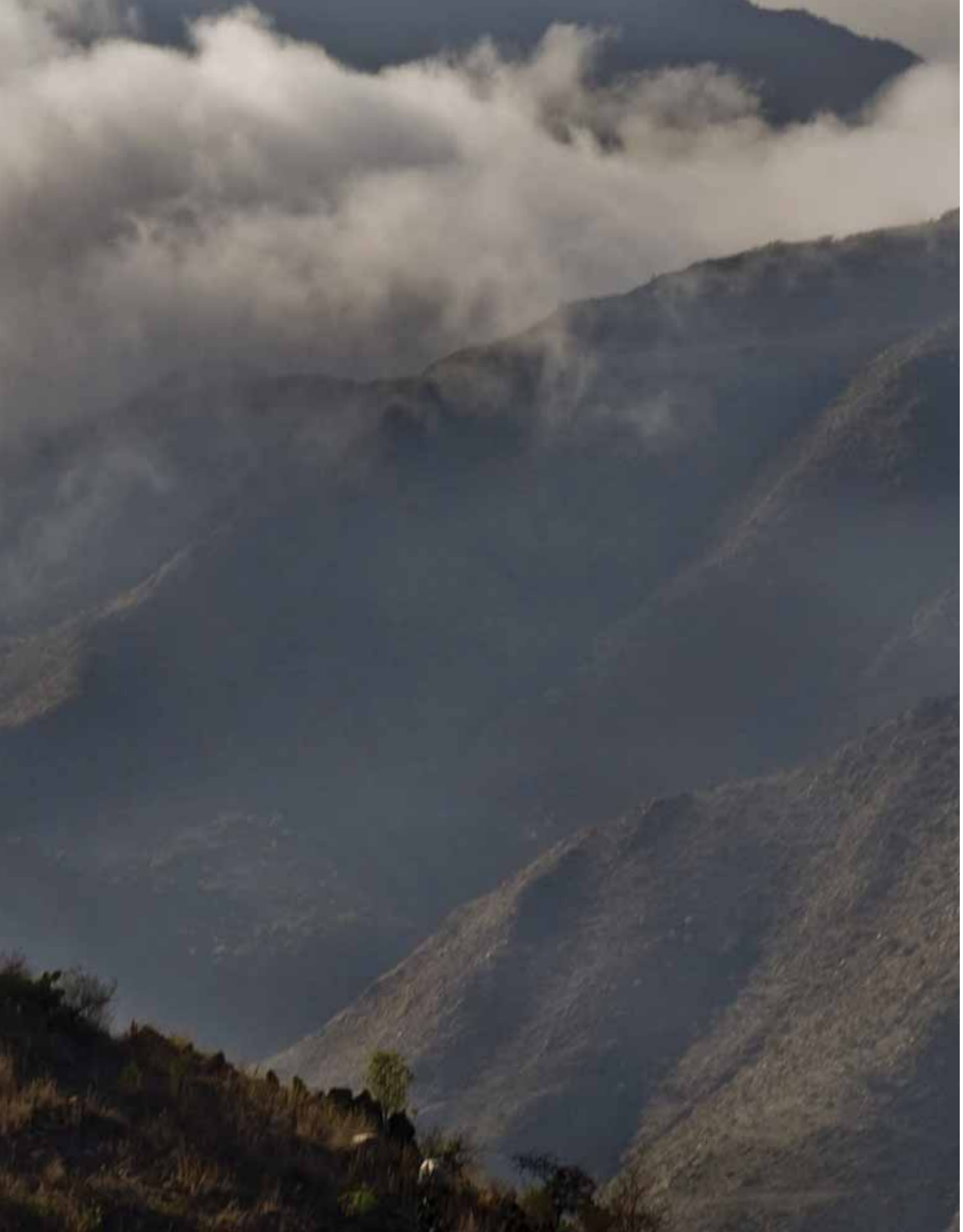
Farming green tea in Boesong, Jeonnam, Republic of Korea.

Dijibouti's Lake Assal, a highly salinated lake in a vast crater, experiences high evaporation.

Conservation Agriculture in the Central Highlands

Natural resources are central to the livelihoods of the Eritrean population, particularly in the Central Highland Zone (CHZ) where 65 percent of the population lives. Land degradation in the CHZ, however, is severe. Six major causes have been identified: inappropriate agricultural practices; unsustainable use of woodlots and natural forests; inherently poorly developed soils; poorly coordinated land-use planning; limited application of knowledge and technologies by farmers to enhance productivity; and insecure land-tenure systems. This last factor has been crucial since, traditionally, farmers could only own land for seven years before having to move elsewhere; the 1994 Land Proclamation gave farmers the right to benefit from a property that belongs to another person. By shifting farmers from a rotational system into usufruct-based permanent possession, the Proclamation gave farmers incentives to make long-term investments on agricultural and individual forest plots to combat land degradation. The decrees of the Proclamation, however, were barely put into practice.

