A Better World

VOLUME 4

Actions and commitments to the Sustainable Development Goals

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Foreword

SEAN NICKLIN, GENERAL COORDINATOR OF THE HUMAN DEVELOPMENT FORUM FOR TUDOR ROSE

With the establishment of the UN Sustainable Development Goals (SDGs) in 2015, the Human Development Forum at Tudor Rose has expanded its publishing operation with the creation of a series of volumes entitled *A Better World*, each dedicated to one or more of the 17 SDGs. This volume, published in September 2018, covers Goal 15: Life on Land, and particularly Goal 15.3, which aims to achieve Land Degradation Neutrality (LDN) globally by 2030.

Goal 15 and the significance of LDN targets have opened a window of opportunity for many countries to strengthen their policies for sustainable use of land and soils. *A Better World: Volume 4* outlines the concept, the main elements and the current international framework for assessing the progress towards SDG target 15.3. It proposes a stepwise approach to further tailor national requirements with the overall goal of LDN implementation. The following articles discuss the progress and challenges in this essential topic, highlighting good practices in a wide variety of societies and disciplines.

By focusing on the experiences and livelihoods of people, especially those in vulnerable human habitats, the book shows the benefits of best policy and practices, and how these may develop further as we come to terms with a changing and more turbulent world. This innovative endeavour is a striking example of sharing respective resources to engage the many official governmental, international organisations, institutional and professional interests in displaying the extent and variety of their efforts to make the world a better place.

Since 1999 Tudor Rose has published 28 books in partnership with the United Nations and its agencies, covering a diverse range of subjects from disaster reduction, water management and climate science to intercultural dialogue and humanitarian assistance. The books are read extensively by the human development sector and especially by community leaders in vulnerable regions around the globe. The books are close collaborations between individual UN agencies, UN member states and civil sector organisations, committed to a better future for the world. They have widened the knowledge of people in vulnerable communities and given them inspiration and knowledge to better their lives in a sustainable way.

Life on Land — An introduction to Goal 15

Monique Barbut, Executive Secretary, United Nations Convention to Combat Desertification (UNCCD)

The United Nations will review progress, up to 2030, made by countries towards the achievement of the 17 Sustainable Development Goals (SDGs) adopted in 2015. Each year, a few of these goals will be reviewed to assess progress and maintain momentum. Goal 15, Life on Land, will be reported on for the first time in 2018, and every four or five years thereafter, as determined by the Department of Economic and Social Affairs of the United Nations (DESA).

Goal 15 is concerned with change in four key areas: degradation of forests, degradation of the land, the loss of biological diversity and the degradation of mountains. It calls on governments to protect, restore and promote the sustainable use of terrestrial ecosystems; to sustainably manage forests; to combat desertification; and to halt and reverse land degradation and halt biodiversity loss.

Target 15.3 is one of ten under Goal 15, with a focus on combating desertification and land degradation as well as mitigating the effects of drought.[1]

Image: Fikret Özkaplan

In Turkey, children are introduced at an early age to the ways of managing land sustainably. It is the only country in the world with a law on soil treatment

Why combat land degradation by 2030?

Global assessments show that land degradation has diverse and perverse impacts on all facets of life, and that preventing or reversing land degradation can advance the achievement of the other 16 goals.

The Millennium Ecosystem Assessment of 2005 concludes that the world's dry areas are home to over 2 billion people, and that 20 per cent of this ecosystem is degraded[2]. In 2017, The Global Land Outlook found that 24 million tonnes of fertile soil is being lost every year, and that, from 1993 to 2013, signs of declining vegetation were evident on approximately 16 per cent of all land on Earth. From 2000 to 2012, about 2.3 million km^2 of forest cover was lost, but only 0.8 million km^2 was reforested[3]. The Thematic Assessment of Land Degradation and Restoration released recently observed that 75 per cent of global land area is degraded, and over 90 per cent could become degraded by 2050 if we continue with business as usual. It warns that land degradation and climate change could lead to a 10 per cent reduction in food production by 2050.[4]

According to the Economics of Land Degradation (ELD) assessment, more than one third of the global rural population is located in agricultural lands or areas that are degrading or that have low productivity or market access.[5] The effects of land degradation impact at least 3.2 billion people worldwide — nearly half of the global population.[6]

In one of the earliest economic assessments of the impact of land degradation, in 1992, UN Environment Programme estimated that desertification and land degradation were costing the international community up to US$ 42 billion. A 2013 study of the rewards of investing in sustainable land management, titled ELD Initiative, shows that preventing and/or reversing land degradation through sustainable land management could deliver up to US$ 1.4 trillion in increased production.[7]

While we know more about the direct impacts of land degradation, the indirect impacts on human well-being through ecosystem degradation are less understood and investigated. The World Atlas on Desertification released in 2018 concludes that some recurring global issues, such as global surface and ground water, have an alarming urgency that was not known 20 years ago.[8]

However, there is growing evidence that, if land degradation can be both reduced now and avoided in future and the health of degraded land is restored, communities everywhere will thrive. They will have access to clean water, and produce more crops that can create reliable, paying jobs in rural areas. Food harvests will increase where hunger persists. The gasses warming the Earth can be restored to the ground.

Image: Nihat Torun

Drylands make up nearly 45 per cent of global agricultural land. Keeping them productive is vital for our food security

Managing life on land enhances life on earth

The United Nations General Assembly recently stated: "Actions to combat desertification, restore degraded land and soil and to achieve a land degradation-neutral world can deliver multiple benefits; and land degradation neutrality has the potential to act as an accelerator for achieving Sustainable Development Goals and as a catalyst for attracting sustainable development financing and climate finance to implement the Convention."[9]

Agriculture, a major driver of land degradation, becomes an instrument of improvement when the pursuit of land degradation neutrality becomes one of its core aims.

One billion people in developing countries live in extreme poverty. Approximately two billion people located in rural areas live on poor agricultural land. Throughout history, agriculture has played an important role in creating rural jobs to alleviate poverty. Estimates suggest that this sector could create up to 200 million full-time jobs by 2050.[10] It would also increase global food production.

But in many regions, agricultural jobs are still created by converting forests or grasslands into farms. These land conversions dramatically weaken rainwater capture and erosion control, leading to job losses in the long term, as the land loses its capacity to produce. At least 52 per cent of all agricultural land is somewhat degraded, in large part due to poor agricultural practices such as overgrazing, salinization, soil pollution, erosion, and leaching.

Land use is the source of nearly 25 per cent of the emissions responsible for climate change. Most of the slow onset and extreme events linked to climate change are manifestations of land degradation — desertification, salinization, land and forest degradation, biodiversity loss and rising temperatures.[11]

Clearly, agriculture can be a creator of sustainable jobs only if new agricultural practices are used that avoid or reduce degradation, or restore already degraded land. The Thematic Assessment of Land Degradation and Restoration found that interventions related to achieving the target on land degradation neutrality are particularly relevant for all the other 16 goals.[12]

Research and field experience both show that it is possible to use land without degrading it, and that it is also possible to restore land that is already degrading. Of the 2 billion ha of forests that are degraded around the world, approximately 1.5 billion are suited for mosaic restoration. Half a billion ha can be restored into closed forest. Planting trees on a further 1 billion ha of land that cannot be converted back from cropland to forest cover can still increase land productivity.[13]

Examples of actions in progress to reduce land degradation and restore degraded areas are: The Transformative Projects and Programmes initiated by the UNCCD; the Great Green Wall for the Sahara and Sahel Initiative in Africa; the Bonn Challenge and its regional initiatives in Latin America and Africa; and the Drought Initiative. These actions reduce the chances of converting natural land, which leads to degradation.

The importance of Goal 15 for human survival cannot be overstated. Efforts to end poverty and hunger by 2030 will depend on the extent to which forests, fresh water resources, rangelands and biological diversity are sustainably managed. Such efforts must be complemented by measures to manage tradeoffs arising from the fact that the same piece of land can be used for multiple purposes that are not always compatible.

Where do we stand on achieving Land Degradation Neutrality?

Sasha Alexander, Policy Officer; Barron Joseph Orr, Lead Scientist; Anja Thust, Programme Officer; Sven Walter, Head, GM Rome Liaison Office; Wagaki Wischnewski, Public Information and Media Officer, UNCCD

In 2000, the link between land management and the Millennium Development Goals was never considered. It was a costly mistake. A decade later, research showed that the bottom billion poor left behind, especially women and children, lived on degrading land.[1]

In order not to leave anyone behind in the pursuit of global progress by 2030, turning degraded lands into healthy and productive ecosystems must become one of the most important social linchpins. To this end, target 15.3 of the Sustainable Development Goals (SDGs) posits the ambition of achieving Land Degradation Neutrality (LDN). It aims to avoid, reduce and reverse land degradation in order to achieve a no-net-loss of productive land.

But the pressures on our land resources are not just huge; they are growing. We can no longer take the land for granted. Competition over land is escalating due to a demand to meet two global needs. On the one hand, there is a growing demand for land to provide goods such as food, water, and energy. This requires exploiting the land. On the other hand, there is the demand for services that support all life cycles on Earth, from regulating a warming climate to refilling ground water sources that are drying up. This requires keeping the land systems functioning. The tension between these two uses is rising, in part, because a significant proportion of the natural and managed land-based ecosystems is degrading.

Image: Levent Ates

Contours for tree planting in a dry region of Turkey — an example of land reclamation on a large scale

Over the last two decades, for instance, between 20 and 30 per cent of the Earth's vegetated surface has shown persistent declining trends in productivity. Poor land and water use and management practices are the key drivers. Climate change and biodiversity loss further jeopardize the future health and productivity of the land.

Over 1.3 billion people are trapped on degrading agricultural land. The world's dryland areas produce close to half of the food consumed globally.[2] But farmers on marginal land, especially in the drylands, have limited options for alternative livelihoods and are often excluded from the wider infrastructure and economic development of a nation.

Higher carbon emissions and temperatures, changing rainfall patterns, soil erosion, species loss and increased water scarcity could render vast regions unsuitable for food production and human habitation. Land degradation decreases our resilience to environmental stresses. The resulting vulnerability, especially of the poor, and women and children, can intensify competition for scarce natural resources and result in migration, instability and conflict.

The scale of rural transformation in recent decades has been unprecedented. Millions of people have abandoned their ancestral lands and migrated to urban areas, often impoverishing cultural identity, abandoning traditional knowledge, and permanently altering landscapes.

More than 40 per cent of the world's poor rely on degraded lands for essential services such as food, fuel, raw material and water purification.[3] Restoring their productive capacity would significantly reduce the economic vulnerability of the poorest. It would also help to promote long-term development for all. That is what makes land degradation neutrality so important. The United Nations General Assembly recently stated that achieving LDN has the potential to accelerate the achievement of other SDGs.

Countries and communities will be able to make the required connections between many of the SDGs and their targets affordably. Safeguarding life on land delivers health for all life on Earth, establishing the basis for communities everywhere to do more than survive, that is, to thrive. Achieving LDN protects the foundation for building a promising future.

The sustainable management and restoration of landscapes — the main pillars for achieving LDN — will deliver many co-benefits including biodiversity conservation, combating climate change, economic growth and human well-being.

Image: Berna Yildirim

Women in a nursery in Turkey prepare the ground to grow tree seedlings

How the land is managed is closely linked to several factors including the capacity to create decent jobs; food and water security; migration and urbanization trends; real climate change mitigation and adaptation action; responsible consumption; and resource conflicts.

What does it mean to achieve land degradation neutrality?
Achieving land degradation neutrality means ensuring that the amount of productive land available (as of 2015) stays stable by ensuring no net loss in productive land. The key to achieving this objective is to take measures to ensure unavoidable land degradation is compensated for through restoration, and to adopt a new approach in land planning that takes landscapes into account.

Why consider a neutrality approach in the first place?
The world's best efforts to confront land degradation have so far failed to keep pace with environmental change, despite the extraordinary advances in science and technology. Policymakers from all over the world acknowledged this fact at the 2012 United Nations Conference on Sustainable Development (the Rio+20 Summit). It was therefore decided, in 2015, to embrace the idea of achieving a land degradation-neutral world and to include the ambition within the SDGs.[4]

A land degradation neutral world is defined as "a state whereby the amount and quality of land resources necessary to support ecosystem functions and services and enhance food security remain stable or increase within specified temporal and spatial scales and ecosystems." The goal of LDN is to maintain or enhance the land resource base to keep it stable.

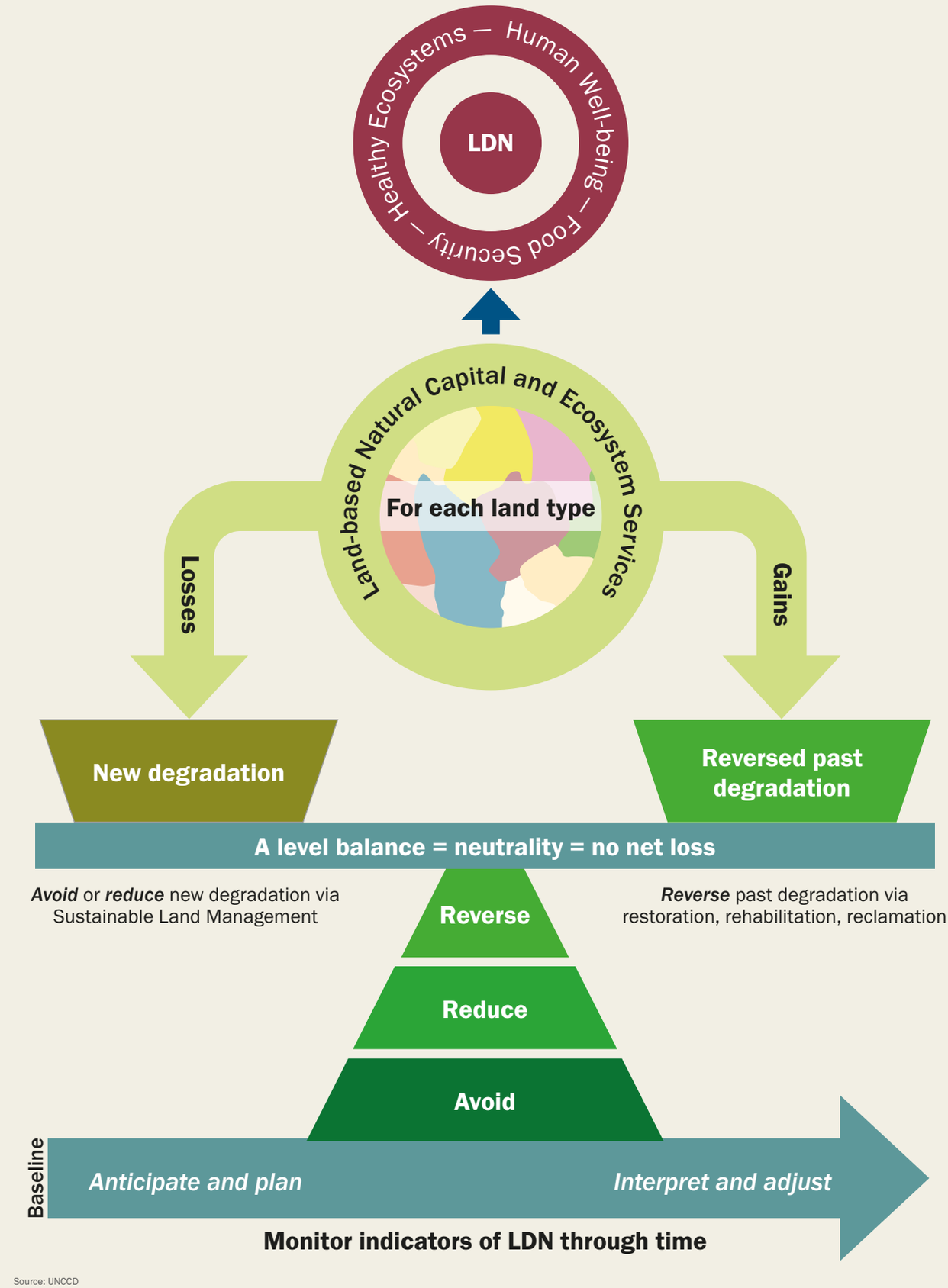
Achieving LDN requires new ways of thinking about land. Instead of using land piece by piece, based on ownership, countries and communities need to consider the land, and all that it contributes to people and nature, in aggregate terms. From this broad perspective, each watershed and parcel of land contributes to a larger system, and it is possible to work out, in an integrated way, how land is used and managed optimally. This requires land use planning — traditionally dependent on sectors such as municipal planning, agricultural planning, and conservation planning — to be carried out collaboratively. Considering that financial resources are scarce, planners require innovative tools to optimize the mix of possible interventions in order to avoid, reduce and reverse land degradation across the landscape.

Also, with competition for land increasing, planners need tools that can minimize environmental, economic and social trade-offs. They also require the relevant and accessible data to design appropriate interventions, monitor progress, and help all affected people to learn and make necessary course corrections. Perhaps most importantly of all, achieving LDN requires social and environmental safeguards. These are the guiding principles that will help to prevent unintended outcomes for people and nature.

In response to a request from policymakers, a team of experts has developed a conceptual framework for achieving LDN that considers all of these concerns. In 2017, the framework was endorsed at global level,[5] providing a scientific foundation for developing an effective land agenda to oversee the complexities and dynamics of managing the land sustainably and equitably.

An agenda based on achieving LDN will influence far more than land, as the inevitable multiple claims placed on land by the SDGs can be integrated, and accelerate the achievement of all SDG targets.

Land Degradation Neutrality in balance



Source: UNCCD

Image: Ministry of Forestry and Water Afairs, courtesy of UNCCD

First steps in halting and reversing the encroachment of sand and dunes on productive land in the Kumluova Fethiye-Mugla area, Turkey

What have countries done so far?

By agreeing to the SDGs, including target 15.3, at the seventieth session of the General Assembly of the United Nations in September 2015, all 193 member countries committed to achieve LDN.

To help countries translate these global goals into reality, the 196 countries that comprise the Convention to Combat Desertification took important decisions during their 12th session of the Conference of Parties held in Ankara, Turkey. They endorsed the SDGs as a "strong vehicle for driving the implementation of the Convention." They also invited countries to formulate voluntary targets specific to their land degradation issues in order to achieve LDN, and they agreed on what to measure to confirm its achievement. This is the LDN indicator, a framework that combines three sub indicators — the change in land cover; land productivity; and the change in soil organic carbon.

As of June 2018, 118 countries had committed to set LDN targets. Sixty of those countries have held national stakeholder consultations and elaborated their targets. Through the LDN target setting process, countries incorporate national priorities and commitments — from agricultural policy to climate action and restoration commitments — to build coherent policies that will help achieve their targets. They identify and use existing national commitments and initiatives that offer the best opportunities to pursue targeted action to achieve LDN at country level.

Burkina Faso's targets to reach land degradation neutrality by 2030

In order to stop land degradation in Burkina Faso, the country has committed to reaching land degradation neutrality by 2030 by restoring 5 million ha of degraded lands and by preventing degradation of non-degraded lands.

More specifically, the country has committed to do everything possible in order to:

- Put an end to deforestation by 2030
- Improve the productivity of savannas and cultivated lands that show productivity decline, that is, 2.5 million ha
- Improve carbon stocks in 800,000 ha to reach a minimum of 1 per cent of organic matter
- Retrieve 300,000 ha of bare land from a total of 600,000 ha.

These targets are consistent with previous commitments entered into, namely, within the framework of the Rio conventions and the Ramsar convention.

The target setting process helped countries to assess and articulate their national land degradation baselines for the very first time. They also have the latest, most accurate data and information on the current state of their land as well as the drivers of degradation. Based on this status and through a consultative process, countries define their ambition of combatting land degradation. They also set time-bound quantified targets with the specific measures to achieve LDN.

After that, they will develop Transformative Projects and Programmes (TPP) for achieving those targets. They are transformative because they will deliver multiple benefits. They will scale up the most effective interventions and provide incentives for responsible and inclusive governance to enhance national or subnational capacities and ownership, and draw in innovative finance from other sectors, especially the private sector. The Global Mechanism of the Convention is supporting developing countries in designing the first 40 TPPs.

Through LDN, countries are blending different types of financial resource to inspire the private sector to engage in the change. Blended resources that combine public and private, development and climate, as well as national and international financial resources offer new incentives and investment opportunities for the private sector to move to sustainable land management and landscape restoration.

The LDN Fund, which is promoted by the UNCCD but managed by an independent company, is one such new financial mechanism. Launched in 2017, it increases the investment opportunity for countries to generate profit from land uses that are managed in a manner that contributes to the achievement of LDN. Some of the TPPs described above can be financed through the fund.

Multilateral, bilateral and country partners are taking bold actions and turning the political vision of the SDGs into measurable LDN targets. They are unlocking new private sector investments to finance projects that, at once, generate social, ecological and financial benefits and separate economic growth from land degradation.

How is progress made by countries measured?

Every two years, the parties to the convention meet in a global conference — known as the Conference of the Parties (COP) — to review progress made towards achieving LDN. Based on the review, the conference then decides what further actions need to be taken to keep each country on track.

Every four years, each country (generally referred to as a Party to the UNCCD) submits a report on its progress to the COP. To enable governments to compare achievements in all the countries, the reports are prepared based on a standardized template. The starting point is a template with baseline information about the country, and the templates are updated regularly against this information. In this way, parties can monitor their progress in implementing the Convention and achieving LDN.

The 2017–2018 reporting process was launched in December 2017, and will capture, for the first time, two types of information — statistical information on quantitative data, and information related to the three land based indicators used to measure LDN. In order to ensure that every country submits a report, the UNCCD secretariat has gathered and provided the default data for some of the biophysical indicators. Parties can start by using this data set, but those with their own national data are able to substitute it.

Image: Hedvika Cumilar

Farming in Slovenia. There are multiple benefits of combatting land degradation

Image: Son Ho Ngoc

A warming climate could negatively affect small farm holders like this one in Vietnam due to the soil's inability to store water and maintain its fertility

In addition to the templates, the UNCCD secretariat, the Global Mechanism and United Nations Environment Programme, with financial support from the Global Environment Facility, held regional workshops to inform parties of the reporting requirements and provided technical assistance throughout the reporting period. A learning course and manuals on how to submit a report are also available online, and can be downloaded for free.

All the reports submitted to the secretariat will be analyzed and discussed at the Conference, during the sessions of the Committee for the Review of the Implementation of the Convention (CRIC), held well ahead of the COP. At the CRIC, technical experts in land rehabilitation and restoration will look at the findings, draw conclusions and submit to the COP targeted recommendations on how to advance implementation of the Convention.

How to get involved?

In order to qualify as an LDN initiative, the design and implementation of the transformative project or programme must involve various actors — governments, individuals, communities, the private sector, local governments and all other land users. The Convention requires national plans and actions for combatting land degradation that are stakeholder driven. These processes provide opportunities for various types of actors to be involved in some or all the phases of planning and implementation. Interested parties should:

- Determine if the country concerned has made the commitment to set a target
- If a target or targets exist, find out the location(s) where the government is planning to take action
- Determine where and when the stakeholder dialogues will take place
- Identify which local authorities or communities it would be of benefit to work with or to provide support for
- Approach the leaders with the offer of contribution, as well as a member of the community that might need assistance or other land users with whom it would be possible to work in order to combine strengths.

Any land user anywhere in the world can make a difference by opting to use methods that increase the natural fertility of the soil and the ability of the land to absorb water and moisture.

In general, governments are the primary entry points of the Convention at country level, but there are also platforms for working with civil society organizations, as well as a separate platform for non-governmental organizations, and one for the private sector. Parliamentarians, scientists and women's groups also have their own forums.

International and inter-governmental organizations mostly partner with the Convention to support countries in carrying out the work. For instance, the International Union for Nature Conservation is helping countries to operationalize LDN. The UN Development Programme and UN Women are supporting the work on gender mainstreaming. UN Environment Programme worked with the secretariat to produce the reporting templates and manuals. The Global Environment Facility is financing many of the activities at country level, including some of the TPPs.

Avoiding, reducing and reversing land degradation is a prerequisite for sustainable development and human security. This makes achieving the goal of Life on Land important, urgent, and a priority for all countries and communities at all levels.

Image: Bayram Ayhan

Preparing the ground for planting. The bunds help rainwater to soak into the ground

Land degradation neutrality and tenure security — the SDG's prospects

Everlyne Nairesiae, Coordinator of the Global Land Indicator Initiative; Oumar Sylla and Judith Mulinge, Global Land Tool Network, UN-Habitat

There is increasing recognition by policymakers, and practitioners worldwide, that secure tenure rights to land are strongly linked to poverty reduction, food security, gender equality, urban development, social cohesion and environmental stability. The securing of tenure rights to land, and related land use practices, can contribute to achieving Land Degradation Neutrality (LDN) by 2030. United Nations Convention to Combat Desertification (UNCCD) defines desertification as "land degradation in arid, semi-arid and dry sub-humid areas resulting from various factors, including climatic variations and human activities". Land degradation therefore means the reduction or loss of defined aspects of the biological or economic productivity and complexity of the land, resulting from land use or a combination of human activities and habitation patterns, such as soil erosion caused by wind and/or water.

Land tenure and governance systems have not often been influencers of policy decisions and strategies for achieving LDN.

Image: UN-Habitat/Judith Mulinge

Mary Katana, a Kwa Bulo informal settlement dweller in Mombasa, Kenya, shows off her newly issued certificate of occupancy

However, the link between land tenure rights and land degradation, including the perception of tenure security and related land use practices, has been strengthened in the context of SDGs 1 and 15, with the monitoring of indicators 1.4.2 and 15.3.1, providing the data required for evidence-based analysis, planning and policy decisions by governments and other actors.

Exploring the link between land tenure security and land degradation

For a long time, land tenure and land degradation have been treated in isolation. Although there is no global empirical evidence that links a specific tenure type to causes of land degradation, studies have suggested that secure land tenure rights for individuals or groups positively affect LDN. Security of land tenure is anchored in the freedom from fear of dispossession of such rights, regardless of their legal status. Current literature shows that individuals or groups with secure land tenure rights are more likely to undertake long-term investment and embrace land use practices that prevent and restore degraded land. Decisions on land use practices may include, but are not limited to, tree planting, prevention of soil erosion, improved governance of range land, and use of enclosure grazing areas.

However, Large Scale Landbased Investment (LSLBI) in agriculture by domestic and international investors has come under sharp criticism for encouraging deforestation and the replacement of local plant species, causing pressure on land resources. Some LSLBI models promote the commodification of land and its alienation from local communities, widening the window for corruption in land transitions, and entrenching gender inequality; and the unfair appropriation of land without fair compensation or Free Prior and Informed Consent (FPIC) promoted by the "Voluntary Guidelines for the Responsible Governance of Tenure of Land, Forests and Fisheries in the Context of National Food Security"[1]. Decision to privatize land, including range lands, has often been misguided by the perception that such land use is less economically viable. An increasing world population has also shifted in character from being predominantly rural to becoming urban, and is projected to grow by two-thirds by 2050, a situation likely to increase the risk of privatization to pave the way for agriculture, eviction and land degradation.

Group land rights, mainly concerning communal grazing land, are often alleged to increase land surface degradation

Image: UN Women/Ryan Brown

Indonesia — Safe Cities — preventing violence at a neighbourhood level

due to overgrazing that causes surface erosion. However, growing evidence from national studies, including a study conducted in 2016 in the Otjozondjupa Region of Namibia based on satellite imagery, disputes the view that communal or group tenure rights are the cause of a higher degree of land degradation. According to a survey featuring the outcomes of the International Fund for Agricultural Development (IFAD)-supported projects on sustainable natural resource management in Lesotho and Tajikistan; conflict management in Tanzania and Chad; and institutional strengthening in Senegal and Mongolia[2]; the improvement of land governance systems of a range of lands results in improved governance of pasture and water resources, the participation of women in decision making, increased land productivity, and strengthened resilience to land degradation. Another study[3] has confirmed that improving tenure security leads to a decrease in disputes, increased investment in tree planting and soil conservation, and increased agricultural productivity, thus contributing significantly to poverty alleviation.

Gender dynamics in tenure rights and land degradation

Evidence shows that in Sub-Saharan Africa and South Asia where the majority of people depend on agriculture for their livelihoods, the average family farms are small, and getting smaller, with 75 per cent being under one hectare in low and middle-income countries[4]. Women constitute the majority of food producers and labourers in the agriculture sector, yet they have weaker land rights than men. Culture and traditions have often hindered women's access and control over land, with some cultures prohibiting women from planting trees. When individualization of land takes place, women are often excluded from decision making and relegated to being the recipient of such projects. Negotiation for compensation and other associated benefits is often done by men who are the perceived owners of land. Inadequate and insecure tenure rights increase vulnerability to land-based conflicts between local communities and investors, and to gender-based violence resulting from intra-household power relations that often discriminate against women's land rights. When competing land users fight for control over land they pose a risk of causing land degradation. Women are 'carers of nature' and are believed to hold greater respect for land conservation practices that are critical for soil conservation.

Achieving LDN through fit-for-purpose and gender-responsive land tools

The Global Land Tool Network (GLTN) has, since its establishment, strived to improve tenure security for all by developing pro-poor, fit-for-purpose and gender-responsive tools that strengthen land governance policies and practices. Over 18 land tools have been developed, tested and implemented including the Gender Evaluation Criteria and Social Tenure Domain Model (STDM), an open-source software application that applies participatory land recordation approaches in order to document communal tenure rights in urban and rural communities. The STDM has been successfully implemented in several countries in collaboration with GLTN partners including the Chamuka Chiefdom in Zambia,

the Kwabulo and Mathare informal settlements in Mombasa, Nairobi County in Kenya, and the Philippines.

GLTN land tools are anchored in principles of human, environmental and natural resource rights, and developed through participatory approaches that embrace the Continuum of Land Rights[5]. The rights along the continuum can be documented as well as undocumented, formally as well as informally, for individuals as well as groups. This highly inclusive approach to land tenure security has been widely endorsed, for example through the SDGs, and explicitly in the New Urban Agenda[6]. GLTN tools continuously aim to improve the perception of tenure rights especially for poor and vulnerable communities, strengthening their capacity to improve productivity, remove gender inequality and reduce land degradation. All forms of tenure should provide a degree of security, with states protecting those rights, ensuring that people are not arbitrarily evicted, and that their rights are not otherwise extinguished or infringed.

Image: UN Women/Joe Saad

Rural women's cooperative generates income and improves community life in the Katfoura village on the Tristao Islands, Guinea

Image: UN-Habitat / Julius Mwelu

A Burundian refugee tends his farm in Kakuma, Turkana, Kenya, 2016

Inclusion of land tenure and land degradation in the SDGs

The link between land tenure security and land degradation is strengthened by their inclusion in the SDGs. The inclusion of land tenure followed intensive advocacy efforts by the global land community including CSOs and UN agencies, coordinated and facilitated by the Global Land Indicators Initiative (GLII) and with the support of The Global Donor Working Group on Land (GDWGL); that successfully proposed indicator 1.4.2 included under SDG 1, Eradicating Poverty in all its forms.

SDG 15, Life on Land, through indicator 15.3.1, aims to achieve LDN by 2030. In addition, SDG 5 also provides two land tenure indicators, 5.a.1 and 5.a.2, that focus, respectively, on women's access and ownership of agricultural land, and legal provisions for protection of women's land rights including customary law at national level. Other land related indicators are included in SDGs 2, 11 and 16. Achieving the SDGs requires an integrated approach for implementation, monitoring and review through strategic partnerships promoted by SDG 17.

Monitoring of tenure security and land degradation in the context of the SDGs

UN member states are now in the third year of implementation of the 17 comprehensive and ambitious SDGs. This includes monitoring national progress against key targets using globally comparable indicators, and methodology approved by the Inter-agency Expert Group on SDG Indicators (IAEG-SDGs). Tenure security indicators 1.4.2 and 15.3.1 acquired Tier II Status in November 2017, following the approval of a global methodology for monitoring these indicators by the IAEG-SDGs. Governments are therefore expected to report on these indicators annually starting in 2018; contributing to monitoring progress against SDG targets 1.4 and 15.3. Specifically, indicator 1.4.2 enables UN member states to monitor the proportion of total adult population with secure tenure rights to land, (1) with legally recognized documentation and (2) who perceive their rights to land as secure, by sex and by type of tenure in rural and urban areas. Indicator 15.3.1 enables member states to monitor the proportion of land that is degraded over the total land area. As countries monitor and report progress on targets 1.4 and 15.3, the collection and use of timely, authentic and reliable data on land tenure and degradation is key to reviewing progress on LDN in support of planning and policy decisions.

Building data evidence linking land tenure rights and degradation

Availability of reliable, timely, regular and disaggregated data is key to building evidence. Tracking progress of targets 1.4 and 15.3 at national level will help provide better understanding of the extent to which people benefit from secure land rights and the effectiveness of land-related policies and land administration systems in helping to achieve LDN by

Image: UN Women/Christopher Herwig

Women's Union training session at the Za'atari refugee camp, Jordan

2030. Key data sets include plant productivity; environmental factors such as climate, vegetation types and land cover; and spatial characterization of the land tenure structure; all of which can easily be triangulated to provide the nuances of key trends in land degradation against tenure rights. This data will enhance the capacity to analyse the footprint of human activities in relation to their tenure types against land degradation, among other environmental factors.

Monitoring indicator 1.4.2 by custodians such as UN-Habitat and the World Bank; and 15.3.1 by UNCCD, present the best opportunity for measuring the inter-connectedness of land tenure rights and land degradation. However, this must be accompanied by efforts to strengthen the capacity of data agencies to fully implement the IAEG-SDGs' approved methodology for data collection and reporting.

Strengthening coordination, comparability of data, and synergies of land and data communities, for achieving LDN

Sharing data and information between custodian agencies and other data organizations will support analysis and triangulation, and build the evidence needed for policy decisions to achieve LDN by 2030. This article affirms the policy recommendation, by UNCCD CSO Panel 2017, on enhancing land rights for the prevention of land degradation and the recovery of degraded lands, including recommendation 1 on the importance of integrating land tenure security into national strategies in order to achieve LDN.

Image: The World Bank/Mohammad Al-Arief

Classroom in the public primary school of Ianjanina, rural Madagascar

The global coordination of land and data communities towards monitoring land governance issues continues with the support and facilitation of the GLII, as inspired by the Voluntary Guidelines on the Responsible Governance of Tenure of Land, Fisheries and Forests in the Context of National Food Security (VGGT), the African Union Framework and Guideline on Land Policy in Africa (AU-F&G), and the New Urban Agenda.

Land and quality education — building the capacities of the change agents of the future

Hafdis Hanna Aegisdottir and Berglind Orradottir, United Nations University Land Restoration Training Programme, Reykjavik, Iceland

We human beings depend on land for our survival. The land has provided us with shelter, food, water and clothes, and we have learned to manage nature for our own benefits. Despite many technical developments and revolutions, we will continue to depend on the services we get from our natural ecosystems. But the pressure on those systems is increasing with population growth and lavish lifestyles, resulting in dire consequences which are vividly expressed in pollution, land degradation and total ecosystem collapse. Multiple signs of degradation such as loss of soil fertility, soil erosion, loss of biodiversity and reduction of water quality and quantity already affects the livelihood and living conditions of many people around the world.[1] We have realized that we cannot continue on this path without destroying the resources we depend on, and thus ourselves.

To address these and other challenges facing mankind and our planet, the United Nations agreed on the 2030 sustainable agenda[2], which includes 17 Sustainable Development Goals (SDGs). One of these goals, SDG 15, Life on Land, and specifically its target 15.3 on land degradation neutrality, addresses the challenges we face with managing terrestrial ecosystems[3].

Changing the world and moving it onto a more sustainable path is a complex task. It cannot be done without changing how we use and manage our land and ecosystems. Well trained and dedicated people who are willing to take the lead in making our planet healthier for future generations are vital for all life on earth. This calls for capacity building in the land management sector, specifically in the poorer countries of the world, where training and empowerment is urgently needed. The United Nations University Land Restoration Training Programme (UNU-LRT) is such an initiative. Over the past decade of work, UNU-LRT personnel have travelled the world and met inspirational people who are committing themselves to combating land degradation, promoting sustainable land management, and restoring degraded lands in their respective regions or countries. Although situations differ between locations and environments, the processes and principles of why land becomes degraded, and how best to restore degraded land and manage it in a sustainable way, are strikingly similar between regions and there is much that can be learned from each other.[4]

Image: Hafdis Hanna Aegisdottir

Soil texture analysed in the field by UNU-LRT trainees

UNU-LRT is an international, post-graduate level programme that works towards SDG 15 and other SDGs by training people in land restoration and sustainable land management.[5] UNU-LRT primarily works with local institutions in developing countries, where the target group is well educated key professionals, who are centrally placed to make changes. The programme works towards its mission by annually offering a six-month training programme in Iceland, where people have worked towards reversing land degradation for over a century[6]. During the programme, professionals from key partner institutions are trained, thus building the capacities of institutions as well as individuals. Short courses focusing on local solutions, as well as development of online courses and other educational materials, are also provided to professionals in their home countries.

The UNU-LRT vision is that the graduates will become global experts, able to act on their knowledge and drive initiatives at various levels, from the local community to national policies. To become a global expert, it is important to provide the specialists with comprehensive biophysical knowledge that underpins successful management and restoration of land. It is also vital to equip them with the courage and confidence to act independently, and to interpret and apply their knowledge in their home countries as well as globally. This means that the training should provide both a solid scientific knowledge and the skills needed to work effectively in diverse environments and communities. Speaking the language of science and having the ability to communicate to policymakers and politicians, while at the same time having the drive to act, is an ability that the graduates are encouraged to master.

Image: Hafdís Hanna Ægisdóttir

Trainees of the UNU-LRT six-month training programme studying land use history and land degradation on a field excursion

But how is a learning experience designed such that it is meaningful, of high quality and meets the changing needs of partners? There are several elements upon which the training programme is built to ensure that it leads to valuable results on the ground.

Select the right people from the right institutions
Many institutions in developing countries working in environmental science and land management are hampered by a lack of capacity to deal with the big environmental challenges that their countries are facing. For this reason, the UNU-LRT approach is through an institutional capacity-building framework. Trainees work at leading institutions, including ministries, local governments, research organizations, academia, and NGOs in their home countries. All of the institutional partners are working on combating land degradation, restoring degraded land and promoting sustainable land management. Candidates are selected via face-to-face interviews, based on their potential and their position to make a difference after completing the training. The aim is to create change agents of the future, who feel responsible for sharing their knowledge for the benefit of their institutions, their country and the planet.

Delivery of training – getting hands dirty
The training programme targets working professionals, so the educational strategy applied is different from that of traditional universities. The training needs to provide both scientific knowledge and theory, in addition to a strong practical grounding that enables participants to see how what they are learning can be used in practice to solve current land management challenges. Mixing lectures, practical training, field trips and individual research projects leads to better results than those from exclusively classroom training.[7]

Focus on knowledge sharing, not knowledge transfer
Another key element to success is avoiding top-down, one-way knowledge transfer, when knowledge exchange is much more effective. Learning from each other and respecting each other's knowledge and experiences is a way to build competence, to work across cultural barriers and to accomplish common goals.

Responsibility and empowerment
Trainees are in charge of their own learning. When attending the training, they are representing their countries, and as such, they are responsible for presenting a critical and thorough analysis of the challenges faced at home. Responsibility is thus a key element in the training, and a former trainee reported that the UNU-LRT training taught him to take full responsibility of his education, and empowered him to share his knowledge and to make use of it when back home.

Professional skills and personal growth
Knowledge empowers people but additional qualifications are needed to bring about necessary changes to how land resources are managed. Thus the training is designed to encompass professional knowledge and skills, and personal competencies. Trainees get hands-on practice and coaching in solving the challenges of complicated land issues, giving presentations, writing and communicating their ideas, and working in international teams. Mixing professional and personal skill development is the key to forging the leaders of the future.[8]

Upon completion of the training programme, graduates return to their home countries and institutions to become a part of the global movement on reversing land degradation and restoring ecosystems.

UNU-LRT works with countries in sub-Saharan Africa and Central Asia, including Niger Republic, Ghana, Uganda

and Kyrgyzstan. These countries may seem to have little in common, but when it comes to land-related challenges there are many parallels. Deforestation, agricultural mismanagement, overgrazing and overexploitation are unfortunately a reality in many countries from different corners of the Earth.[9]

Trainee case studies

Moustapha Ibrahim, Niger Republic

Niger Republic in West Africa is one of the poorest countries in the world.[10] Frequent droughts, climate change and poverty escalate the serious environmental challenges faced by the country such as desertification and land degradation.[11] Moustapha Ibrahim is well aware of those challenges. His passion for the environment started in 1984, when he was a child in a Niger village. A severe drought had hit the region, destroying crops, killing animals and leaving his village more susceptible to hunger and subsequently famine. Mr. Ibrahim was an attentive child and noticed that the drought had more severe impact on degraded land than on healthy land with trees and shrubs. He then decided to get involved. In 2008, after university studies and environmental work for a local NGO, he joined the Niger Ministry of Environment and Natural Resources. Two years later, he attended the UNU-LRT six-month training programme in Iceland. The training strengthened Mr. Ibrahim's capacity in the field of land restoration and sustainable land management, filling a serious knowledge gap in his country. He was promoted several times upon returning home, and now Mr. Ibrahim is in a key position to influence decision making as well as to lead activities and projects on restoring degraded ecosystems, promoting sustainable land management and raising environmental awareness among the local people.

Esther Ekua Amoako, Ghana

Before coming to Iceland, Esther Ekua Amoako, a PhD candidate and lecturer at the University for Development Studies in northern Ghana, had experienced environmental challenges in her area such as deforestation and bush burning. She had a dream of educating and sensitizing the local people to the need for protecting the environment and conserving their common natural resources, but wasn't sure of how to formulate that dream so it could become a reality. During her training at UNU-LRT in 2012, she finally acquired the knowledge and ideas to realise her vision of environmental education. Less than a year after she returned from the training, she had established three eco-clubs for children in elementary schools in northern Ghana, which have now grown with over 200 children attending the clubs in four different schools. In early 2018, UNU-LRT visited Ms. Amoako's eco-clubs and was fascinated by the interest and dedication of the children and teachers in learning about and working on environmental issues. The children proudly showed pictures they had made to illustrate the environmental challenges they see on a daily basis in northern Ghana and expressed how they, as future leaders, can contribute to a healthy and sustainable environment.

Evelyn Mugume, Uganda

Evelyn Mugume is a senior environmental officer for Kasese Municipal Council in Western Uganda. Like other environmental officers in the country, she has a wide range of responsibilities in her daily work. She is in charge of community awareness on environment management and ensures projects' compliance to environmental standards. She also

Image: Hafdis Hanna Aegisdottir

Women in the Niger Republic create structures in the land to capture water, a vital component of land restoration

Image: UNU-LRT

Azamat Isakov participating in the 12th Conference of the Parties to the Convention to Combat Desertification, Ankara, Turkey, 2015

Image: Hafdis Hanna Aegisdottir

Evelyn Mugume leading an excursion in a UNU-LRT course in western Uganda on sustainable land management, land restoration and linkages with climate change

works on restoring degraded areas, including wetlands and riverbanks. During the UNU-LRT in 2014, Ms. Mugume acquired skills and knowledge that have become valuable while tackling the challenges she deals with at work. These include an awareness of the importance of using native plant species in restoration work and how the use of alien species constrains such work, where many hectares of mono-stand alien species have replaced indigenous vegetation that used to provide food and medicine for the local people. Another aspect she took from the UNU-LRT training, is the importance of community awareness of environmental issues and the value of involving various stakeholders in restoration work. Ms. Mugume stated that: "Once the people are aware, they contribute individually to the bigger picture". In 2017, she was involved in developing and implementing a course in her district held by UNU-LRT in collaboration with local partners. The course — Sustainable land management, land restoration and linkages with climate change — targeted government officers working within the environment and natural resources sector. It covered local challenges and solutions, and built on existing institutional partnerships and a pool of alumni. Ms. Mugume feels that the course was essential for capacity building and increasing collaboration among the environmental officers.

Azamat Isakov, Kyrgyzstan

When Azamat Isakov returned to his home country of Kyrgyzstan in Central Asia after studying at UNU-LRT in 2013, he was elected Director of the CAMP Alatoo Public Foundation, a Central Asian NGO working in the field of sustainable land management and the use of natural resources[12]. In Kyrgyzstan, grazing pressure is high, resulting in degraded forests and pastures.[13] In his role at CAMP Alatoo, Mr. Isakov is able to work on these environmental challenges, enabling local communities to better manage their natural resources, and bring about positive changes. He leads projects on pasture monitoring and the development of pasture grazing and management plans. These projects involve various stakeholders and, while studying at UNU-LRT, he improved his skills in needs assessment, strategic development and the importance of drawing various stakeholders into dialogue. Under Mr. Isakov's leadership, CAMP Alatoo has flourished and expanded, now having a branch in neighbouring Tajikistan.[14]

These stories are a small example of the impact derived from UNU-LRT training. As of June 2018, the programme has trained 118 professionals from 13 countries, and these cohorts of trainees form a strong network of change agents that have used the knowledge gained for the benefit of their countries and local communities, having the added value of contributing to sustainable land management and the restoration of degraded ecosystems. It is gratifying to hear stories of successful projects and initiatives that can be attributed to the training.