To tackle these challenges, the UNDP/GEF Sustainable Land Management Pilot Project is creating an SLM enabling environment at both policy and community levels. In refurbishing unsustainable agricultural practices, the project launched the concept of a village-based land-use system to ensure that land generates the best possible economic and ecosystem services. Over the hilly and complex landscape of the Central Highland Zone, the project is promoting the principles of Conservation Agriculture, whereby intensive soil and water conservation and re/afforestation minimize land degradation and soil erosion. Through community participation, 470 kilometers of hillside, 575 meters of bench terraces, and 300 cubic meters of check dam were constructed, while 22.5 hectares of land were leveled for irrigation. In addition, the project planted 255,938 indigenous trees, including *Eucalyptus, Bitter leaf, Pepper tree, Olia africana, Acacia, Azadirachta indica, Jacaranda, and Bottle brush.* These complementary interventions are expected to strengthen communities and livelihoods, as well as boost agricultural production.



In the shadow of the mountains, near Asmara, Eritrea.

Corn dries on a highway near Beijing, in the People's Republic of China.

Integrated ecosystem management for multiple benefits in drylands

The People's Republic of China (PRC) suffers from some of the world's worst land degradation problems, with more than 40 percent of its land area adversely affected and millions of livelihoods threatened. To respond to this challenge, the Government worked with multiple stakeholders to create the PRC-GEF Partnership to Combat Land Degradation in 2002. The Partnership helped the western provinces of Gansu, Qinghai, and Shaanxi, as well as the autonomous regions of Inner Mongolia, Ningxia Hui, and Xinjiang Uygur, to improve legal and regulatory frameworks for combating land degradation, formulate integrated ecosystem management (IEM) strategies, and strengthen capacity to implement IEM. The Partnership has also worked closely with local communities to pilot on-the-ground sustainable land management practices to improve livelihoods. In one such project, 18 pilot sites covering 556.4 square kilometers of land were targeted for SLM, benefiting around 6,000 households and 27,000 people.

Supported by best practices, thematic studies, and cost-benefit analyses, the Partnership is developing innovative market-based mechanisms to further scale-up SLM. These include the Sustainable Development in Poor Rural Areas Project, which will build capacity of local governments and communities to analyze land degradation and climate change risks and vulnerability, and implement appropriate measures to address such risks (including pilot indicators for sustainable land management in national poverty monitoring).

The project is also providing investment support for small-scale infrastructure and equipment to pilot innovative but simple low-carbon development measures. Apart from a positive impact for the 80 participating villages, expected global environmental benefits include increased soil vegetation cover and the renewable use of biomass, as well as increased carbon storage. By the project's end, carbon stock is expected to increase by 5 percent across all pilot villages—the equivalent of about 96,000 tons of carbon. For the total project area of 800 villages, an estimated 400,000 tons of carbon will be sequestered.

In the People's Republic of China, more than 40 percent of land is severely degraded.

Simple low-carbon projects are expected to generate significant environmental benefits in rural areas of the People's Republic of China.

Stubble burns in the drylands of Kazakhstan.

Carbon benefits in pasture and rangeland management

Faced with marginal drylands, the Government of Kazakhstan put in place a sustainable livestock-based land-use system to safeguard its rangelands and generate carbon benefits. The World Bank/GEF Drylands Ecosystem Management Project was designed to provide initial service support to producer groups, improve national capacity to quantify carbon sequestration, promote public awareness, and develop a strategy to replicate interventions in similar areas of Kazakhstan. With active participation of local communities, the project has achieved significant results in terms of demonstrating and promoting sustainable land uses.

Through the project, 9 associations comprising 133 small and medium farmers manage assets and disseminate results to other farmers. This support has shown how appropriate technical assistance and start-up inputs can help diversify land use and generate income from the sustainable use of natural resources in drylands. The project's integrated ecosystem management approach has created benefits at a local, national, and global level, including the restoration of 105,000 hectares of degraded and remote pastures with annual carbon sequestration benefits of four tons per hectare/year. In addition to improved management of a pilot area in the Shetsky region, policy and institutional mechanisms are facilitating the scaling-up of interventions.

Rotational grazing on the mountain slopes of Tajikistan.

Herding and nomadism have a long tradition in Kazakhstan.

Mist covers the Bihor Mountains in Romania.