Reaching the targets of SDG 15 requires sharp minds, passionate people and cooperation across sectors among individuals, institutions, corporations, governments and nations. UNU-LRT is working towards training tomorrow's leaders, empowering them with knowledge, skills, and competencies to lead the much needed change toward a sustainable use and management of our natural resources.

Image: Hafdis Hanna Aegisdottir

Trainees at the UNU-LRT six-month training programme work on an assignment on ecosystem disaster risk reduction

How can Earth Observation support agriculture development in rural areas?

EO4SD – Agriculture and Rural Development cluster

Anna Burzykowska, European Space Agency; Almudena Velasco, SpaceTec Partners; Annemarie Klaase, eLEAF; Silvia Huber, DHI GRAS; Paul Geerders, P. Geerders Consultancy; Remco Dost, eLEAF; Arjen Vrielink, Satelligence; Eva Haas, GeoVille; Rolf A. de By, ITC, University of Twente; Evelyn Aparicio, Nelen & Schuurmans

Long-term environmental and land degradation processes represent a major development barrier in many developing countries, especially in rural areas. Concrete evidence on the extent, severity and underlying drivers are not fully understood. This makes it difficult to identify policies and investments that will effectively halt and reverse land degradation such as desertification. However, many of the contributing biophysical factors such as climate, physiology and soil erodibility, as well as anthropogenic causes such as unsustainable land management related to population pressure, could be monitored using Earth Observation (EO). EO is particularly suited to observe extreme weather conditions, climate variability, deforestation, land use changes, and unsustainable farm management practices such as inappropriate irrigation, cultivation, resource management, and overgrazing.

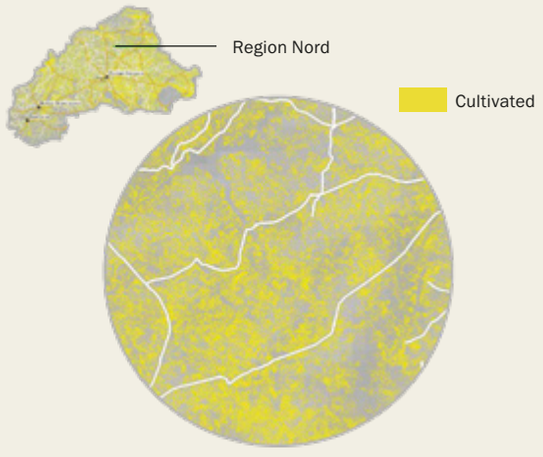
Several initiatives have begun building information systems to measure drivers and impacts of land degradation at local, national and regional levels. These systems help analyze land degradation status and trends. They also play a role in monitoring improvements and progress towards land degradation neutrality and the UN's Sustainable Development Goals (SDGs).

With the launch of the Sentinel satellites of the European Union's Copernicus Programme, an unprecedented amount of free and open data has become available. To demonstrate the benefits of EO-based information, products, and services, as comprising a significant component of the UN's SDGs, the European Space Agency (ESA) has worked closely with Multilateral Development Banks (MDBs) — such as the World Bank and the International Fund for Agricultural Development — and their client states to harness these benefits in global activities. Therefore, the cluster dedicated to agriculture and rural development of ESA's Earth Observation for Sustainable Development (EO4SD) initiative is focused on MDBs' programmes and projects that deal with land degradation, soil erosion, food security and irrigation systems management around the globe.

The EO4SD-Agriculture and Rural Development Cluster demonstrates how EO-derived information measurably enhances the effectiveness of the MDBs' technical assistance interventions and financial investments in the agriculture sector. What makes the EO4SD services exceptional is their integration of thematic layers at various spatial and temporal resolutions and scales. The integration of multiple satellite-based products that consider land use, productivity, climatic and other environmental factors allows for a comprehensive assessment of land degradation and its drivers. The same thematic information is available at several spatial resolutions — 250m, 30m and 10m — and at different spatial scales, connecting the regional dimension with national and

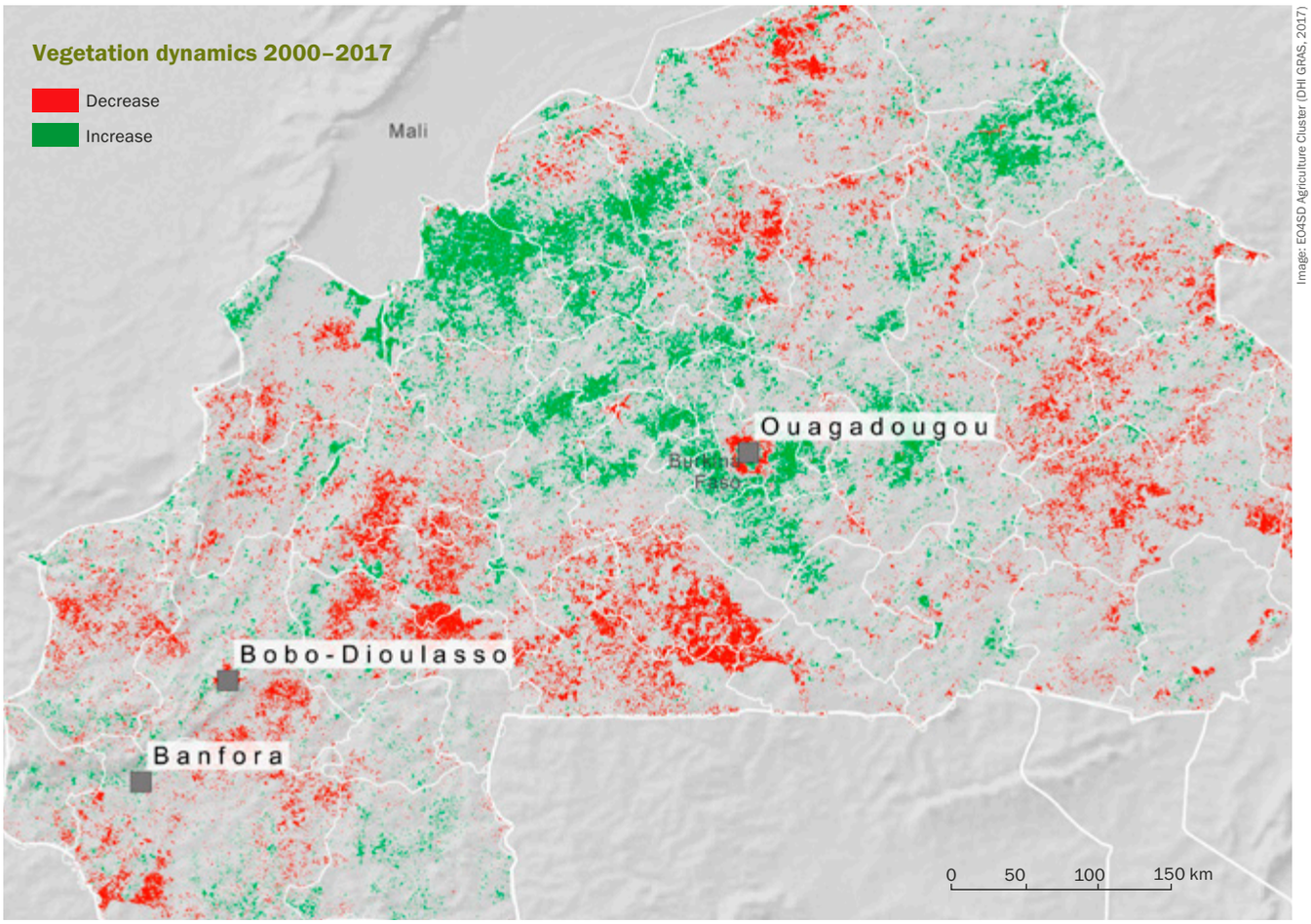
Information on national croplands for Burkina Faso

Burkina Faso is a landlocked sub-Saharan country with limited natural resources. Its agro-ecological conditions are negatively impacted by climatic deterioration and increasing human pressure. EO4SD is providing development programmes in Burkina Faso with up-to-date information that can guide land management decisions to safeguard natural resources. In the image below, croplands in Burkina Faso are highlighted in yellow. EO-derived statistics are produced by the EO4SD-Agriculture and Rural cluster and provided to development projects and programmes for monitoring and reporting progress activities. In the absence of national data, EO can provide near-real time information on croplands and cultivated areas, which is essential for food security.



Non-cultivated: 11,553km² Cultivated: 4,845km²

Source: EOSD Agriculture Cluster (Satelligence, 2017)



Analyses derived from Earth Observation imagery on vegetation cover trends obtained over the years can indicate changes in land productivity, a sub-indicator used for land degradation monitoring. This helps to pin-point areas of productivity change and target areas for further investigation and possible intervention. The same tools allow monitoring of the impact of conservation and rehabilitation of degraded land, along with the effectiveness of the mitigation and rehabilitation efforts. The image above shows the decrease and increase in levels of vegetation dynamics from 2000 to 2017 in Burkina Faso. Decreasing vegetation cover is obvious around Ouagadougou, reflecting the city expansion. Other areas show decreasing trends related to agricultural expansion

local processes. Depending on the indicator, the information derived is typically available on a daily, weekly, monthly, or yearly basis, both historically and near-real time. With these characteristics, the cluster provides land status indicators, land degradation assessment, land degradation monitoring and soil erosion mapping, features that are key to rural development.

The EO4SD cluster has a strong focus on African countries because they are generally affected by population pressures and extreme conditions. Events such as frequent and severe droughts result in desertification and land degradation threatening the livelihoods of their populations. Development priorities for the agriculture sector in Africa range from preventing land degradation, such as erosion and desertification, to increasing land and water productivity. Therefore, the Agriculture and Rural Development Cluster is supporting various development projects under the Global Environment Facility's (GEF) new integrated Approach Pilot (IAP) programme on "Fostering Sustainability and Resilience for Food Security in Africa", as well as the Sahel and West Africa Programme (SAWAP), among others, by providing key biophysical information, for instance for baseline mapping or Monitoring and Evaluation activities in countries seriously affected by environmental degradation and loss of ecosystem services.

The information provided by the cluster is essential for saving time and resources. Improved visualization of phenomena and better insight into actual situations improves strategic planning processes. The integration of information layers allows a better understanding of cause-effect relations and better-informed decision making. Once the project is running, near-real time information and year-round data collection provides a synoptic view on project progress, leading to improved process control. Early identification of threats and potential risks reduces damage and lives lost while improving the preparedness to take action.

Capacity building is an important component for the agriculture cluster. It is used to strengthen the use of EO information and services among the staff from MDBs, their client countries, international and national organizations, governmental and non-governmental organizations, as well as national and local decision makers. A series of capacity development training sessions has already been organized in Uganda, Morocco and Ethiopia. Upcoming workshops will take place in Cambodia and Bolivia. The second edition of each of these workshops will be organized in 2019. The purpose of these training activities is to demonstrate the opportunities and benefits of using EO-based information

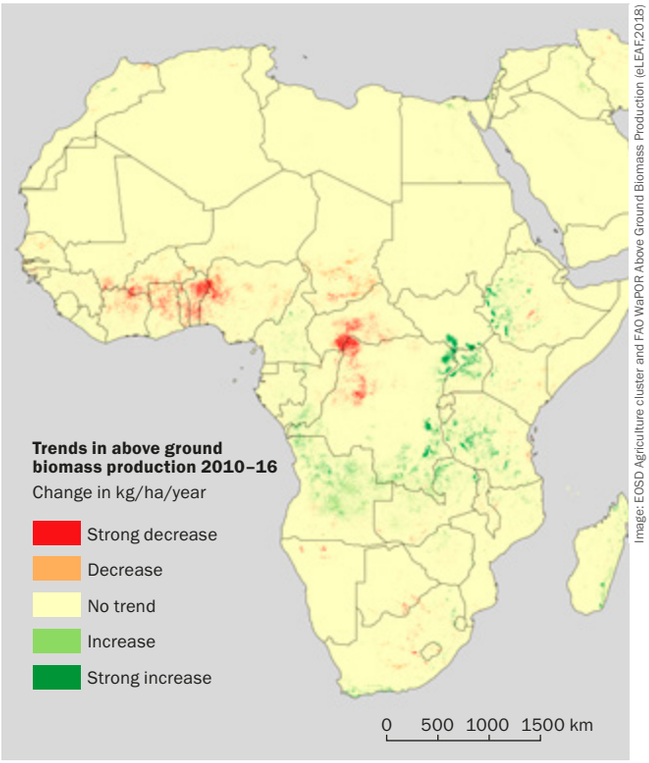


Image: EOSD Agriculture cluster and FAO WaPOR Above Ground Biomass Production (eLEAF,2018)

services, eventually making them an integral part of the planning, operational, monitoring and evaluation phases of projects. Ultimately, the concept helps to strengthen and harmonize the information base for sustainable development around the world.

The EO4SD-Agriculture and Rural Development Cluster will continue to develop innovative EO-derived statistics and indicators in support of the efforts to monitor land degradation evolution and achieve land degradation neutrality. This project is proving that information derived from EO has a unique potential to support decision making, planning, monitoring and evaluation, and policy development. It may prove largely effective to key issues such as sustainable development, preparation for the impacts of climate change and the management of risks.

Left: Biomass production trend map from 2010 to 2016, produced by the EO4SD-Agriculture and Rural Development cluster showing trends in biomass decrease and increase for Africa and the Middle East. This map includes the twelve countries (Burkina Faso, Burundi, Ethiopia, Ghana, Kenya, Malawi, Niger, Nigeria, Senegal, Swaziland, Tanzania and Uganda) involved in the Global Environment Facility's new integrated approach pilot programme on "Fostering Sustainability and Resilience for Food Security in Africa". The programme targets agro-ecological systems in the drylands of sub-Saharan Africa to promote sustainable management and resilience of key ecosystems. Information is produced at several scales to connect the regional dimension with national and local processes

Image: EO4SD – Agriculture cluster, 2018

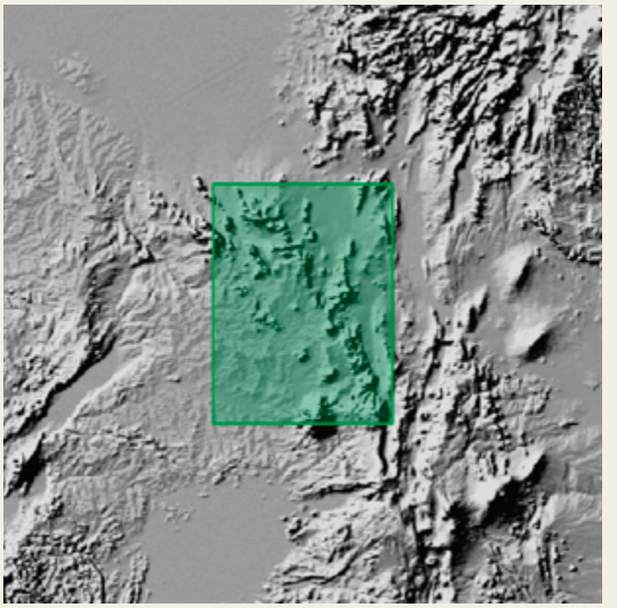
Capacity building workshop in Ethiopia. Remote sensing experts of the Agriculture and Rural Development cluster offered the audience an in-depth knowledge and hands-on training on the EO4SD services provided in the country

Agricultural production changes in Uganda

Uganda has an estimated population of 35.8 million, 80 per cent of whom are involved in agricultural production, which contributes to about 22 per cent of the total Gross Domestic Product (GDP). Providing farmers with the knowledge and tools to make better-informed decisions based on information regarding crop and climate status will impact their way of farm management. Hence, their productivity, sustainability and income will all improve. The EO4SD-Agriculture Cluster initiative leverages and contributes to several ongoing operations and projects carried out in Uganda by various national and multilateral donor organizations, along with their local stakeholders.

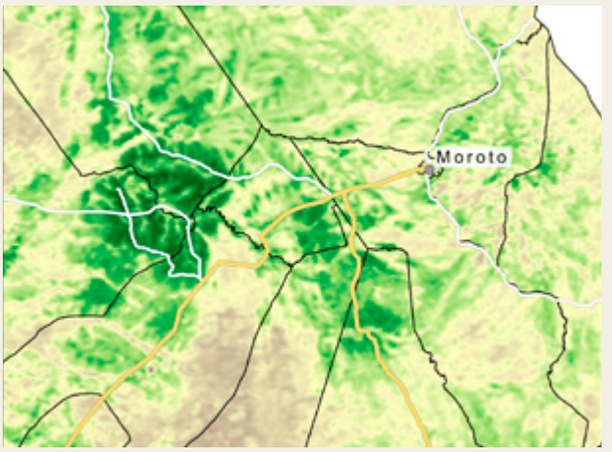
The EO4SD project provides information on crop biomass production, agricultural water productivity, water consumption and deficit levels for monitoring sustainable agriculture, as well as land cover change and deforestation monitoring of the environmental impact of palm oil commodity.

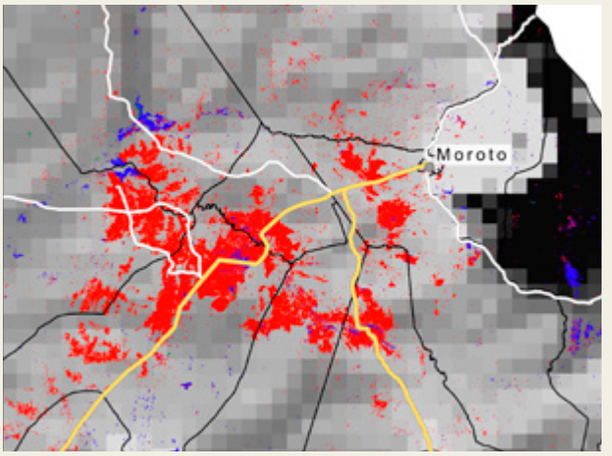
For multi-scale agricultural monitoring, daily data is collected for the whole of Uganda, showing regional trends. For example, it may indicate that crop growth or biomass productivity in the regions of Mukono and Luwero are higher, on average, than in the regions of Kitgum and Ngora. When making comparisons between seasons, it was observed that production in the first season of 2018 started later than the first season of 2017. The information is used as the basis of the agronomic recommendations provided by the market-led, user-owned ICT4Ag-enabled Information Service (MUIIS). The information may also be used as baseline measurements for monitoring and evaluation.

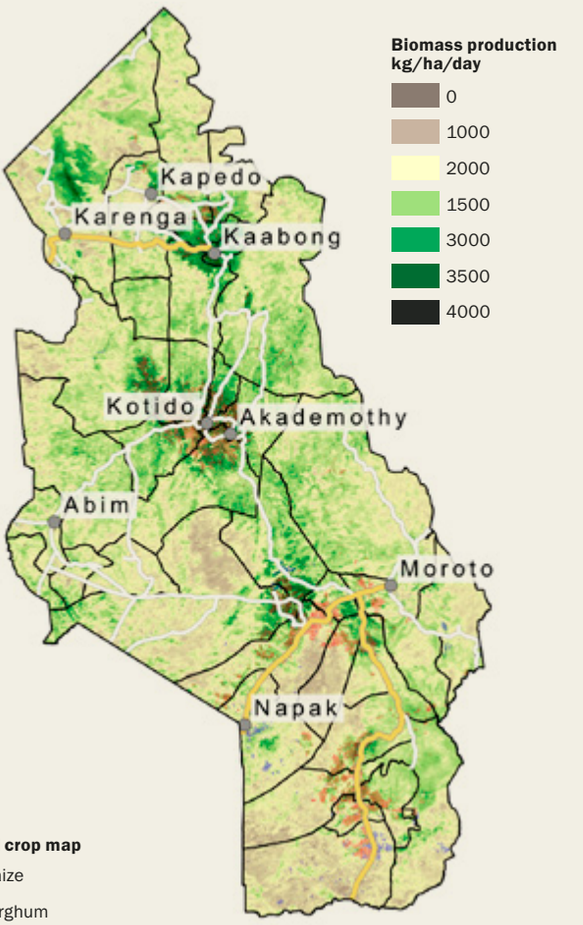


Karamoja
Biomass production on 7 February 2017

Image: EO4SD Agriculture Cluster (eLEAF/ESA/MUIIS, 2018)







Crop map by WFP, using Sen2Agri

Scalability and comparability, from maps to indicators in Ethiopia

The production of comparative and combined quantitative assessments, along with corresponding mapping over large geographical zones, would help the task leaders of many development projects and programmes to achieve a complete picture of the situation and set policy priorities. For instance, for the Angolelana Tera region of Ethiopia, which has a surface area of 836km^2, the EO4SD cluster has combined satellite imagery and information on land cover, land productivity, and erosion risk.

These indicators are produced at multiple scales, from local to regional. The maps below on the left show the trends in annual biomass production from 2010 to 2016 for Central Ethiopia, Ethiopia in total, and the 12 GEF-IAP countries. The maps on the right show the land cover classes and erosion risk classes for Angolelana Tera, which have been combined to extract statistics on the areas with erosion risk by land cover, meaning forest, cultivated areas and grasslands.

Central Ethiopia

Image: EOSD Agriculture Cluster (eLEAF, 2018)

FOREST —	**No risk: 28km^2**	**Risk: 4km^2**
AGRICULTURE —	**No risk: 465km^2**	**Risk: 71km^2**
GRASS LAND —	**No risk: 206km^2**	**Risk: 7km^2**

Angolelana Tera, Ethiopia, 836km^2

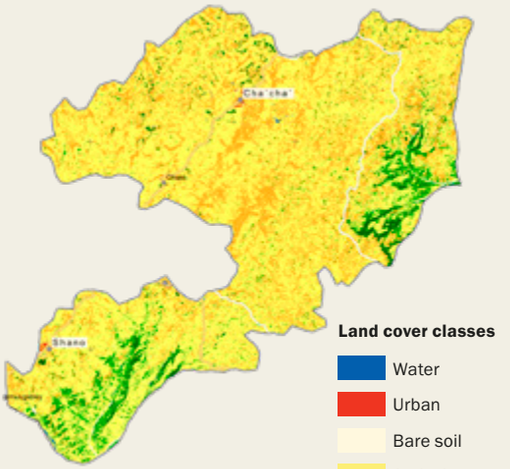


Image: EO4SD Agriculture Cluster (GeoVille, 2017)

Ethiopia

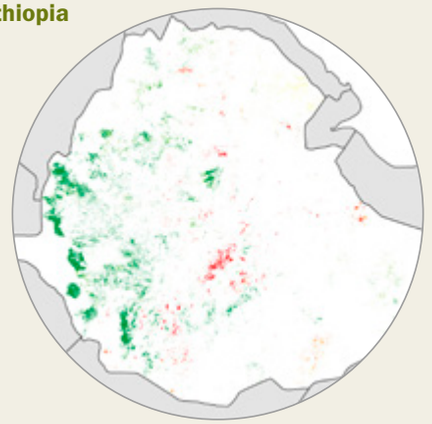
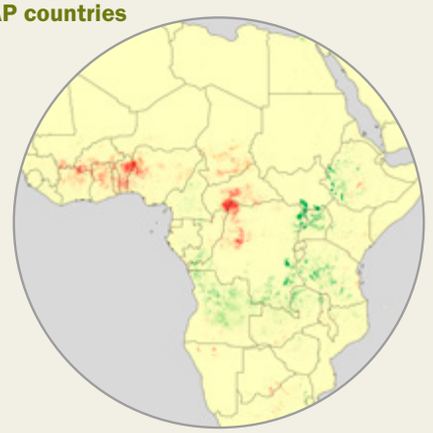


Image: EOSD Agriculture cluster and FAO WaPOR Above Ground Biomass Production (eLEAF,2018)

IAP countries



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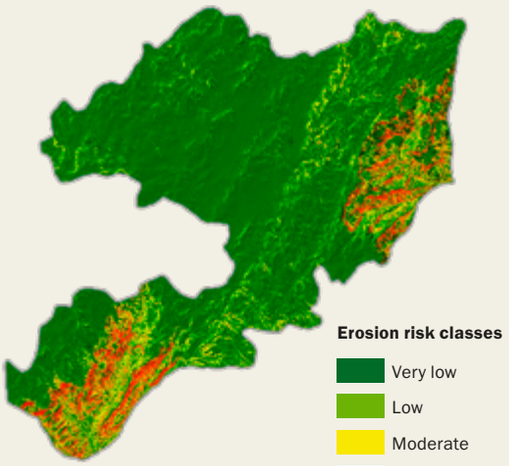
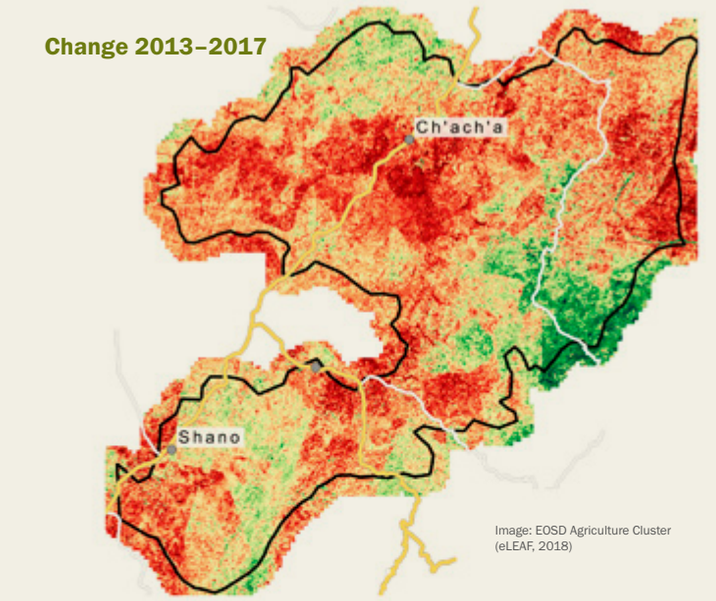
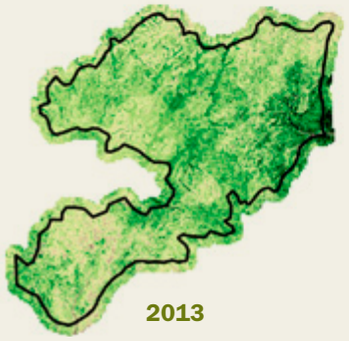
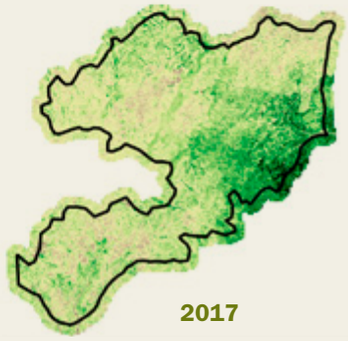


Image: EO4SD Agriculture Cluster (GeoVille, 2017)

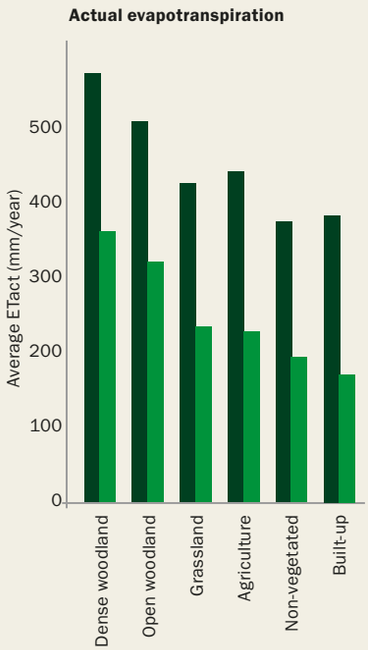


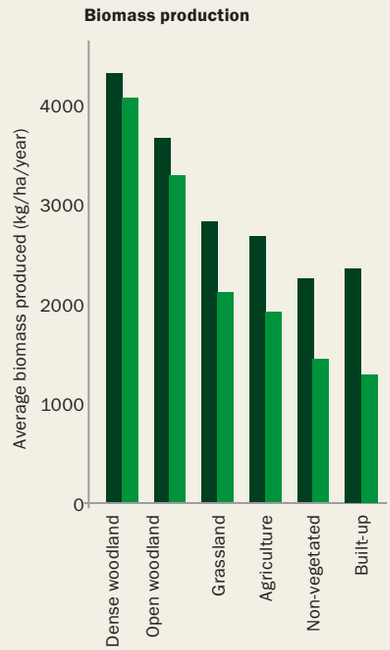




Tons/ha/year	Tons/ha/year change
0	-20
10	-10
20	-5
30	0
40	5
50	10
60	20

Monitoring biomass production is key to tracking whether land degradation neutrality activities enhance or increase land productivity. Biomass production refers to the growth of total living plant material above and below the ground, such as stems, leaves, roots, fruits and grains. It is defined as dry matter and is measured as incremental biomass production per time step. The map shows the biomass in tons/ha/year and the change over time. The graphs below show the average biomass produced per land cover type in Angolelana Tera region of Ethiopia.



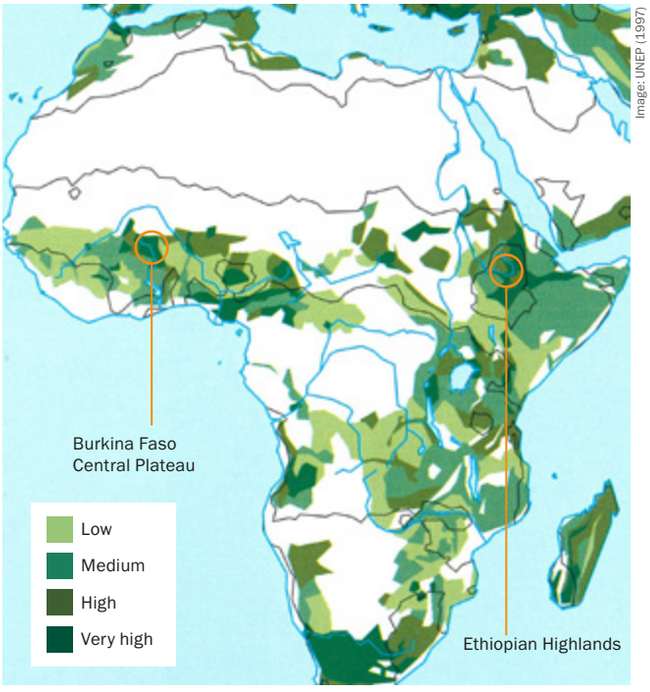


Images: EO4SD Agricultural Cluster (eLEAF,2018)

Development of intensive watershed management models for areas prone to soil erosion in Sub-Saharan Africa

Fujio Nagumo, Director, Crop, Livestock and Environment Division, Japan International Research Center for Agricultural Sciences (JIRCAS); Kenta Ikazaki, Researcher, CLED, JIRCAS; Koichi Takenaka, Senior Researcher, Rural Development Division, JIRCAS; Satoshi Tobita, Director, Environment and Natural Resource Management Programme, JIRCAS

Land degradation such as soil erosion by water and/or wind has been a serious problem in many regions of Sub-Saharan Africa (SSA), due to a continuous increase in deforestation caused by the desire to expand farmland and to obtain firewood from the forest. To develop agricultural technologies that assist in preventing soil erosion, the Japan International Research Center for Agricultural Sciences (JIRCAS) is implementing a research project at Burkina Faso's Central Plateau in the Sudanian Savanna zone, and in the Ethiopian Highlands. Both regions have been identified as having the highest severity of soil erosion by water in SSA.[1] The research activities and findings from the two project sites chosen for intensive and sustainable watershed management are outlined below.



Water erosion severity in Africa

Burkina Faso

The Sudanian Savanna (annual rainfall, 600–900mm) in West Africa is a transition zone between the Sahel (annual rainfall, 200–600mm) and the Guinea Savanna (annual rainfall, 900–1,200mm). It stretches for approximately 3,300 km from central Senegal and Gambia to northern Nigeria. The climate is mainly BSh (hot semi-arid) in the Köppen climate classification.

Crop production in the Sudanian Savanna is said to be limited by several factors such as low water availability, poor soil fertility, and the limited technical, managerial and financial capacities of the farmers. These factors are aggravated by ongoing and severe water erosion. The United Nations Environment Programme (UNEP) reported that water erosion is severe in the Sudanian Savanna, particularly in the Central Plateau of Burkina Faso, because of high rainfall intensity and fragile soils. Loss of soil by water erosion threatens sustainable agriculture as it depletes soil nutrients and productivity.

Conservation agriculture (CA) has been recommended by the Food and Agriculture Organization (FAO) as a soil and water conservation technique. According to the FAO[2], CA consists of three components: minimum soil disturbance (i.e., reduced, minimum or no tillage), soil cover (with crop residues or cover crops), and crop rotation/association (e.g., mixed farming or intercropping). Although CA has been widely adopted in North and South America, it has not in SSA. Previous studies have reported that low CA implementation is a result of its promotion as an indivisible package without sensitive adaptation to local conditions. Conservation agriculture was expected to be an effective countermeasure against water erosion in the Sudanian Savanna but it has been argued that the promotion of three-component CA to the smallholder farmers in SSA is unrealistic. It is therefore imperative to determine which component(s) of the three contributes to the desired effects.[3]

As in the other regions of SSA, the three-component CA package imposes a heavy burden on farmers who are econom-

ically challenged and have a limited workforce. Therefore, JIRCAS examined whether all three components of CA are required for reducing water erosion in the area, with the assumption that the crop rotation/association component may not be necessary and that a lessening of the burden of its adoption could facilitate the future promotion of CA to the smallholder farmers.

Three-year field experiments were conducted in runoff plots at the experimental station of Saria, Institute of the Environment and Agricultural Research (INERA), located on Burkina Faso's Central Plateau. The four treatments applied to sorghum fields were:

- Conventional practice with full tillage, no sorghum residue mulching, and no intercropping
- Two-component CA with minimum tillage and sorghum residue mulching without intercropping
- Three-component CA with velvet bean (VB) or pigeon pea (PP) intercropping.

It was revealed that minimum tillage and sorghum residue mulching (without intercropping) effectively reduced runoff and water erosion by more than 35 and 50 per cent, respectively.[4] These reductions were mainly due to the improvement of soil permeability by the boring of termites and wolf spiders induced by the sorghum stover mulch as well as the retardation of runoff water flow by mulching. Contrary to expectations, the PP did not survive the long, dry season. Moreover, intercropping with VB in combination with the other two CA components had no effect on water erosion control, mainly because the VB did not effectively function as a cover crop owing to its slow growth, and did not increase mulch biomass, especially sorghum biomass which prompts the boring of termites and wolf spiders. It was therefore established that the legume intercropping is not always necessary and that the two remaining components of CA, i.e., minimum soil disturbance and soil cover, are sufficient for soil conservation in the area. This finding lightens the burden of adopting CA and thus facilitates its future promotion to the smallholder farmers in the Sudanian Savanna.

As well as CA, JIRCAS develops and proposes improved sorghum cultivation techniques and animal feeding management to promote an intensive agricultural land use system. The introduction of techniques on the efficient use of resources is evaluated by using the Soil and Water Assessment Tool (SWAT) and Modified Universal Soil Loss Equation (MUSLE). Also monitored is the income of agricultural households due to the implementation of technologies, based on a survey of farmers' conditions.

Ethiopia

As Ethiopia covers an area of over one million square kilometres, its climate and topographic conditions differ widely, with many varieties of agro-ecosystems and vegetation types. Biomass and natural resources also vary across the

Image: Kenta Hazaki

Demonstration of two-component conservation agriculture to university students in Burkina Faso

Image: Koichi Takenaka

Daily firewood collection in a rural area of the Tigray region, Ethiopia

regions. In the distant past, Ethiopia's forest resources were exhausted due to land reclamation and fire wood collection for household energy. An Ethiopian emperor ordered the afforestation of Addis Ababa in the late nineteenth century, along with orders to conserve forest resources. Ethiopia is now becoming one of the world's leading countries in the field of environmental conservation.

The Tigray region is the northernmost state of Ethiopia, covering over 40,000km^2 and home to approximately seven million people. The highland area stands over 1,500m ASL, covering 47 per cent of Tigray, and is characteristic of mountainous areas, with many steep slopes. The region's population typically manages very small farms, raising animals on extremely limited arable lands. Household energy such as combustible wood and herbal plants were collected from the surrounding areas even under the proscription of by-law.

There are many mountain plateaus with gully erosions formed on the hillside. In such degraded areas, native acacia tree vegetation, which appears as scrub forest, becomes dominant. It has been reported that, within living memory many giant trees have disappeared and the forest has lost its vivid greenness. Today, there is evidence of only dwarf shrub communities in the surrounding areas. Moreover, large volumes of sediment have been exposed at the end of the watersheds regardless of the area's size, and it is thought that this has been brought about by soil erosion. Also, agricultural productivity and natural resource biomass are low due to surface soil erosion and recent unstable climate conditions.

The local government of the Tigray region has called on the people to become highly conscious of the environment. Soil-water conservation activities have been implemented, with the public and private sectors applying free labour, with 20 days per year of voluntary participation. As a result, soil-water conservation activities have been carried out over 960,000ha, and there has been 1.2 million ha of enclosure effected for the rehabilitation of herbal and woody vegetation, groundwater recharge, and mitigation of soil erosion. In recognition of these achievements, the regional state was granted the Future Policy Award 2017, organised by the World Future Council[5] along with the United Nations Convention to Combat Desertification. The state has vowed to continuously push for further conservation and restoration of the natural resources.

Results from the current study in the region shows that the biomass of the native acacia community increased by only 1 to 2 per cent over three years because of their innate slow growth and the problem of seedling survival because of failure to adapt to alkaline soils and severe, arid conditions. There is also an increasing demand from local people for firewood from the acacia trees.

In 2016, JIRCAS commenced a research project, chiefly in collaboration with Mekelle University, Ethiopia, to develop an integrated technique for improving small-scale farming

and natural resources management to prevent soil erosion and land degradation in the Tigray region. The project also aims to develop a good land management system, with emphasis on the socio-economic aspects. Two main pillars have been decided for the research:

- The introduction of complementary techniques, from the viewpoint of the biological sciences, to maintain small-scale farms and conserve woody vegetation on hillsides of the watershed areas through observing the lands as natural resources capable of sustaining the population's livelihood.
- With sensitivity to the socio-economic aspects, encouraging the local people and administration officers to contribute ideas for better uses of natural resources and management of small-scale farms in watershed areas.

As described above, the *Acacia etbaica* (Schweinf.) community at the project site in Tigray grew very slightly in biomass over the last three years. The local people are obeying the environment policy and trying to shift household energy from natural wood to specially planted trees, herbs, and dried faeces as much as possible. Some have switched to biogases or solar energy. However, it is expected that natural resources will still chiefly be used for household energy in the area because technologically advanced energy sources have not yet become widely available. It is therefore urgently necessary to increase the biomass of existing woody vegetation until the energy supply is thoroughly modernised.

The project works to:

- Encourage soil improvement using wood charcoal and other materials to maintain air permeability, moisture retainability and fertilizer-holding ability, thus increasing the plants' survival rate and initial growth
- Use the agroforestry technique of applying arbuscular mycorrhizal fungi (AMF) to help plants capture nutrients such as phosphorus, sulphur, nitrogen and micronutrients from the soil
- Utilize the sediments deposited at the end of water channels — possibly eroded from the upper area — for small-scale farming such as vegetable cultivation, tree nurseries and seedlings for afforestation.

Eroded surface soil can be returned to its origin of the upper area of the watershed as the area is not too large and the land users are determined. Efforts are hampered, though, because the younger people of Tigray are emigrating to other regions or countries, because of the lack of work opportunities in the villages with decreasing arable lands. To conserve highly productive lands, people that can manage the land should be encouraged to settle in the regions. The socio-economic environment is currently being examined for the future of land management from village level to district level.

However, rural populations must still rely on the available natural resources for their life security, where local people and the government of Tigray will endeavour to achieve further environmental policy implementation.

It is hoped that the results of the collaborative research between JIRCAS and the Ethiopian partners will develop techniques and suggestions for sustainable natural resources management to prevent soil erosion and land degradation in the Tigray region.

Image: Koichi Takenaka

Degraded land with thin vegetation of *Acacia etbaica* in a watershed in the Tigray region, Ethiopia

Securing soils through people-centric watershed management for sustainable agricultural development

Suhas P. Wani and Mukund D. Patil; International Crops Research Institute for the Semi-Arid Tropics (ICRISAT)

The sustainability of agricultural production systems is the plausible outcome of carefully managed natural resources to produce more per-unit input, which will also help to achieve the goals of 'no poverty' and 'zero hunger'. Soils from croplands and uncultivated wastelands are degraded due to erosion and nutrient depletion, requiring urgent attention to maintain the sustainability of the production system. By adopting a holistic, integrated watershed management approach, soil security measures backed by scientific knowledge have demonstrated a positive impact on agricultural productivity and profitability, with reduced soil loss and increased water availability.

"Upon this handful of soil our survival depends. Husband it and it will grow our food, our fuel, our shelter and surround us with beauty. Abuse it and the soil will collapse and die, taking humanity with it." – Rigvedas (1500 BC).

The importance of — and need for — soil security measures was recognized by ancient intellectuals, and is also highlighted in the framework of the Sustainable Development Goals (SDGs)[1]. However, with pressure to achieve food security and other economic priorities, soil security has received less attention than required for sustainable development. Technological innovation in crop husbandry, the use of chemical fertilizers, an increase in crop coverage and cropping intensity, and access to water for irrigation have increased the production rates of agriculture commodities[2, 3]. But this has also resulted in land degradation in the form of soil erosion, depletion of soil nutrients, hardpan development, and soil salinization because of inappropriate use of the technologies. Another important factor in the increase of production rates is irrigation, although rainfed agriculture systems are suffering from both low crop yields and high land degradation[4].

Soil erosion and the depletion of soil nutrients are major causes of land degradation. Globally, 75 billion tonnes of soil are lost from arable land each year along with an estimated US$ 400 billion in agricultural production costs[5], although a recent study on global soil erosion has challenged this estimate and suggested 35.9 billion tonnes of soil loss per annum[6]. In either case, soil erosion remains the main cause of land degradation upstream as well as increasing sediment loads in downstream water bodies[7]. In India, river basins are losing 0.5 to 1.0 per cent of storage capacity every year[8].

The rate of soil erosion changes with soil type[9], rainfall intensity[10], land use, and land management practices[6]. Data from long term observations (1976–2010) of soil loss from croplands with alfisols and vertisols, at the International Crops Research Institute for the Semi-Arid Tropics, Patancheru, showed a large difference in both the mean annual soil loss and sediment concentration between these two soils[9]. Alfisols

The community role in biodiversity conservation and management

95 ha of community pasture land in Gokulpura and Goverdhanpura villages was facing land degradation due to overgrazing and failure to produce sufficient fodder to support an increasing population of livestock. People from the villages came together to devise a plan to rehabilitate the community pasture land as a part of an integrated watershed management activity. Half of the pasture was kept for the rehabilitation process, with the other half kept available for open grazing. The stakeholders — grazers, herder, and farmers —through the Gram Panchyat (village level governing institution) agreed to erect a stone wall around the 45 ha pasture area, and banned cattle from grazing within it. Thus, the area was physically and socially fenced.

An improvement was observed in the density of vegetation in the protected area, in contrast to the unprotected area. Moreover, the treated area attracted many birds and animals, prominent among which were blue bulls. The community efforts over six years brought about remarkable changes in the flora and fauna of this piece of land and, most importantly, it has begun to produce a good quantity of quality livestock fodder. These activities have generated a good income for the community, particularly for marginal and small farmers.

Farmer witnessing the transformation of grazing land, Gokulpura, Rajasthan

Various soil and water conservation structures at the Gokulpura-Goverdhanpura watershed. The soil and water conservation structures including 13 gabion structures (top left), 1,500 gully plugs, 34 loose boulder structures (top right), and 20 check dams (bottom left) were constructed in a watershed of 1,355 ha, which reduced the annual soil loss from 5.5 t/ha to 1.5 t/ha

are more susceptible to soil erosion than vertisols — the mean annual soil loss in alfisols was about 3.0 times higher in comparison. Also, soil erosion rates from croplands are several times higher than soil erosion rates from forests[6].