Incentives for community-based afforestation

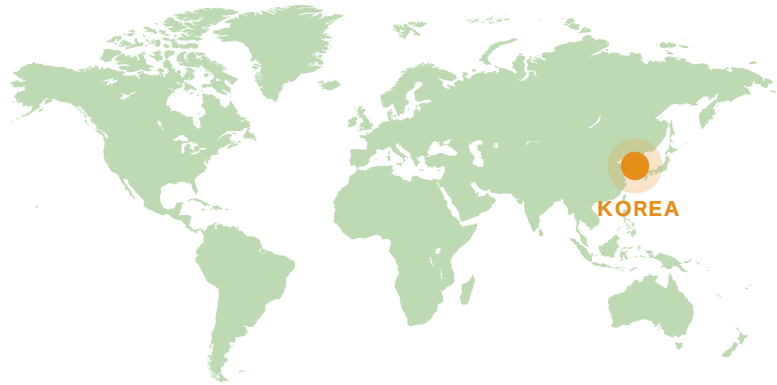
Rural communities in Romania depend highly on crops and livestock, yet soil erosion, salinization, and other factors have significantly degraded production landscapes, often leading to serious economic losses. To counter these developments, the Government has established a national programme of afforestation that makes degraded lands eligible for afforestation financing. The National Fund for Land Reclamation applies to both public lands belonging to the central government, as well as lands managed by communities and municipalities. Local committees prioritize landscapes for afforestation, and feasibility studies then assess options. Local forestry agencies (inspectorates), which manage public works, verify financing claims. The plantations must meet applicable standards for afforestation of degraded lands, including consistency with native forests in the area.

If afforested lands are deemed successful after five years, they are officially designated under the “forest” land-use category, becoming subject to forest management plans and the forestry regime. Between 2005 and 2006, under this programme, more than 5,000 hectares of degraded lands were afforested. The cost of afforestation (including plantation maintenance) is up to 5,000 Euro/hectare. Between 2008 and 2009, due to the economic recession, funding and afforested areas decreased considerably (from 2,500 to 1,000 hectares). In 2010, the Government demonstrated its commitment to the programme by investing in new afforestation areas, which are also included as Afforestation/Reforestation activities under the Kyoto Protocol (LULUCF).

Farm workers in Romania pitch hay during the harvest.

Hop plants, a traditional crop in Transylvania, Romania.

A farmer harvests barley in the Republic of Korea.



Village grove in agricultural landscapes

In the Republic of Korea, the typical spatial arrangement of land use in villages includes forested mountains that serve as boundaries for the village, the residential area, ponds or rice fields in front of the village, and groves known as *Maeul-soops*. Research shows that the traditional village land-use practice based on topographical features is a good way to enhance internal cycling of resources within the watershed. A *Maeul-soop* is usually established at the mouth of a watershed for historic landscape management and influenced by local religious beliefs. *Maeul-soops* are a distinct feature of traditional Korean agricultural landscapes, and an important element of cultural life in the villages that also generate ecosystem service benefits.

In addition to safeguarding parts of the village that are vulnerable to biophysical factors such as wind and flooding, *Maeul-soops* help increase landscape connectivity by acting as a corridors or stepping stones, as well as by providing refuge for many terrestrial and aquatic organisms. By serving as windbreaks and for erosion control in the production landscape, *Maeul-soops* also protect organic matter in the soil. The multiple ecosystem service benefits of *Maeul-soops* are largely overlooked in modern Korean society. Yet the practice still represents a model of sustainable land management in rural landscapes that can be harnessed for climate change mitigation and biodiversity conservation.

About 82 percent of Gangwon, a province in the Republic of Korea, is surrounded by mountains.

Farming Chinese cabbage in Gangwon, Republic of Korea.

Olive groves near Sevilla, Andalusia, in Spain.

Olive husks for soil fertility and carbon benefits

Organic waste, a carbon-rich source of plant nutrients, is commonly used to maintain acceptable levels of organic matter in soil. Yet the practice is often constrained by inadequate knowledge of readily available sources, such as olive husks in the Andalusia region of Spain. While the region produces 80 percent of Spain's olive oil, the final product only uses 21 percent of the olive harvest. The rest, a by-product of the olive press process, is the olive husk, known locally as *alperujo*. It is predominantly organic matter but represents all that is not olive oil. Until now, the olive husk has had little economic value and its disposal was becoming a major problem. In Andalusia, for example, each production cycle generates four million tons of a*lperujo*. At the same time, soil erosion averages 23.17 metric tons per hectare every year, equal to the loss of about 1 millimeter of topsoil per year. The result: land degradation.

Between 2004 and 2006, the Spanish National Institute of Agricultural Research and Technology (Instituto Nacional de Investigación y Tecnología Agraria, INIA) explored the idea of recycling *alperujo* as a sustainable and profitable alternative to disposal. Field trials showed *alperujo* improved soil quality significantly. In addition to improved soil structure, the husks also helped protect fields from water runoff and erosion. As a result, the husks reduced soil loss and improved land fertility, which in turn leads to more olive oil production and fewer disposal costs. Moreover, *alperujo* in soil contributed up to 10 tons of carbon sequestration per hectare by increasing above-ground biomass. Based on these results, widespread use of *alperujo* in Andalusia could enhance long-term sustainability of the region's lucrative olive oil industry.

The Andalusia region produces 80 percent of Spain's olive oil.

The mild climate of the Sierra region, in Ecuador, is ideal for growing cereal grains and potatoes.