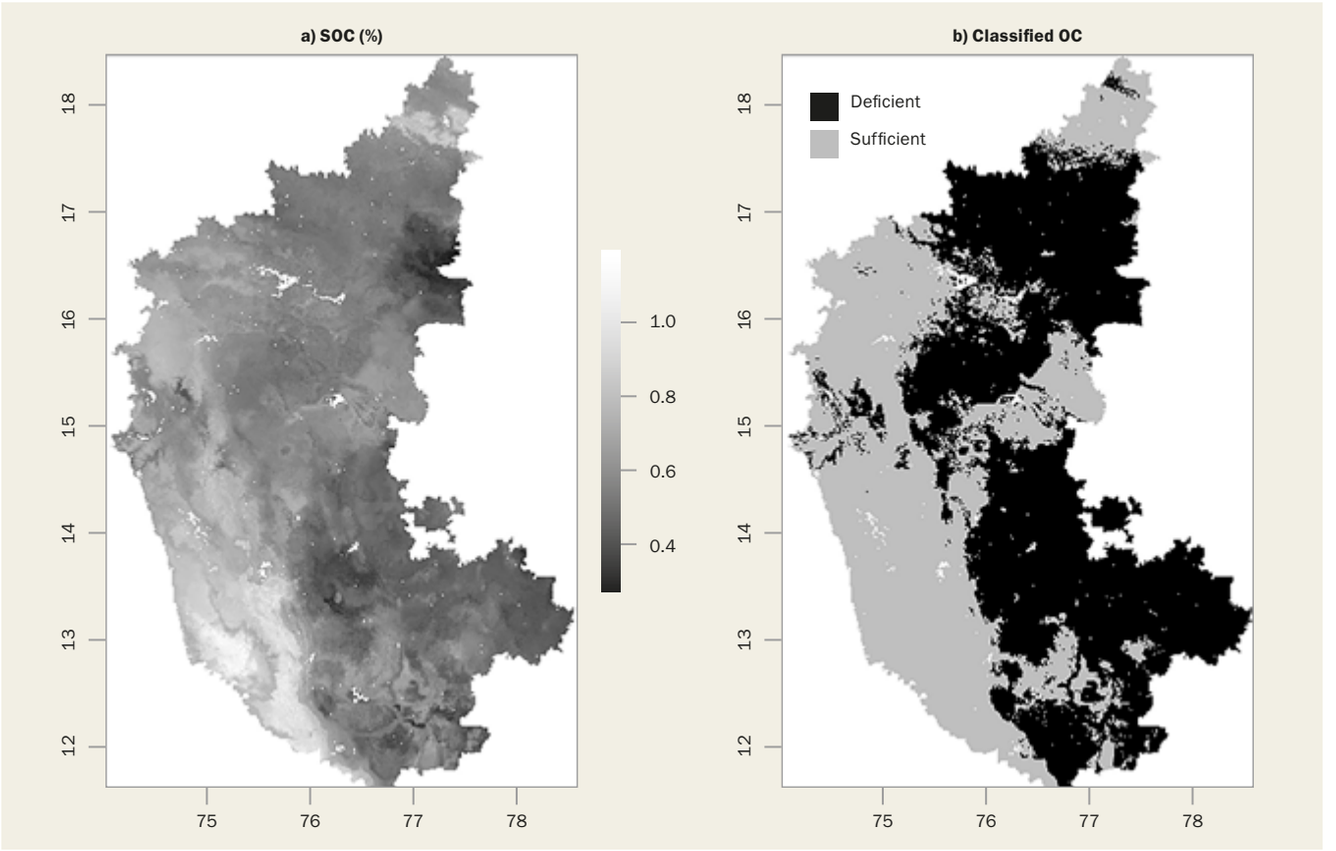
Another mechanism of land degradation is soil nutrient depletion which may result directly from sediment transport or through crop uptake and imbalanced nutrient applications. During soil erosion, sediments also carry useful soil nutrients and harmful agricultural chemicals to downstream waterbodies, thus causing nutrient deficiencies in croplands, and water contamination downstream.

The nutrients depleted from croplands are not being replenished appropriately. For example, since the era of the green revolution in India, attention has been given to only three macronutrients: nitrogen, phosphorous, and potassium, but the application of micro- and secondary nutrients such as boron, zinc, iron and sulphur has been ignored, leading to widespread deficiencies of those micronutrients[11]. Although the quantity required of secondary and micro-nutrients is very small compared to macro-nutrients, their role is critical for maximizing crop yield.

ICRISAT and its partners have been working together with farming communities to alleviate land degradation, overcome water scarcity, and harness the potential of rain-fed agriculture by adopting integrated watershed management programmes. The important interventions adopted are low-cost soil and water conservation and rainwater harvesting structures, soil test-based balanced nutrient management, and the reuse of treated wastewater.

The participatory Integrated Watershed Management approach is a holistic rural development intervention targeting the soil, water, ecosystem and community. This approach was taken a step forward through a comprehensive public–private partnership (corporate social responsibility programme). Through one such partnership in the drought-prone semi-arid Bellary area of south India, where water scarcity is a major issue, 7,680 people across four villages have been positively impacted. The holistic approach has increased the groundwater level by 1.5–2 metres in less than five years. Check dams and water conservation structures built as part of the programme have conserved a gross amount of 45,000m^3 due to refilling in the rainy season. An additional 25,000m^3 of rainwater was harvested, providing water security to the community. This helped sustain crop yields during long dry spells and the overall yield of groundnut and maize increased by 19 and 27 per cent respectively from 2013 to 2018.

With the help of a loan from the Asian Development Bank, the Government of China piloted 100 watersheds in pre-selected provinces. Today, this model has reached 12 million farmers in five countries across Asia and Africa. In addition, through spillover and dissemination, holistic watershed intervention has reached at least one billion people.



Prediction maps of surface layer soil organic carbon (SOC) derived using digital soil mapping techniques. The environmental covariates used for creating these maps were elevation, slope, aspect, annual mean temperature, mean diurnal range of temperature, temperature seasonality, maximum temperature of warmest month, minimum temperature of coldest month, temperature annual range, annual precipitation, precipitation of wettest month, and precipitation seasonality

Soil security measures adopted in watershed programmes

Understanding that soil erosion is one of the most serious threats to the soil in India, the Indian government initiated a watershed development programme in the early 1970s with the aim to reduce soil erosion in agricultural lands and to control gully formation. The investment in soil and water management has resulted in reduced sedimentation which has a positive impact on the water quality downstream, but also on the water harvesting interventions which are strengthening the resilience to drought. These interventions have reduced the soil loss by a factor of five to ten and is expected to make a positive impact on in-stream river ecology and runoff generation for other downstream water uses[10]. Moreover, a higher groundwater recharge from 9 to 20 per cent of total rainfall, together with a 10 to 30 per cent higher soil moisture availability in the fields resulting from the watershed interventions, have enabled the farmers to provide supplementary irrigation to crops during dry spells, enhancing greenwater use efficiency.

Resource conservation technologies were also adopted for practicing resilient and climate-smart agriculture. Two of these conservation technologies are zero or minimum tillage and retention of crop residues on the soil surface, which are also basic principles of conservation agriculture. Minimizing tillage reduces the volume and velocity of surface runoff, leading to a reduction in soil erosion and nutrient loss[12–14]; the incorporation of crop residues; enhanced soil water availability; reduced evaporation loss; improved infiltration by restricting surface runoff; and reduced surface sealing from raindrop impact[13]. A study to assess the global impact of land use on soil erosion[6] has suggested that conservation tillage practices have reduced the soil erosion from croplands by 64 per cent.

Nutrient cycling and rectifying nutrient deficiencies

Bhoochetana (rejuvenation of soil) was a mission project from the semi-arid tropic region of Karnataka state in southern India. The project addressed soil nutrient deficiencies on a large scale through policy interventions aimed at characterizing the fertility status of soils and adopting integrated nutrient management holistically to increase productivity and profitability for the farmers. The statistically proven random stratified sampling method[15] was adopted to collect 95,000 soil samples representing farming fields of 30 districts covering approximately 5.3 million ha in Karnataka. In 2009, the samples were analysed and soil fertility maps and soil health cards were prepared. The collected samples represented a huge variability in terms of rainfall, topography, cropping system, farm size, and management.

The soil fertility maps[16] and descriptive statistics indicated that almost 50 per cent of the area was deficient in organic carbon, sulphur, boron, and zinc, thus requiring a soil fertility management programme, especially within the croplands. Soil organic carbon (SOC), values ranged from 0.3 to 1.5 per cent. The soils in the Western Ghats had higher SOC values compared to the South Deccan Plateau. Moreover, the south-

ern part of Western Ghats gave the highest values of SOC, a trend that could be due to a combination of high vegetation and precipitation. The SOC map also indicated that almost 50 per cent of the area in Karnataka state showed less than 0.5 per cent SOC.

The soil fertility maps prepared during this project have changed the perception of policymakers that fertilizer requirements are same at every location. The crop wise balanced nutrient recommendations prepared during the project were incentivized by state government through subsidizing the cost of the required inputs by 50 per cent.

Another major hurdle in any scaling-up project, is reaching out to large farming communities through a limited and poor extension system. This issue was addressed by introducing an innovative system of farm facilitators — progressive farmers who have practiced agriculture and have a minimum of academic qualifications. The farm facilitators were trained by State Agriculture Universities to spread good agricultural practices. The project covered 4.75 million farmers with US$ 353 million net benefits to the state between 2009 and 2013. Overall the project recorded a significant yield increase from 25 to 47 per cent in cereals, 28 to 37 per cent in pulses and 22 to 48 per cent in oilseed crops[17].

Rehabilitation of the wastelands through agro-forestry

The wastelands often have undulating topography and severely degraded soil with a very shallow depth, supporting no more than a scattering of short, and stunted bushes exposed to the increased pressure of grazing, and facing severe land degradation. Open grazing practices, typical in villages, have over-exploited common pasture and forest land adjoining the village. Deforestation and mining activities have reduced the fodder source, increasing pressure on common grazing lands. The most appropriate solution to reduce the degradation of wastelands and to achieve fodder security in a village is to develop the wastelands as fodder banks. A silvopasture system comprising suitable species of fodder grasses and trees on wasteland treated with soil and water conservation structures can provide a sustainable source of fodder for livestock. Here, the village committee is responsible for the development of wastelands and the protection of the silvopasture system.

Another option for rehabilitating the wastelands is to grow biofuel plants such as Jatropha (*Jatropha curcas* L.). These plants are drought tolerant and suitable for degraded soils with a low nutrient content. This option is also considered as a means of addressing concerns about climate change and improving energy security while at the same time providing an additional source of income for the community. There is also the benefit that nutrients are recycled through leaf fall, for example a three-year-old Jatropha plant recycles 21 kg/ha nitrogen back into the soil.

In collaboration with the National Oilseeds and Vegetable Oils Development Board, the Indian government, ICRISAT and village community have initiated a project to rehabilitate the 160 ha common property land in Velchal village, India

Plantation in the wastelands of Velchal village in which Jatropha seedlings approximately 30–60 cm high were planted in 2m x 2m spacing

by planting the Jatropha as biofuel plants. Firstly, the soil and water conservation structures were established in the wasteland for reducing soil erosion and rainwater harvesting. Then the plants were grown as rainfed crop, but fertilizers were applied as per requirements for achieving optimum yield. The beneficial effects of wasteland rehabilitation included the effective use of rainfall for producing biomass, an increase in groundwater recharge, a reduction in runoff and soil loss, and an improvement in downstream water-bodies[18]. The annual average soil erosion in the villages was high, ranging from 10 to 15t/ha as the soils in the village are shallow with a low water holding capacity. The Jatropha plantation reduced the intensity of runoff and thus reduced total soil loss by almost 50 per cent[18]. Moreover, Jatropha as a biofuel crop also creates a complementary source of income for the village community.

The way forward

The Indian government's goal of doubling farmers' incomes was successfully demonstrated through corporate social responsibility projects in the states of Telangana, Andhra Pradesh, Karnataka, Maharashtra and Odisha. More than 500,000 most-at-need people benefited with increased productivity and incomes. With improved management of watershed pilot sites, farmers' incomes doubled with an increased cropping intensity of 70–100 per cent over the baseline[19]. The initiative to double farmers' incomes was piloted in 27 districts of Maharashtra and Uttar Pradesh.

Because of the impact of these pilots, the initiative was scaled up across regions, into national level policies and shared with countries across the world.

The strategy to arrest land degradation depends on its cause. Soil and water conservation interventions reduce soil erosion; balanced nutrient management in crops checks excessive nutrient mining from the soil; appropriate tillage practices reduce soil and nutrient erosion from croplands; and the development of wastelands provides a sustainable solution to fodder production as well as additional income. These interventions are being implemented as a part of integrated watershed management programme and provide beneficial effects in terms of crop production and environmental security. Scaling-up of these initiatives is urgently needed to achieve food, nutrition and water security for the growing population; which is always a challenging task as it requires coordinated and collective efforts from both the scientific and farming communities, and from policymakers.

The Bhoochetana project may be a guiding example for such scaling-up activities. Another critical limiting factor for the sustainable land management programme is the availability of correct and actionable information to end users. Such information may often be available in a complex form that very few could understand and use for planning process. The digitization of this information, and the building of a spatial data infrastructure for natural resource management would be the first step towards developing agro-ecoregion-based planning and implementation processes.

The *Jatropha* is a shrub with the potential for use in rehabilitating degraded lands

Towards managing Africa's twin challenges — mitigating land degradation and meeting food security

Bashir A. Jama, Lead, Global Practice, Food Security Specialist, The Islamic Development Bank (IsDB), Jeddah, Kingdom of Saudi Arabia; and Nur Abdi, Manager, Agriculture Infrastructure Division, IsDB

More than ever before, the research and development community is tasked to address the twin challenges of food insecurity and land degradation that is threatening land and livelihoods in Africa. It is estimated that over 200 million people, nearly a third of the population of Africa, are hungry and malnourished; with the number increasing due, in some cases, to the high frequency of droughts and floods that are closely associated with climate change.

Along with its development partners, the Islamic Development Bank (IsDB) is actively engaged in addressing these twin challenges across its 27 member countries through solutions that are scalable and sustainable. A recent publication[1] highlights the lessons learned from the bank's investment in the agriculture and rural development sector over the past 40 years. This article highlights five key interventions that are relevant to achieving Sustainable Development Goal (SDG) 15: Life on Land.

First is the need for sustainable solutions to increase the productivity of smallholder agriculture that is otherwise generally unproductive in sub-Saharan Africa. Yields of staple food crops are typically less than one-third of global levels. Because of the low yields of land currently used for production, the efforts of farmers to raise more to meet their needs often involves bringing marginal lands into production, thus exacerbating the land degradation process.

In efforts to reverse this situation, targeted investments have been made by member countries with the support of IsDB and its development partners to increase the uptake of integrated soil fertility management (ISFM) technologies. ISFM, by necessity, involves the judicious use of mineral fertilizers with manure (both livestock and compost); soil and water conservation measures; cover crops including grain legumes that can obtain nitrogen biologically from the atmosphere; and agroforestry technologies that may include planting leguminous trees such as *Faidherbia albida*.

In addition to these soil-related interventions and agronomic practices, member countries are supported to expand and improve existing irrigation systems. Less than 7 per cent of Africa's potential agricultural land is currently irrigated. Improving irrigation systems, including harvesting water that would otherwise cause erosion and land degradation, is key to increasing food security, and land and ecosystem productivity.

ISFM practices also require the use of high-yielding and locally adapted crop seeds and planting materials. To this end, both the public and private sectors are facilitated to increase the supply of improved seeds and fertilizers. Farmers' cooperatives are also strengthened by the agricultural projects to procure improved seeds and fertilizers for their members, and through economies of scale, cut the cost of delivery to their members. This partnership arrangement to improve input delivery is a key component of IsDB development programmes, and is exemplified in most of its agricultural investments such as the Millennium Villages Programme in Segou, Mali.

To guide the application of ISFM technologies, national programmes need to improve their land and soil fertility diagnostic capabilities. To this end, IsDB and its partners will roll out, in 2018, a regional programme in six member countries to map soil fertility in the main agricultural areas, including lands that are degraded and/or vulnerable, and to develop recommendations for farmers, the fertilizer industry and policymakers. This mapping exercise will deploy light spectroscopy innovations in combination with remote sensing, allowing for a rapid pace of analysis at reduced costs relative to traditional soil laboratory techniques, and mapping at landscape levels. This will be in partnership with several research and development organizations, including the Africa Soil Information Service.[2]

The Millennium Villages Programme, Segou, Mali

Nyeta Farmers' Union is an association of 10 grassroots cooperatives from Faro Massa Commune in the Segou region of Mali. Onward lending of fertilizers to its 911 members (97 are women) has helped to bring 10,000 ha under irrigated rice production over 3 years; raised yields from under 1.0 to 3.5 t/ha on average of high quality paddy rice; and achieved an average of 86 per cent repayment by union members of the funds lent. The union built its own storage facility that allows the sale of the produce when markets are attractive. The women members add value to the rice through a process of parboiling[3] which enables selling to major cities in Mali, including the capital, Bamako, thus attracting higher returns on investment. The key need for this group and others like it is affordable financing to grow their businesses. A second need is alternative sources of energy to replace the current use of biomass for parboiling, including trees and manure, that are scarce and contribute to degradation of land and natural resources.

Image: Bashir Jama, 2018

Parklands of *F. Albida* and other trees of economic importance in Faro Masa Commune, Segou region, Mali. Note the presence of farmyard manure in the fields to improve soil fertility. Livestock is integral to production and contributes to combating nutrient depletion through use of the manure

Second is the need for interventions to improve access to structured markets. This is key to sustaining farmers' investments in the interventions to intensify production. Improved market access could also reduce post-harvest losses that are high under smallholder conditions in Africa. Typically, 30–40 per cent of produce is lost before it reaches the markets. With IsDB's support, member countries are investing in rural access roads that connect farmers to input and output markets. Investments are also made in establishing rural grain storage facilities that allow farmers, through their cooperatives and associations, to aggregate produce for sale collectively and at better prices. This is evident in many projects such as one in Sierra Leone that links farmers to markets.

Third is the need for innovations to improve access to affordable financing, and two approaches have been deployed to this end. One is through the private sector where, under certain conditions, value chain financing is facilitated for the production inputs (seeds, fertilizers, land preparation), with the produce being bought through contractual agreements. Although generally difficult to construct, this is probably the way to sustainably finance smallholder agriculture in Africa. The second is improving access to Islamic micro-financing in rural areas. The unique features of this financing mechanism include the principle of joint ownership of the benefits and risks by the lender and borrower, making it particularly attractive to farmers and rural agribusinesses. Success stories are growing fast, for example in Benin where women's groups have deployed the use of Islamic micro-financing to grow their production and marketing activities.

Fourth is the need for sustained investments in national agricultural research and development systems. This is particularly important in relation to climate change, and the urgent need to increase the adaptation and resilience of the farmers and their farming systems to it. National agricultural institutions, including forestry and agroforestry, need to be innovative and forward looking in developing and facilitating the uptake of technologies at the appropriate scale by farmers that can enhance their productivity and mitigate land degradation. However, the ability of many national research bodies to do this successfully is currently low because of inadequate funding. Their connectivity with international research and development organizations is weak. To this end, the IsDB invests continuously in strengthening the agricultural delivery systems of its member countries.

A key intervention is the promotion of South-South cooperation and the exchange of expertise and knowledge through programmes such as Reverse Linkage. This facilitates the transfer of knowledge from one member country to another that is in need. Additionally, agricultural development projects include significant resources to strengthen national projects' implementation teams in managing their initiatives for tangible results. While this is useful, a key challenge is the limited agricultural experts in most countries. With the structural adjustment programmes of the 1980s and 1990s, governments spent little on the agricultural sector, leading to its downfall in most countries. An important consequence of this is that there are currently few available replacements for ageing and retiring staff. This calls for urgent and large scale investment in capacity development by countries with the support of their development partners. Strong national institutions are critical to bringing innovations and seizing opportunities that address current and future problems of the agricultural sector, in ways that generate jobs and cut abject poverty in many of our rural agricultural communities. One such opportunity is a US$ 0.5 billion Transform Fund established by the IsDB in 2018 to promote the generation and

use of science, technology and innovation in increasing the achievements of sustainable development in member countries. Many projects related to SDG 15 stand to benefit from the Transform Fund in the coming years.

Fifth is a commitment to develop and sustain strong partnerships with all key stakeholders, including the private sector, civil society and local communities. All can contribute to achieving the SDGs as articulated in Goal 17. This is much needed in SDG 15, given its cross-cutting nature. As part of its development strategy, IsDB supports its development partners for many reasons. For instance, it is important to increase the resource envelope and to improve project delivery by supplementing national capacities, and civil society increasingly plays a significant role in this area. For example, the Federal Republic of Nigeria accepted a proposal to outsource a major component of an agro-pastoral development project in Kano State, funded by the IsDB, to a local non-governmental organization, Babban Gona[4], that has demonstrated effective delivery of agricultural programmes in the country.

Elsewhere — including Mali, Uganda, Sudan, Senegal, Guinea and Chad — the MDG Centre for West and Central Africa[5] based in Dakar, Senegal, has partnered with the national programme in the delivery of integrated agricultural and rural programmes that have strong land productivity and rehabilitation components. These partnerships have helped significantly in setting robust monitoring and evaluation systems, as well as communication mechanisms. They have also helped to set up stakeholder platforms that facilitate the sharing of information and experiences in this complex area that is critical for sustainable development.

Image: Bashir Jama, 2018

Parklands systems at Faro Masa Commune, Segou, Mali. The main food crop, sorghum, has been harvested and the residues removed for use as livestock feed. This is a major source of 'nutrients mining' and of soil fertility loss. The fields are then left to households and community livestock grazing. The livestock manure left in the fields helps recycle nutrients and mitigate soil fertility decline and associated land degradation

Image: Bashir Jama, 2018

Bags of livestock manure, which is used to fire the boilers to parboil rice. Manure is a substitute for wood fuel which is limited in this semi-arid region of Sahel, West Africa

Summary

Lessons learned from the development of IsDB-supported programmes and others provide a good foundation with which to accelerate national efforts towards achieving the SDGs, and in particular SDG 15. The main challenge is in sustaining the gains already made. Key to this is the forging of strong partnerships with the private sector through value chains that allow development of input and output markets, some of which could be regional and international. For this to succeed, governments and their development partners should focus on creating enabling environments that allow the private sector, including farmers and their associations, to make the commensurate investments and minimize their risks, including those associated with climate change. This is a prerequisite for achieving SDG 15, and which the global community is committed to accomplishing by 2030.

Image: Bashir Jama, 2018

Rice parboiling facilities at Faro Masa Commune, Segou region, Mali

The Great Green Wall Initiative — building resilient communities in Africa's drylands

Elvis Paul Nfor Tangem, Coordinator, Great Green Wall for the Sahara and Sahel Initiative;
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Land Degradation Neutrality (LDN) was adopted as global target 15.3 of the Sustainable Development Goals (SDGs) in 2015 to address desertification, land degradation and drought. The United Nations Convention to Combat Desertification (UNCCD), as custodian of the LDN target, supports more than 115 country parties to set their own national voluntary targets for LDN.[1]

LDN is firmly anchored in the UNCCD process with the adoption of the 2018–2030 Strategic Framework agreed in 2017. The UNCCD parties now need to translate the framework into national policies that are coherent with the LDN concept. Those national policies should be consolidated with, as well as leverage, other relevant policies including the United Nations Framework Convention on Climate Change (UNFCCC) and the Convention on Biological Diversity (CBD).

The UNCCD parties have highlighted the importance of partnerships to support the implementation of the convention and LDN. With their investments and resources, inclusive partnerships from central and local governments, private sector, civil societies, and local communities can greatly facilitate the implementation of LDN at national, regional, and global levels.

Many activities have begun that directly or indirectly support LDN and UNCCD implementation globally. These include the Changwon; Ankara; One Belt One Road; 3S; and Drought initiatives in Asia and Eastern Europe. Several programmes have been developed in Africa over the years that are instrumental in achieving the LDN objectives, the most iconic of which is the Great Green Wall for the Sahara and Sahel Initiative. Support for the UNCCD work is one of its main objectives as shown in the initial 2009 plan that "is designed to strengthen the implementation of national action plans under the United Nations Convention to Combat Desertification and action plans targeting sustainable development and poverty reduction in the desert margins north and south of the Sahara, which have been adopted by all the countries concerned with the initiative".

The initiative serves as a successful platform mandated by Africa to foster broader partnerships in strengthening UNCCD implementation.

The objective of the initiative

In 2007, in order to overcome climate change and understand its variability as manifested in the dry lands of Africa — especially the Sahel and the Circum-Sahara regions through desertification, land degradation and drought — the African leadership launched the Great Green Wall for the Sahara and the Sahel Initiative (GGWSSI). It is a pan-African mission to take effective and urgent action to end or reverse land degradation and loss of biodiversity in African drylands and to ensure that ecosystems are resilient to climate change, continue to provide essential services, and contribute to human well-being and the elimination of poverty and hunger. The Initiative aims to help the majority of over 500 million Africans living in the drylands to embrace sustainable development practices by ensuring the effectiveness of the double fight against poverty and towards environmental protection. This is particularly important given the fact that the cost of inaction — forced migration, reduction of crop yields, political uprising, hunger and malnutrition — has been estimated to be 3.8 to 5 times higher than the estimated cost to avoid land degradation according to the recent assessment of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES). Not taking urgent action to reverse this harmful trend can undermine the attainment of the SDGs in the drylands of Africa, especially SDG 15 whose objective is to "protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss."

Harmonized Regional Strategy for the Great Green Wall for the Sahara and the Sahel Initiative

	Great Green Wall objectives	LDN objectives
1	Improve resilience of natural ecosystems	Maintain or improve ecosystem objectives
2	Improve security of people living in dryland areas	Maintain or improve productivity in order to enhance food security
3	Improve living conditions of local populations in the arid lands of Africa	Increase resilience of the land and populations dependent on the land
4	Be a continental platform for implementing the Rio conventions	Seek synergies with other environmental objectives
5	Put in place systems promoting sustainable land management	Reinforce responsible governance of land tenure

Image: GGWSSI

Harvesting of straw for fodder in protected pasture land, Louga region, Republic of Senegal

The Great Green Wall Initiative and multilateral development agendas: Agenda 2063 and the SDGs

The GGWSSI is usually perceived as a row of trees linking West and East Africa, a perception from the initial conception of the programme which was to create a line of trees from Dakar to Djibouti, a metaphorical representation of the scale of the idea. However, the GGWSSI concept is a set of integrated mosaic actions that address the multi-sectoral problems affecting the lives of people in African Sahelo-Saharan areas[2]. As outlined in its regional harmonized strategy, the blueprint of the initiative, these cross-cutting actions address a wide range of concerns, including natural resource management, sustainability of rural production systems — agriculture, livestock breeding, forestry, and water — the development of rural production and trade infrastructures, diversifying economic activities and wealth creation; all with the consideration of gender, youth and wealth issues within its development. Therefore, the Wall references the socio-economic and environmental activities that are typically carried out to build a wall to fight the external influences jeopardizing the well-being of peoples living in Africa's drylands and its ecosystems.

As a development strategy, the Initiative intends to strengthen the implementation of existing continental frameworks and plans, addressing the menaces of land degradation and desertification in the margin of the Sahara desert. Such frameworks include the Comprehensive Africa Agricultural Development Programme; the Regional, Sub-regional and National Action Programmes to combat desertification; the overarching vision of Agenda 2063 — the fifty-year endogenous framework towards sustainable development for Africa — and the SDGs, especially target 15.3 which urges to "by 2030, combat desertification, restore degraded land and soil, including land affected by desertification, drought and floods, and strive to achieve a land degradation-neutral world". The aim is to encourage a synergistic approach in the implementation of the activities of these global, continental, sub-regional and national bodies aimed at combating land degradation and desertification in Africa.

Although launched before the SDGs, there is a clear symbiosis between the GGWSSI's objectives and SDG 15, especially target 15.3 on LDN. Both LDN and the Great Green Wall aim at protecting the environment while looking for sustainable solutions to reinforce coping capacities of populations confronted with the effects of climate change. In addition to SDG 15, the Initiative contributes to the achievement of almost all of the other SDGs, including SDG 17 on strengthening the means of implementation and revitalizing global partnerships for sustainable development targets. They set the pace for more empowered communities in areas where vulnerability is worsened by the effects of desertification, land degradation, drought, and others.

Some of the Initiative's key achievements

Giving a voice and a place to vulnerable populations

The GGWSSI is first and foremost designed for the people and implemented by the people for the good of the people. Populations are at the centre of the entire process and their empowerment is the main objective. Therefore, the guiding thread of each activity implemented as part of the Initiative is to ensure that vulnerable populations, including women and youth are the main beneficiaries.

At country level, where projects are being implemented by various governments, communities and local groups, with the support of international partners, activities mainly target the local level in order to consider the underlying causes of poverty in the communities.

One of the identified challenges is gender and the lack of inclusiveness in the communities, with the marginalization of women and female children. Despite the central role they play in building resilience in communities, they hardly enjoy the benefits. The GGWSSI is reversing this trend, and women are now playing a greater role in combating land degradation. In Niger, one of the countries involved in the Initiative, women in several municipalities are at the forefront of implementation. For example, in 2017 in the municipality of Tera, of the 677 people benefitting from implementation of the programme, 528 were women.[3] They have been the main actors in the land restoration process that has contributed to rehabilitating just over 28,000 ha in the Tera community alone. Apart from the benefit to agriculture of restored land, the restoration activities can generate economic returns for women who can use them to support their families and to invest in income-generated activities.

The Great Green Wall Initiative and sustainable livelihood enhancements

As discussed above, the main purpose of the GGWSSI is to radically transform and strengthen people's livelihoods in drylands. The main tool used to reverse land degradation is the adoption of sustainable land management practices including a range of integrated actions that add value to the life of people in the communities. One particular success is the creation of multi-purpose gardens that have contributed to the empowerment of communities in Senegal, Nigeria and Mali.

Between 2008 and 2017, Senegal put in place nine multi-purpose gardens — areas in which a part (one-third or one-half) is devoted to gardening and the rest to the cultivation of fruit trees[4]. The gardens are usually equipped with a drip irrigation system to support agriculture. Once the crops — usually fruit and vegetables — are ready to harvest, they are sold for cash or credit to the group members at the garden. According to the Great Green Wall National Agency of Senegal, of more than 1,500 people, 85 per cent of those working in the gardens across the country are women, with the average income for each garden amounting to approximately US$ 3,555 after consumption by families.

Image: GGWSSI

Women in Burkina Faso applying the indigenous half moon land management practices under the AUC-FAO ACP-EU Actions Against Desertification project, 2016

In pastoralist communities, the gardens have contributed to the provision of alternative pasture and fodder gardens during the lean/dry season to control transhumance, mitigating the potential for conflict. About 100 per cent of children in the communities now attend school, transhumance has reduced by more than 40 per cent, and there has been improvement in health and nutrition.

Creating a winning synergy for LDN with international partners

The GGWSSI is coordinated by the African Union Commission whose role it is to integrate various regional institutions such as the Pan African Agency of the Great Green Wall, and the Permanent Interstate Committee for Drought Control in the Sahel; civil society organisations such as ENDA Tiers Monde, SOS Sahel International, and CARI; and international development and technical partners such as the European Union, Food and Agriculture Organization, the World Bank, and UNCCD. This integration is crucial to the upscaling of restoration activities. Guided by SDG 17 that urges for global partnerships in the implementation of Agenda 2030, all of these partners have collaborated to achieve LDN.

One of the programmes currently implemented as part of the GGWSSI is the World Bank Sahel and West Africa Programme (SAWAP). It is carried out in 12 African countries with a budget of US$ 1.1 billion. Thanks to the Initiative, by December 2017, 1,080,956 ha were under restoration and more than 21,302,160 people benefited from livelihoods activities promoted by the programme. The fruits of implementation in Burkina Faso clearly show the importance of using an integrated development approach in addressing issues related to land degradation. SAWAP has been at the forefront of closing the gaps in education in drylands. The drylands are home to many poor people, usually lacking access to basic services, including education. Therefore, the programme has contributed to building classrooms in regions where the children were used to studying under impoverished conditions.

Impacts of the multipurpose gardens in Senegal and Nigeria

In Senegal, over 1 million trees are planted annually through the GGWSSI, and it is estimated that over 2 million ha of land have been restored and planted with indigenous tree species. These initiatives have restored ecosystems and improved livelihoods through the development of small forest product based enterprises, especially in the gum arabic value chains.

Through the multipurpose gardening activities of the GGWSSI in Senegal and Nigeria, alternative off-farm employment has been created for over 2,000 vulnerable smallholder farmers, increasing some household incomes by over 150 per cent, leading to better schooling for the children, less transhumance, more stable families and communities, and better living and health conditions. These activities have reduced seasonal migration and Internal Displaced Persons (IDPs) to less than 50 per cent in some communities and transhumance practices to less than 60 per cent since the start of the programme.

Achievements of implementation in the Republic of Niger

It is estimated that, through farmer-controlled natural resources management in the Niger Republic, partly supported by the GGWSSI, the communities have succeeded in restoring 5 million ha of land and around 200 million trees, and have produced an additional 500,000 t of cereal grain per year, which is enough to feed 2.5 million people at very low cost.

From 2010 to 2017, a number of projects were carried out in Niger, including dune fixation over 80,040 ha; soil restoration conservation over 310,310 ha; reforestation of gum trees and other forest species over 364,615 ha; assisted natural regeneration over 2,150 ha; the creation of 40,150 km of firebreaks; and the production of 145,572,000 plants.

Community development activities involved the production of 216,526 straw bales per year, generating an average income of US$ 78,000 for producers. Also, 265 head of cattle were distributed to the 10 women's groups for sustainable off-farm livelihood activities.

For capacity building, more than 60 training and refresher sessions were held for 1,200 people on nursery plant production techniques, nursery construction, and modern collection and handling techniques of germ plasm.

In terms of the impacts, operational activities favoured the reinforcement and strengthening of social cohesion, solidarity and the culture of associative life, the creation of 21,487 jobs, the increase of cultivable areas, and fodder production. The actions of Sustainable Land Management (SLM) favoured a good biological recovery but also a good development of planted woody species.

The production and sale of straw and grass seed on the site of the municipality of Simiri in the Tillabéri region has been evaluated by the site management committee at an annual revenue of US$ 450 to US$ 625.

Economic impacts

Land reclamation and reforestation activities have also contributed to an increase in agricultural and pastoral production. The opening of anti-erosion structures such as half-moons, benches, trenches, and stony ridges, provides important financial income for the local population, varying between

Financial mobilization for implementation summary

- Resources mobilized and provided by partners for the implementation of the GGWSSI: US$ 1.1426 billion, including:
  - 1.1 billion for SAWAP and US$ 4.6 million for Building Resilience through Innovation Communication and Knowledge Services (BRICKS), provided by GEF and World Bank
  - US$ 24 million for the FAO–AAD project and US$ 8 million for the GM–UNCCD–FLEUVE project, provided by the EU
  - US$ 8 million for filling the gaps provided by Global Environment Facility.
- Other funds mobilized at national level and through bilateral agreements stand at more than US$ 1 million.
- Area under restoration, including planted area, natural regeneration, and green space: 766,441 ha (754,441 by SAWAP and 12,000 ha by AAD).
- Beneficiaries of restoration activities, including income generation activities: 15 million, including:
  - 14.9 million by SAWAP, 100,000 by AAD, FLEUVE and National Agencies.
- Number of persons having benefited from capacity development activities: 12,194, including:
  - 5,894 by SAWAP, 5,300 by AAD, 400 by FLEUVE, 600 by National Agencies.

US$ 175 and US$ 215 per ha which is transferred to the population because of the high labour intensity of the work. Approximately 80 per cent of the income from the project was distributed to the local people as cash for work. For example, of the US$ 38,275,000 funds for the emergency programme in 2011, approximately US$ 24,750,000 was distributed to the villages, and used to reduce the cereal deficit of 700,000 t through the purchase of additional cereals, confirming that, in Niger, drought should not be synonymous with famine.

Image: Elvis Paul

Children around a shea tree, Binduri, Kassena/Nankanna District, Upper East Region, Ghana

The economic impacts observed are also related to the increase of agricultural and pastoral production on the restored sites. Thus, an evaluation of the production of intercrops carried out in 2014 on the bio-carbon sites shows an increase of 273,179 t of millet; 70.68 t of sorghum; 54.92 t of cowpea; 78 t of sesame; and 63.79 t of peanuts.

It is envisaged that the strategy of strengthening advocacy for the mobilization of both traditional and new financing will result in the scaling up of SLM activities, the implementation of more projects, and the establishment of national alliances with the Great Green Wall for the Sahara and Sahel Initiative.

Conclusion

The GGWSSI has huge potential to contribute to the achievements of multilateral environment agreements, Agenda 2063 and especially the SDGs. However, for this to take place, there is a need for long-term investment in diverse and multifaceted activities, focusing on a sentinel landscape approach with the recognition of indigenous knowledge and socio-cultural approaches. The setting of LDN targets should be undertaken not in isolation, but rather in consideration of the other targets such as the Nationally Determined Contributions and the GGWSSI.

Image: Actions Against Desertification Niger

Women involved in afforestation activities, Niger

Beyond neutralising land degradation — BADEA's integrated rural development efforts in West Africa

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The Arab Bank for Economic Development in Africa (BADEA) was established in 1975 with the aim of strengthening economic, financial and technical cooperation between Arab and African countries through financing crucial sectors in the development of Sub-Saharan Africa. The Bank is one of the major players in South-South cooperation between Arab and African Countries.

According to recent estimates, poverty in Africa fluctuates between 40 and 45 per cent of the population, with more than 60 per cent of Africa's population still living in rural areas. The majority of the rural population relies on agriculture as its main source of nutrition and income. The volume of agricultural land in terms of total land area stood at 42.18 per cent in 2015; however only approximately 9 per cent of the total land area is considered to be arable.

BADEA believes that, through its projects in the agricultural sector, efforts towards land reclamation and neutrality of land degradation would play a vital role in achieving economic and social development and food security for the beneficiary countries. Development in the agriculture sector would also be instrumental in alleviating poverty, reducing unemployment, encouraging women's participation in development and improving the overall living conditions of the rural population.

To that end BADEA has, since 1975, provided loans to its beneficiaries for the financing of the agricultural sector, with rural development and food security amounting to approximately US$ 1,251 million, equivalent to about 25 per cent of its total financial flows to Africa. To date, BADEA's financing has contributed to the development of 24,000 ha of agricultural land, the laying of 600 km of irrigation canals, the construction of more than 14,000 km of rural roads, and the digging of some 6,300 boreholes, in addition to many other achievements in the sector.

The Food and Agriculture Organisation of the United Nations (FAO) estimates that land degradation already impacts over 20 per cent of the world's population. This constitutes a challenge for development finance institutions (DFIs) such as BADEA to combat. These efforts need to be aligned, unified, and implemented in conjunction with the African countries.

BADEA's interventions in agriculture and rural development covers efforts in land reclamation for facilitating the production of cash and food crops as well as irrigation, livestock development, fisheries, forestry, and the development of rural infrastructure such as roads, boreholes and electrification.

A number of operations are ongoing in some Western African countries, targeting rural improvement where land development and rural water supply are among the components of BADEA's operations. The projects aim mainly at alleviating poverty in rural areas and contributing to food security through the rehabilitation of irrigated land; reducing reliance on rainwater; improving economic and social infrastructure for rural populations, especially with roads; rural water; and improving the productivity of the main agricultural crops in the projects' areas.

Mali

In Mali, BADEA contributed US$ 10 million to the Integrated Rural Development Project in the Bani Basin, in partnership with other DFIs. The project covers the regions of Koulikoro Segou and Mopti, with 383,000 inhabitants, most of whom work in agricultural activities such as crop production, livestock breeding and river fishing. However, 75 per cent of the agricultural land is currently dependent on rainfall. The project area is considered to be one of the poorest, with poverty estimated at 70 per cent compared to 56 per cent at national level. The project aims to reduce the shortage of agricultural investments; improve the traditional patterns of agricultural systems; and address the impact of the deteriorating climatic conditions over the last four decades that has resulted in a decrease in vegetation cover, decline of river floods, and an increase in reliance on rain-fed agriculture by about 90 per cent. The project aims to improve land use efficiency to facilitate food security, population stability, income improvement and poverty alleviation in rural areas.

The estimated total area that can benefit from the project is approximately 33,000 ha, which will be reclaimed. It will utilise 25,455 ha of land in agricultural intensification, resulting in an annual increase in rice production by 52,240 t. Some 6,820 ha will be used to grow the necessary fodder crops to provide food for cattle, where the annual additional production of fodder crops will reach approximately 82,300 t. In addition, the exploitation of about 554 ha in the cultivation of vegetables will increase production annually by approximately 3,620 t. The project will also help reduce the effects of floods on the land area by the construction of flood protection

Image: BADEA

Agricultural development project in the N'Diawara region, Senegal River Basin, Republic of Senegal

barriers and bridges. Additionally the project will work on the reclamation of agricultural land and the protection of pastoral areas. It will also work to sustain the increase in rice production and other agro-sylvo-pastoral and piscicultural products in the programme area.

Togo

In Togo, partnering with other DFIs, BADEA allocated US$ 9 million to finance a rural development project in the Oti basin. The proposed project was part of the state's strategy for the development of agricultural crops in order to provide food security and income increases for local farmers in the project area and at country level. The project was of particular interest to the Bank due to its impact on women empowerment in an area where 75 per cent of the work in these sectors has traditionally been done by men. The project is expected to contribute towards achieving land degradation neutrality through the reclamation of 750 ha of agriculture lands and the construction of dams and reservoirs to store water for the irrigation of agricultural projects in addition to building sand barriers to protect the irrigated land from flooding.

The project also aims to support and strengthen the capacity of government, institutions and associations in the project area to enable them to provide the necessary technical and support services to rural farmers and women. This will be done through training workshops and providing essential infrastructure such as primary schools, literacy classes, health clinics and the provision of drinkable water.

Ghana

Partnering with the government of Ghana and the OPEC Fund for International Development (OFID), BADEA allocated US$ 8.6 million in a contribution to Ghana's integrated rural development project. BADEA aims to bring the rural population out of poverty, improve standards of living, provide food insurance, and improve social indicators. Although the country does not have a large food gap and frequent famines, there is a deficit in the production of some cereals, meat and fish, which, according to food statistics, results in a shortage of nutrition. The project will also provide microfinance facilities to farmers to help spur better yields from agricultural activities and help better utilisation of land resources.

Cape Verde

BADEA also partnered with the Republic of Cape Verde's government in the financing of a rural development project in the Percival basin by contributing US$ 8.6 million. One of the greatest challenges facing the country is the provision of foodstuffs for the population. This is due to natural constraints in the growth of agriculture owing to the mountainous topography, low rainfall levels, and the rising demand for food. The project area, like areas in the other islands, is exposed to soil erosion and deterioration of the natural vegetative state due to the slope gradients and long droughts followed by short periods of heavy rain causing the formation of water drains that sweep the soil. Food security

in the project area can be improved by constructing a dam at the bottom of the principal valley to store water to be used for irrigation; and reducing land erosion through the development of forests, vegetation cover and pastures. The project also aims at reducing poverty by opening up isolated areas, and improving agricultural diversification and production by providing microcredit.

The project will help in the development of forests and pastures by rehabilitating 200 ha in Serra Malagueta Nature Reserve; enhancing fodder production and forest cover over some 400 ha; and providing microcredit to finance the development and diversification of agricultural production by improving drip irrigation and livestock profitability, as well as financing parallel income-generating activities.

The project will also work on achieving sustainable exploitation of natural resources by planting and building land protection facilities that contribute to the development of vegetation cover and improve the use of agricultural and pastoral lands to increase their profitability. Additionally, the project is expected to strengthen the capacity of water collection and storage through the building of the water dam, as well as improving accessibility to the region.

Summary

BADEA has been working in cooperation with many DFIs to help in the development of the African countries. The Bank is part of the Arab Coordination Group (ACG), which also includes the Islamic Development Bank Group, Saudi Fund for Development, OFID, Abu Dhabi Fund for Development, Arab Fund for Economic and Social Development, Kuwait Fund for Arab Economic Development, Qatar Development Fund, Arab Gulf Program for Development, and the Arab Monetary Fund. The ACG has contributed to BADEA's efforts towards land degradation neutrality by funding agriculture projects amounting to US$ 5.6 billion.

Additionally, BADEA partners with institutions such as the African Development Bank, World Bank, European Investment Bank and the French Development Agency in these sectors. The Bank will continue to strive for collaboration with other institutions to help attain its objectives for the development of the African continent through projects and technical assistance interventions based on the conservation and optimal usage of agricultural land.

BADEA is concerned about sustainable approaches to natural resource management in Africa, and will therefore continue to enhance its development efforts in agriculture and rural development, bearing in mind the importance of achieving land degradation neutrality.

The focus of progress will be within the framework of each of the countries' developmental strategies and mid-term development frameworks that aim at achieving national food security, enhancing land-based natural capital, protecting the rights of land users, and applying a participatory process that includes stakeholders — especially land users — in designing, implementing and monitoring interventions to achieve land degradation neutrality.

Image: BADEA

Reclamation of the Flamengos and Principal water basins, Republic of Cape Verde

Agricultural innovation platform as a framework for sustainable land utilization

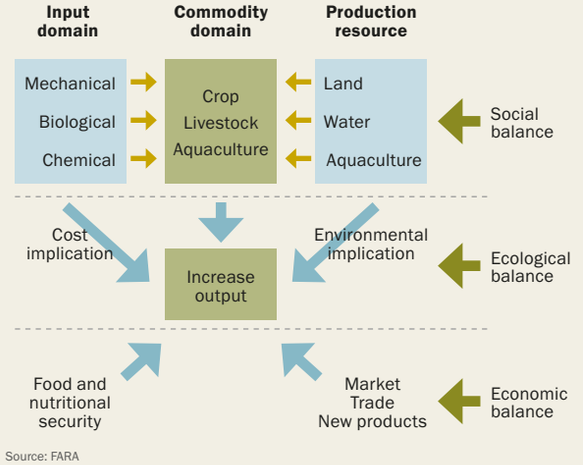
O.O. Akinbamijo and A.O. Fatunbi, Forum for Agricultural Research in Africa (FARA)

The Sustainable Development Goals (SDGs) have provided smart guidance for countries to orchestrate their own development and improve the quality of life of their citizens. The SDGs also present much-needed opportunities to achieve specific development in a way that ensures the availability of natural assets for future generations. Some of the 17 goals focus on issues of food agriculture, health, environment and the sustainable use of natural resources. SDG 15 brings an understanding to the improvement of life on land, involving the moderation of human activities and their interaction with key elements of land systems to ensure continuous support to human life and the delivery of returns for the future. SDG target 15.3 proposes the achievement of remarkable success in combating desertification, restoring degraded land and soil, preventing drought and flood, and endeavouring to realize a world without land degradation.

Many of the issues targeted by SDG 15.3 concern agricultural production practices and related sectors that use natural products derived from farms and forests. The prevailing agricultural practices involve the removal of vegetative cover to allow the cultivation of desired crops; a practice that disrupts the sequence of natural activities, especially the relationship between soil fauna and flora and nutrient cycling within the system. Soil tillage activities that aim to provide a suitable rooting environment for crop growth also introduce the possibility of degrading the soil as well as the land. The worst types of land degradation include erosion; decline of soil organic matter; soil chemical contamination; soil surface sealing, structural hardpan and soil compaction by heavy machinery; decline in soil biodiversity; salinization; floods; and landslides.

The scourge of soil erosion is evident on most arable land across the globe, with current statistics indicating that arable-usage soils become degraded within the first five years of cultivation, and that 30 per cent of the world's arable land has been lost to various kinds of degradation over the last 40 years. This portends a huge problem for a world with a global population growth of 1.09 per cent (83 million individuals) per year.[1] This suggests that the world has an additional 83 million people, minus the number of those that have died, per year to feed using a land resource that is being continuously degraded. It is imperative that concerted efforts are made to curb land and soil degradation as part of the global efforts towards natural resource management.

Interaction of key elements of agricultural intensification



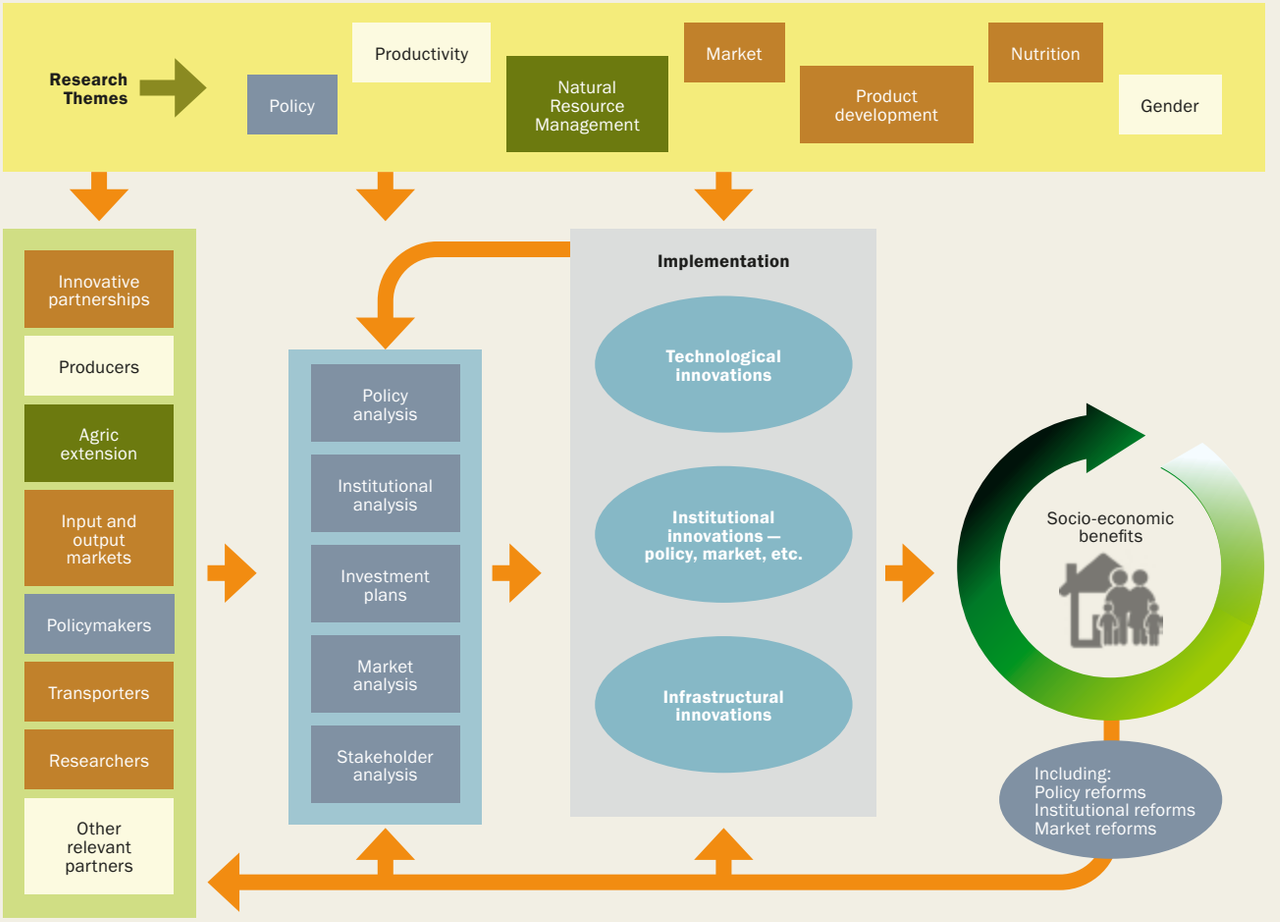
Source: FARA

Intensification and agricultural land degradation

Curbing agricultural land degradation is pertinent to the recent demand for sustainable intensification of agricultural production. Apparently, the availability of arable land is not increasing in proportion to population growth, hence the agricultural production systems must change extensively to yield more output per unit input. This defines the philosophy behind various intensification methods for agricultural production. The Food and Agriculture Organization defines agricultural intensification as "an increase in agricultural production per unit of inputs (which may be labour, land, time, fertilizer, seed, feed or cash)".[2] Attaining agricultural intensification calls for increased use of external inputs, such as mineral fertilizers, agrochemicals and improved seeds. It also requires the more efficient use of machines to ensure good soil tilth and the coverage of large expanses of land. Intensification thus calls for maximal utilization of mechanical, biological and chemical advantage to boost the natural capacity of a unit of land to yield increased returns.

The interaction of various intensification inputs is built on sound scientific knowledge, but the boost in outputs also comes with certain tradeoffs. Intensification in the production of crops, livestock and aquaculture remains the most

IAR4D framework for sustainable transformation of technologies to impact



Source: FARA

suitable option for meeting the growing demand for food and fibre from agriculture. Its efficacy is further threatened by the growing effects of climate change on the principal production domains of the world. The implication of this and other new and emerging issues is that science must be utilized further to develop technologies for adaptation and to avert any adverse effects on productivity.

The recent upsurge in the use of biotechnology and genetic modification appears to be a respite in some respect, although there are issues of acceptance of this in some quarters. Third world countries in Africa, parts of Asia and the Pacific seem to be at the losing end of the argument as they lost out completely from the benefit of the Asian green revolution that built on the strength of fertilizer, improved seeds and mechanization. Third world countries still lack the advantages of available technologies because of the prevalence of the smallholder systems that limit the use of machinery and ultimately preclude the benefits of the economy of scale. The need to continuously generate the required technologies is vital, but this must render optimum productivity while limiting the often negative tradeoffs.

The magnitude of the various tradeoffs needs to be factored into the evaluation of the cost and benefits of the approaches, to inform the choice of the end-users and encourage sustainability-friendly recommendations. The various agrarian developments in the West took maximum advantage of the drive for intensification, with the use of mineral fertilizer, mechanization, pesticides and other chemical inputs. These were used in combination on monocrop fields with little consideration for the natural balance of soil flora and fauna and their interactions with nutrient balance. This practice had dire consequences for the environment in the long term, especially with the pollution of water bodies by nitrates, heavy metals and other pollutants. Most nitrate pollution in water bodies is traced to the use of nitrogen fertilizers, with nitrate contamination presenting a serious public health threat, especially in the form of methemoglobinemia, known colloquially as blue baby syndrome.

Land use practices are thus vital but, prior to bringing technologies to end users, it is essential to subject them to a sustainability test.

Achieving sustainable intensification, and the place of agricultural innovation systems

Achieving the use of sustainable resources in agricultural production systems needs more than the generation of technologies, production systems and models. It requires the development and institutionalization of workable systems

that ensure technologies undergo sustainability tests before they are released for the use of farmers, especially the African smallholders. To ensure a broad based productivity increase in a sustainable way, the Forum for Agricultural Research in Africa (FARA), implemented the Sub-Saharan Africa Challenge Programme (SSA-CP). The SSA-CP subsequently developed the Integrated Agricultural Research for Development (IAR4D) concept to ensure that technology generation is demand-driven, and that outcomes of research are smartly translated into development outcomes. The concept has prioritized Natural Resource Management (NRM) alongside productivity, market, policies, gender and product development as core research criteria in developing technologies and ensuring that they are translated into real impacts. The diagram on the previous page indicates the various interactions among the research priorities as well as the issues and actions that constitute the enabler to ensure a coherent transformation. The framework emphasizes the importance of multistakeholders, partnerships, and multi-institutional engagements. It indicates the analysis required to inform the feasibility of actions in a sustainable way.

The implementation of the IAR4D concept is carried out on an innovation platform, where multiple stakeholders are engaged along the commodity value chain as well as the enabler actors such as policymakers, researchers and extension agents. The stakeholders interact to jointly identify problems around the various commodities or systems of production. They jointly source solutions, and implement options commercially until workable innovations are generated with benefits to all stakeholders. The innovation platforms operate commercially to tease out measurable impacts. The proof of the efficacy of the IAR4D framework has been promoted widely. The institutionalization of the concept is gaining ground with various countries as well as among agricultural research and development projects.

Integration of NRM in technology generation and use — Bufundi Innovation Platform, Uganda

The Bufundi Innovation Platform (IP) was established in the Kabale District of Uganda as part of the SSA-CP programme. Established in 2008, the IP comprises stakeholders along the value chain of beans and Irish potatoes. A major constraint to sustainable production is the rapid land degradation through soil erosion and drainage in the area's mountainous terrain.

Image: FARA

Planting across a terrace to control erosion and ensure natural resource integrity, Kabale, Uganda

Image: FARA

Soil water control studies, carried out to ensure natural resource integrity

The IP mobilized a collective action towards increased productivity of the commodities, NRM, market linkages, and active private sector engagement. Research actions were demanded to generate technologies that will resolve NRM issues. Researchers further established erosion control plots on the four prominent land use systems around the Lake Bunyonyi catchment for annual crops, perennial crops, woodlots, and grazing lands. The land uses were studied at the three landscape positions of hill summit shoulders, mid-slopes, and foot slopes. This joint technology testing resulted in the identification of best-fit technology for erosion control and sustenance of the natural resource integrity for continuous crop production and sustainability of the IP enterprise.

Summary

Efforts to achieve SDG 15.3, as well as other goals, need to build on a proven framework to deliver the required output. This is particularly vital for goals that focus on NRM; an issue that concerns everyone, with implications for future generations. Attaining the goals will require the active engagement of a multiple stakeholders group and the mobilization of collective action. Current wisdom suggests that collective action is only useful if it enables mutual benefits, creating a win-win scenario for all categories of stakeholder. Collective action works best if it concerns the livelihood of the stakeholders engaged in it; if it yields ease of effort and the generation of profit. Achieving the SDG 15.3 goals in combating desertification, restoring degraded land and soil, preventing drought and flood, and achieving a world without land degradation, is feasible. The task now is to build on the successes of the innovation systems approach, using innovation platforms for consistent actions at country level.

Protection, restoration and the sustainable use of landscapes — remedies to land degradation, and solutions to achieve the SDGs

Lulseged Tamene, Wuletawu Abera, Kifle Woldearegay, and Rolf Sommer,
International Centre for Tropical Agriculture (CIAT), and Mekelle University, Ethiopia

Land degradation is a serious global environmental problem affecting at least 3.2 billion people worldwide[1]. Approximately 33 per cent of global land coverage is degraded, costing over US$ 10.6 trillion every year[2]. Avoiding land degradation through sustainable land management can generate up to US$ 1.4 trillion of economic benefits[3]. Sub-Saharan Africa (SSA) is the most severely affected among all of the continents[4], and vulnerability to land degradation and its associated damages are severe due to the poor economic status of the majority of the population.

Despite its deep rooted and widespread effects, land degradation seems not to have received the attention it deserves. The main reasons for this are the complexity of measurement and communication; inconsistency in the values of severity and spatial distribution; and the tendency of the scientific community, development organizations, donors and policymakers to favour more clearly profitable issues such as climate change. The result is that we lack adequate and accurate quantitative information and thus lack appropriate guidelines for targeting.

Recent initiatives to restore degraded land (RDL) such as the Bonn Challenge and New York Declaration on Forests, — global efforts to begin restoring 350 million ha of degraded forest and agricultural landscapes by 2030[5] — together with the Land Degradation Neutrality (LDN) concept are, however, encouraging developments. The fact that RDL and LDN are integral parts of the sustainable development goals (SDGs), 15.3 in particular, provides a firm foundation from which to tackle land degradation. In response, many countries have pledged to restore significant amounts of degraded land, and have promised to follow green economic development paths, providing a firm foundation from which to tackle land degradation.

Even though RDL has gained momentum within international agendas, and many initiatives exist, the implementation of RDL on the ground poses many challenges for practitioners, scientists and decision makers. This is because of many related reasons such as:

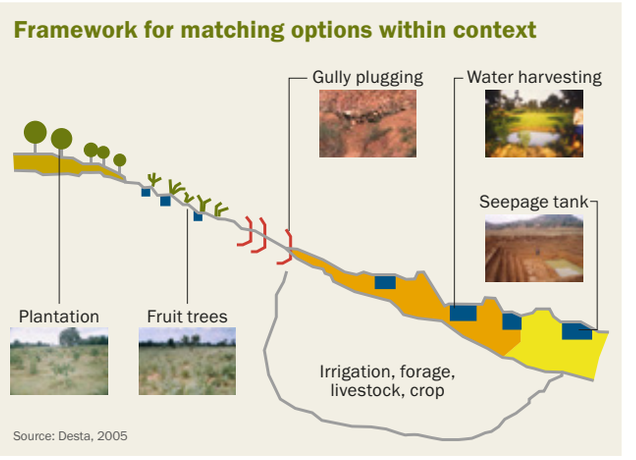
- Users and policymakers lack the patience for long-term solutions, resorting instead to short-term problem fixing, as land restoration takes time, with benefits accruing slowly
- The apparently huge investment required for restoring degraded areas discourages implementation practices
- Due to the lack of comprehensive approaches that clarify all of the benefits, functions and services of restored land, the value of land restoration investments tends to be underestimated
- Restoration is costly, but many of the conclusions that have been drawn about its net benefits are based on incomplete accounting
- In many cases, cost-benefit analysis of restoration activities is based solely on financial values instead of a broader value set that reflects the additional benefits that restoration would create.[6]

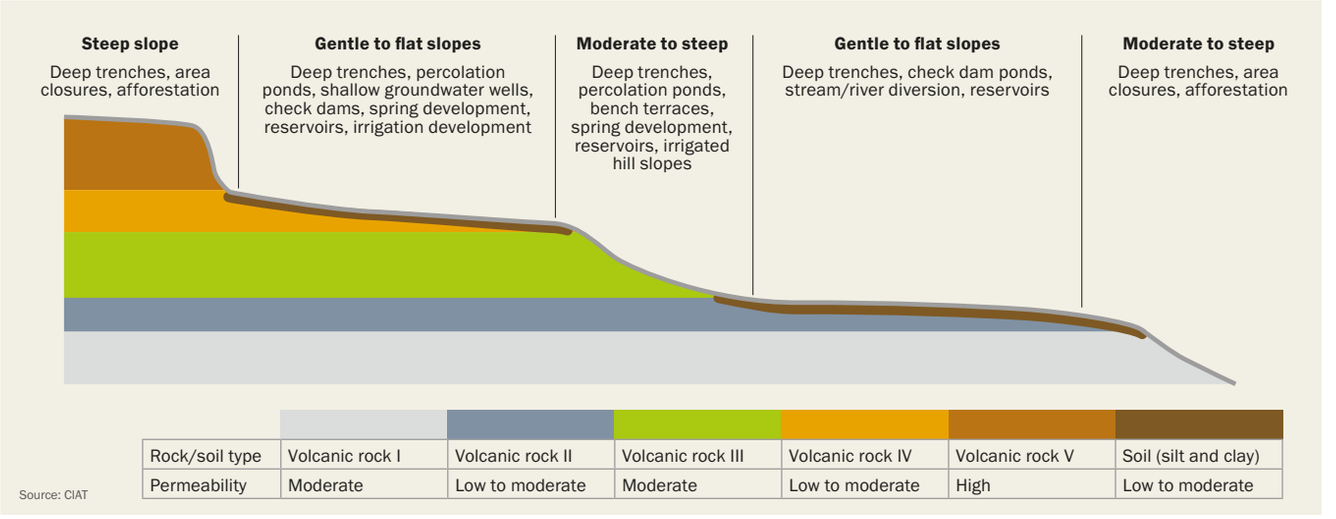
Efforts and key achievements in Ethiopia

Ethiopia exemplifies both the land degradation challenges and the progressive policies and guidelines required to arrest it and to tackle climate change. The country has developed a climate resilient green economy strategy that aspires to promoting environmentally friendly and climate conscious economic transformation and growth. Ethiopia is also one of the countries with the highest pledge to achieve AFR100, aiming to restore over 15 million ha of degraded landscapes by 2025 — a number increased to 22 million at the 2014 UN Climate Summit in New York. The country's growth and transformation plan aims to place 2 million ha of natural forests under participatory forest management, while identifying and demarcating 4.5 million ha of degraded land for afforestation or reforestation and supporting national tree planting initiatives to increase national forest cover by 4.5 per cent.

Various programmes, the most prominent and ambitious being the Sustainable Land Management Programme (SLMP), have carried out tremendous soil and water conservation activities as well as protected hillsides across hundreds of districts, and vast areas of land have been placed under improved management. Large tracts of natural forests have also been placed under Participatory Forests Management where communities and local governments enter into agreements to manage the forests according to communally agreed management plans. In addition, hundreds of thousands of hectares of degraded hillsides and grazing and farm lands have been rehabilitated using area exclosures.

Image: CIAT





Rock/soil type	Volcanic rock I	Volcanic rock II	Volcanic rock III	Volcanic rock IV	Volcanic rock V	Soil (silt and clay)
Permeability	Moderate	Low to moderate	Moderate	Low to moderate	High	Low to moderate

Framework designed to facilitate matching options within the context, and to guide the targeting of site- and context-specific interventions following the landscape continuum. The framework considers major biophysical factors that determine land conditions and suitability and allocates complementary options to tackle land degradation and improve system productivity across scale

Recently, water harvesting in various forms has been integrated into reforestation, exclosures, sustainable land management (SLM) and soil and water conservation (SWC) activities to enhance resilience of both landscapes and communities to climate change and human pressure. Ethiopia can thus be considered a good example of where landscape restoration through SLM, SWC and water harvesting is genuinely implemented at scale. Although the extent varies from place to place, evidence suggests that landscape restoration, reforestation, development and management interventions have had a huge impact on improving ecosystem health as well as the livelihoods of millions of people.

Visible signs of resilient landscapes and communities are also emerging in association with restoration initiatives. However, there is still a range of serious challenges in successfully and sustainably executing restoration efforts. These include financial problems; a lack of adequate coordination between sectors and across scales; and limited research evidence for targeting and prioritizing, with some of the evidence generated being limited in scale and extent, and thus unable to reflect the real benefits of restoration work and/or cost of land degradation.

Combining research and development

Landscape restoration and sustainable land management practices require integrated approaches, interdisciplinary teams, the engagement of multiple stakeholders and institutions, and the involvement of local communities. These need adequate financial resources as well as sound coordination, collaboration and building ownership to promote synergy and reduce tradeoffs.

While many challenges for general land restoration projects are obvious elsewhere, the focus in Ethiopia is on several issues that are pertinent to most countries but that receive less attention. These are: poor documentation and dissemination of past restoration efforts; lack of sectoral/institutional integration; and limited research and development interaction and linkage. The former is caused by a lack of stocktaking to learn from past experience and improve practices for better success rates and more efficient use of resources in future restoration investments. Generally, there is a lack of quantitative evidence about the performances of the various RDL interventions in improving livelihoods and enhancing ecosystem services across scales. The results of some of the studies are also inconsistent, non-comprehensive, based on limited spatio-temporal analysis, and assessments are often made at

plot level. Thus, it is necessary to develop measurable indicators of impacts and transformation, along with clear targets.

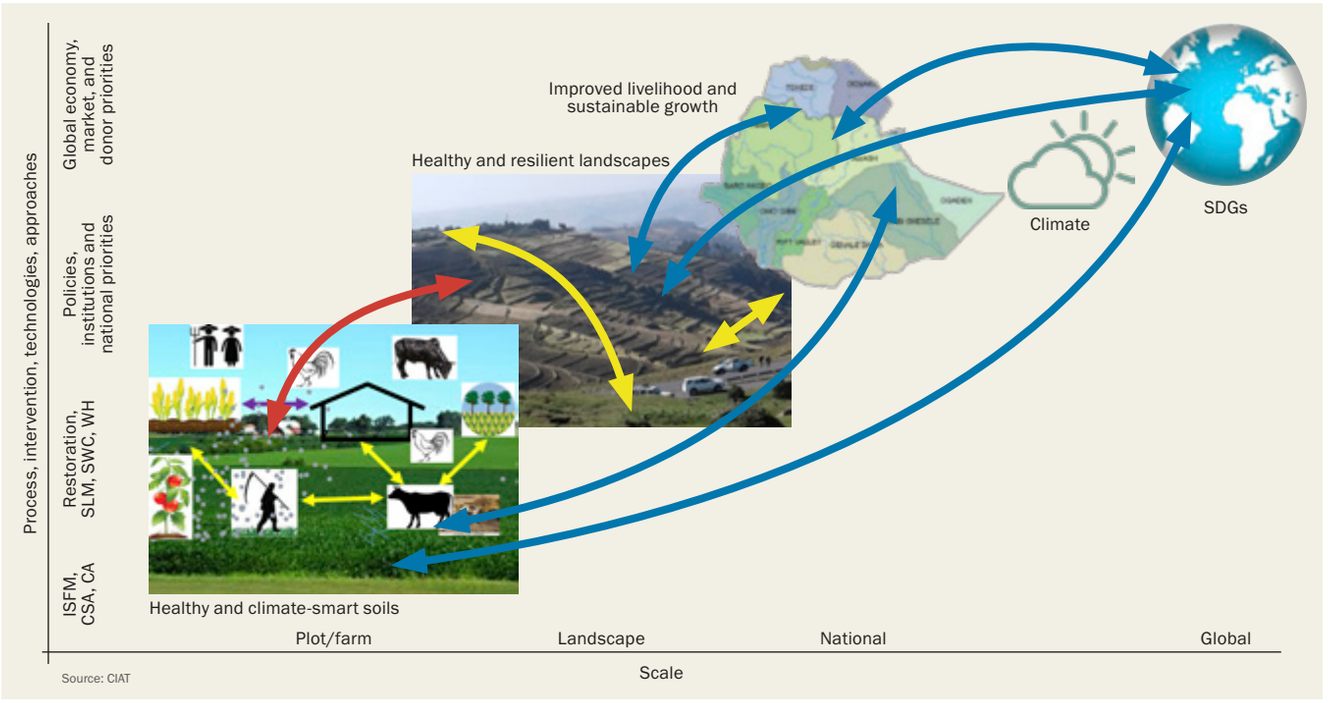
The lack of sectoral integration is due mainly to difficulties in coordinating activities of sectors related to farming, livestock, forestry, and water, among others. It is thus vital to create a platform whereby the various entities can discuss and plan their interventions related to land and water management such that there will be linkages and synergies. The role of local institutions with indigenous knowledge is also a crucial component of the synergy for developing multipurpose restoration activities. Finding ways to better engage the youth and to implement and mainstream gender-sensitive approaches is also a very relevant challenge that needs clear strategy for targeting.

The issue of research, vis-à-vis development, is largely a matter of who leads. The scientific community should support the development actors — those that implement SLM, SWC, and water harvesting options — in providing guidance related to the 'what, where, how' of technologies and approaches to land restoration interventions. If that is not done in tandem, and the development actors implement restoration activities without adequate research guidance, matching options with context can be difficult, causing efforts to fail in tackling the critical issues, wasting time and resources.

Appropriate targeting — marrying options with contexts

The primary idea of landscape restoration through SLM practices is to create multifunctional landscapes that are climate-smart and can support ecological, economic and socio-cultural benefits. Sustainable intensification and niche-based diversification should be coupled with integrated landscape management to enhance overall system productivity and livelihoods without putting an additional burden on women or disenfranchising the youth. To achieve this, well-planned site- and context-specific complementary options should be implemented following the landscape continuum. To guide such implementation, the International Centre for Tropical Agriculture (CIAT) and its partners have developed a customized framework that can facilitate the matching of options with contexts, considering site specificities. The framework outlines the types of complementary or linked technologies required (based on requirements) together with the location (based on land conditions), and assesses the potential benefits as well as tradeoffs. This framework has been successfully tested on the ground and is now being automated to guide targeting and evidence generation with the support of the Water, Land and Ecosystems (WLE) programme of the Consultative Group for International Agricultural Research.

For landscape restoration efforts to succeed, there needs to be an integrated approach whereby plot/farm level processes and interventions are linked with those of landscape level ones, and overall intervention needs to be linked across scale (plot/farm, landscape and regional) in order to facilitate complementarity and synergy. Integrated soil fertility management, irrigation, livestock fattening, and homestead management at farm scale are key for reducing pressure on landscape and generating the benefits of SLM activities, both onsite and offsite. Landscape level interventions such as reforestation, agro-forestry, exclosures, beehives, terraces, and water harvesting should be designed to provide production, adaptation and mitigation co-benefits at plot scale, through reducing erosion, enhancing soil fertility, and improving soil moisture and pollination services. Such integrated landscape management presents an opportunity to scale and leverage restoration interventions such that the benefits of the whole are greater than those of the sum of individual interventions.



Outline of processes and interventions across scale, demonstrating the challenges of RDL and the need to consider interactions and feedback between processes and the impacts of interventions within and between scales

Combating desertification in the Sahel region by recuperating degraded land and managing its potential within the community

Werner Sels, Founding President, Entrepreneurs without Frontiers (OZG)

Sustainable development is hindered in some regions because of the communities' inability to capitalize on the potential of their land. In order to activate and strengthen their capacity to do so, the fertility of degraded land must be restored through carefully judged interventions, after which it must be continuously valorized through targeted exploitation. To that end, the natural regeneration of the Sahel region of Africa can be catalyzed using best practice techniques from earth and social sciences to restore and optimize original ecosystems, and by utilizing simple agricultural techniques such as direct sowing. With the cooperation of investors from developed countries, it is possible to regenerate degraded soils on a large scale among areas vulnerable to climate change and marginalized from the world economy.

Between 2010 and 2017, Entrepreneurs without Frontiers (OZG) achieved the regeneration of degraded land in two regions of Burkina Faso, namely Sahel and North-Centre. Covering an area of approximately 8,000 ha the project was run by focusing on the concepts of sustainability, profitability, and access to a global economy.

Image: Daan Degroote

The Mogho Naba, ruler ("king of the world") of Wogodogo, one of the Mossi Kingdoms located in present-day Burkina Faso. He gave OZG the moral support to plant forests in the Mossi region

To achieve these results, OZG implemented a rigorous system, dubbed "Trees That Count", which runs in three phases. Firstly, the provinces, municipalities and villages are engaged. Then, land is gradually recuperated over a period of three years per village. Finally, these interventions are valorized through exploitation over 15 years.

Each year during the project, OZG organizes ecological and socio-economic monitoring of the progress, and shares the scientific results and objectives with the villages, resulting in remedial actions.

The operational model is based on a requirement for the villages to repay the investments on the basis of a valuation of their participation and the monitoring and qualification of the duties and services of the village partner at each stage. A positive score triggers the next stage in the intervention process.

OZG then continues to support and strengthen its village partners in their challenges in four areas of intervention:

- Communication and awareness
- Administration and security
- Science and knowledge
- Entrepreneurship and local economy.

Phase 1 — Engagement

Stage 1 — Introduction of the project to the authorities

The beginning of a collaboration in a region or province begins with a clear presentation of the project, given first at the regional and/or provincial level, with an explanation of the vision and expectations, and aiming to stimulate motivation and willingness among the local stakeholders to become involved in the project.

If local opinion is favourable it promotes discussion on the securing of investment, the agreement of guarantees in execution and recovery, the definition of a collaboration charter and the mechanisms for exclusivity on the land to be recovered.

In the case of municipalities, they are presented with the selection criteria along with a discussion on expectations and operational methods of the project, with explanations of the processes and the commitments of each of the parties. An understanding of the conditions under which the project will be managed is then formalised by signing a collaboration agreement.

Image: Daan Degroote

Tractor with Delfino plough demonstrating the Vallerani technique; a water retention system used in areas where yearly rainfall is between 200 and 400mm. The tractor makes small "half-moon" water collection ditches prior to the short rainy season from July to September. This automated agricultural method is also known as the Zaï or Tassa technique of digging pits in the soil during the pre-season to catch water and concentrate compost

Stage 2 — Preparatory studies
Before commencing land recovery, OZG undertakes two types of investigation, resulting in a list of intervention sites, each qualified and classified by its potential for successful regeneration.

Firstly, a mapping study is carried out using cartographic tools such as National Digital Topographic Database (NDTB) and Topographic Objects Database (BDOT). This is done only once but can be updated after ten years. The aim is to achieve good cartographic evidence of soil, land use, watercourses, protected areas, proximity to villages and access to fertile lands. The maps are then printed for use in the field.

Secondly, a baseline socio-economic study of the province, municipalities and villages is conducted to compile and analyse the skills and dispositions of potential villages. Socio-economic data collection tools are used such as survey forms, questionnaires, interviews, focus groups, tests, or any other means of obtaining as much information as possible about the various areas.

A report is then compiled for the communes and villages using information such as community organization, development plans, forest perception, local economy, challenges, local potentialities, expectations, land occupation, schooling, youth organization, and gender equality.

Stage 3 — Proposal and awareness of activities and commitments with the villages
OZG enters this stage having compiled a list of qualified villages with scores that are subject to entry requirements. Project aims and activities are presented in greater detail, along with the conditions of engagement between stakeholders.

Stage 4 — Identification of sites
GPS coordinated mapping tools are used to confirm the quality of the soils. This begins the process of collecting general data on intervention for a particular village. For each new village a volume of 250 ha must initially be identified, even if implementation will be gradual, extending over three years in three phases:

- Mechanical, over 125 ha
- Manual, over 62 ha, and executed by the villagers
- Mechanical, over 62 ha, and conditional on the qualification of the village for further intervention.

Stage 5 — Proof of commitment
A village indicates its interest and commitment through its capacity to build a stock of local quality seed ready to be used in the event that the project is given the go-ahead. OZG checks and confirms this commitment by quantifying the


Image: Daan Degroote

Counting trees and determining the species during the hot hibernation season


Image: Daan Degroote

Harvesting the water collected in the half-moons during a rain shower

volume of seed and identifying its species and then begins the payment and refund process.

Stage 6 — Formalization of commitment
Recovery work begins following a number of primary guarantees through which a partnership is formalised by:

- The qualification of the village through its score
- The signing of a final collaboration protocol, including recognition of the investment and the repayment obligation
- Development of joint preliminary intervention planning
- The establishment of a village management unit
- The development of recognizable symbols to act as internal marketing and as a reminder to each party of its personal commitment to the project and its duties. Symbols can take the form of, for instance, the "house" of the project; a table including an "investment counter"; teeshirts; signs on the sites; and plates at the entrance of the village.

Phase 2 — Recovery
This phase starts with the gathering of elements that attest to the willingness and powers of the village to engage in the project according to the mechanisms and rules that condition the partnership.

Stage 7 — Seed collection and logistics
Training sessions are organized on seed harvesting, storage, and conservation, with the aim of enabling a village to build up sufficient stocks to execute the project. The village receives a delivery of storage bags and uses the "Project House" as a store. Specific training is given by a forestry worker.

Each year, a village must collect local seeds that will be monitored and quantified, with the monetary equivalent of the effort capitalized as their participation in the repayment of investments. A basic standard price is agreed with the village and included in the protocol. The reimbursement system takes this price into account.

At the end of each year a village is graded and qualified according to its ability to collect seeds, the seed quality, and the management of the economic impact of the project.

Stage 8 — Ploughing
Most of this activity is entrusted to the implementing partners, accounting for 70 per cent of the budget of the "Trees That Count" programme. For each village, ploughing is carried out in three phases as follows:

1 — Mechanical, per implementing partner
A tractor and Delfino plough is used over 125 ha, with one tractor ploughing 15 ha per day. 1 ha has 260 half-moon water retention structures to harvest the rain.

OZG assigns a site inspector with the implementing partner to progressively control the installations and judge their qualities in terms of level, curves, slopes, number of half-moons per hectare, and the depth of the half-moons. The inspector ensures that the Vallerani ploughing technique is applied correctly.

As stipulated in the agreement with the implementing partner, a third party is responsible for evaluating the quality of the works and for making recommendations.

2 — Manual labour by the villagers
After the first intervention the site is evaluated for three years to validate the participation of the community, which must give proof of its commitment — a *sine qua non* condition for a second intervention. During these three years, the village organizes itself to carry out the renovation of an additional 62 ha, paid by OZG per half-moon. A person can make approximately five half-moons per day.

This participation in the ploughing is managed entirely through the gradual repayment of the initial investment, with the village receiving assistance to acquire the necessary hand-held equipment such as shovels, pickaxes, wheelbarrows and carts.

3 — Mechanical
In Year Four, OZG increases the mechanical tooling to match the level of manual labour over the preceding years.

Stage 9 — Sowing
After ploughing, the village organizes itself to sow the sites with harvested seeds plus the coated seeds from goat and sheep droppings. Goat droppings must be collected by the community to a set level of sufficiency.

The village cell organises this activity with the OZG team such that:

- 125 ha requires 15 working days

- The entire village participates in the sowing process (up to 250 people)
- The participation is valued in the progressive repayment system
- A lump sum is allocated to the village to support the sowing and equipment used.

The extent of sowing is subject to third party monitoring, and the results of this monitoring add or remove points from the village's score.

Stage 10 — Ecological and socio-economic monitoring/remediation
Scientific monitoring is carried out annually, with the results communicated in a transparent way through feedback, including analyses and recommendations for remediation. OZG organizes an annual ecological monitoring session in each village and works together with the university of Burkina Faso to check herbaceous cover, biodiversity, ground impact and hydraulic impact. The university of Ghent also works with OZG to measure the capture of CO_2 in the biomass. The period of execution is from September to November, and the annual report is validated by the OZG General Assembly of Burkina Faso that meets before the end of each calendar year.

A country coordinator is responsible for presenting, in detail, the monitoring results and proposed remediation actions to each village. A workshop is convened in which a schedule for implementing remediation actions is defined. It is then validated by OZG technical support.

Ecological monitoring is complemented by socio-economic monitoring, with a report also presented at the Annual General Meeting of Burkina Faso at the end of each year. Again, the monitoring of its intervention in each village is carried out by OZG, to include:

- Compliance with the commitment for participation in activities
- Economic impact and the increase in financial capacity contribution to schooling
- Improvements in living conditions, centring on the involvement of women.

Stage 11 — Monitoring after three years
After three years from the initial intervention, the monitoring results are used to classify and decide on the additional and final volume to be granted to each village, according to its score. A minimum of 450 trees per hectare must be reached, a target that triggers the next stage of the project and the possibility of adding surface.

If the village manages to increase the volume of trees on the site to exceed 450 trees per hectare, the surplus is capitalized as repayment of the investment.

Image: Daan Degroote

Women collecting grass seeds to use on degraded prepared land sited elsewhere

Phase 3 — Operation
After three years, and as a prelude to the fertility exploitation phase, OZG explores the possibilities of collaboration through further partnership. A partner acts as an implementing party with a commitment between itself, OZG and the local communities for the beneficial exploitation of the land. The partner should have solid experience in:

- Farming, either arable or livestock
- The organization, monitoring and management of farmers' collectives
- Microfinance and recovery
- Marketing and distribution of agricultural and livestock products.

The purpose of the partnership is to develop a programme of activities and marketing models that generate direct revenue on the basis of expanding:

- Community agriculture
- Community livestock farming
- Alternative models of income-generating activities to energize the local economy and create added value for the community, the partner, and OZG as the manager and representative of the investor.

At the end of 2017, management of the entire Burkina Faso project was transferred from OZG to a local organization, run by Burkinese, which continues to organize the reforestation of the Sahel and the North-Centre of Burkina Faso.

In 2018, OZG began deploying its concept in Senegal in adapted form.

Image: Daan Degroote

A woman weeding in her garden near the new agroforests in Bossey, North of Burkina Faso

Image: Daan Degroote

Counting young trees during the second year of interventions in the "Trees That Count" programme

The African Forest Landscape Restoration Initiative

Mamadou Moussa Diakhité, Team Leader, Principal Programme Officer, Sustainable Land and Water Management, New Partnership for Africa's Development (NEPAD)

Nearly two-thirds of Africa's land is degraded, resulting in millions facing hunger, malnutrition and poverty. To survive, they have to further deforest and overexploit the continent's natural resources. These actions not only intensify the effects of climate change, but also severely hinder economic development and threaten the ecological functions vital to all Sub-Saharan African (SSA) economies. Every year, nearly 3 million ha of forests are lost on the African continent, with 3 per cent of GDP lost annually from cropland soil and nutrient depletion.

Forest loss and land degradation are among the most critical of the many challenges facing SSA. Rural smallholder farmers and households suffer the most from degraded land, as their activities are largely dependent on stable weather patterns, healthy soils and tree cover, as well as on water. Framework conditions such as governance of natural resources and policy coherence do not often favour restoration at scale, and numerous barriers impede progress, including weak institutional coordination, inadequate devolution mechanisms for local resource users, and insufficient economic incentives for local and foreign investment in sustainable land management.

These issues have led to an increasing awareness of the potential for forest landscape restoration (FLR) to generate numerous benefits for the population, and support progress towards multiple national development goals such as food security, poverty reduction, land degradation and restoration, biodiversity conservation, and climate resilience. Within this context, dozens of national governments have made commitments to restore deforested and degraded lands as part of global and regional restoration initiatives, including the New York Declaration on Forests, the Bonn Challenge, Initiative 20x20, and the African Forest Landscape Restoration (AFR100) Initiative.

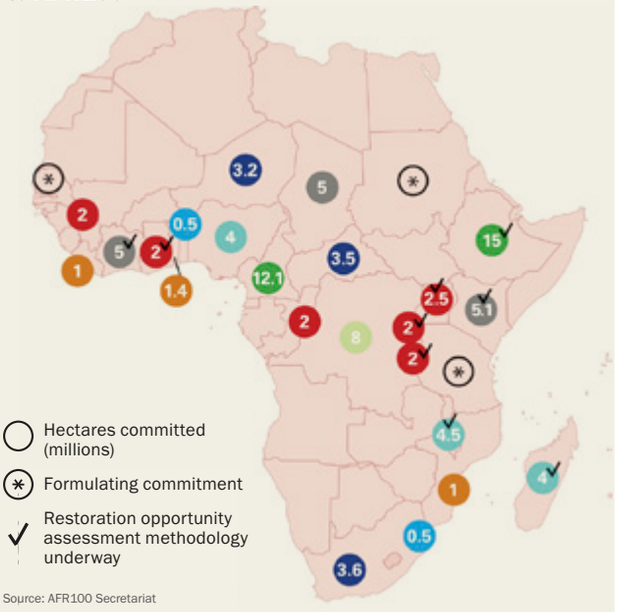
The Bonn Challenge targets the restoration of 150 million ha by 2020 and 350 million ha by 2030, which is supported by the AFR100 Initiative, a country-led effort to place 100 million ha of deforested and degraded landscapes under restoration across Africa by 2030.

There are numerous opportunities for African countries to scale up FLR by restoring both deforested lands and degraded agricultural and pastoral landscapes where tree cover has been depleted. Africa is unique in that it has the largest restoration opportunity of any continent in the world, with more than 700 million ha (1.7 billion acres) of degraded landscapes that can be restored. Experiences across various countries, including Ethiopia and Niger, have demonstrated that FLR delivers a wide range of benefits and can be achieved over millions of hectares.

Image: Andrea Borgarello and TerrAfrica Partnership

Village community in Chad discusses a local restoration project

Current status of African countries committed to AFR100



Source: AFR100 Secretariat

Image: Andrea Borgarello and TerrAfrica Partnership

Rebuilding a dry stone wall to restore landscape functionality in Ethiopia

Successful experiences with proven restoration practices such as Farmer Managed Natural Regeneration (FMNR), Assisted Natural Regeneration (ANR), improved management of smallholder woodlots, reforestation, evergreen agriculture with intercropped trees, and associated sustainable land management practices such as water harvesting and erosion control, have been documented, along with practical steps that can be supported to catalyze their adoption at scale.

Additional work is needed to take stock of the successful cases of FLR, as well as to expand communications, advocacy and outreach, and to support the implementation of comprehensive strategies and concrete plans to trigger the widespread adoption of forest landscape restoration practices. The AFR100 Initiative will accelerate restoration to enhance food security, increase climate change resilience and mitigation, conserve biodiversity, and combat drought, desertification and rural poverty.

The AFR100 Initiative comes in response to the African Union mandate to bring 100 million ha of degraded land into restoration by 2030, as expressed in the political declaration endorsed by the Africa Union in October 2015 for the creation of the umbrella Africa Resilient Landscapes Initiative (ARLI). The initiative complements the African Landscapes Action Plan (ALAP) and the African Union's broader Climate Change, Biodiversity and Land Degradation (LDBA) programme. AFR100 also directly contributes to the Sustainable Development Goals (SDGs) and the Paris climate agreement for climate change adaptation and mitigation.

FLR is seen as the long-term process of regaining ecological functionality and enhancing human well-being across deforested and degraded landscapes, and is implemented using a landscape approach, combining natural resource management, restoration opportunities and livelihood considerations across jurisdictional boundaries with the aim of restoring a mosaic of land uses, including those of forests and woodlands, pastures, croplands, and wetlands. The FLR approach is centred on stakeholder engagement together with the well-being of the inhabitants. FLR can restore ecosystem services and landscape functionality, boost and stabilize land use productivity and enhance resilience to climate change through both the restoration of forests and tree cover outside of forests.

AFR100 recognizes the benefits that forests and trees can provide in restored and resilient African landscapes, which include improved soil fertility, enhanced agricultural productivity and food security, greater availability and improved quality of water resources, the combating of desertification and drought, increased biodiversity, green jobs, economic growth, and increased climate change mitigation, adaptation and resilience.

Landscape restoration, when supported by national policies, has been shown to be achievable in many African countries. Key indicators have been identified to monitor progress and desired impacts, and provision is made for adaptive management for successful implementation. Restoration can be misconceived as being either too lengthy a process or as requiring the removal of land from production. However,

this is not the case as, for example, when FLR is implemented across a watershed in collaboration with farmers and industry, restoration, increased productivity, and cleaner water can be achieved within a few years.

It is important to note that there is no "one-size-fits-all" approach to monitoring. A monitoring system must be tailored to suit the unique needs and circumstances of each country and situation. Some monitoring systems are based on commitments made at national level, where others are more focused on the scale of the landscape. Many countries have experience with monitoring and are already restoring lands.

The measuring and monitoring of deforestation has continued for years as part of REDD+ and other initiatives. Although many of the same techniques used in monitoring deforestation can be used for monitoring restoration — including satellite remote sensing, inventories, national statistics, and community-based surveys — there are important differences that need to be taken into consideration to ensure that monitoring of restoration is efficient and useful.

As AFR100 nears its goal, strategic and streamlined implementation is required. The AFR100 member countries and partners will continue to collaborate, learning and restoring as they proceed. To date, the initiative consists of 26 countries with 21 technical and financial partners that are committed to restoring 85 million ha of degraded and deforested landscapes.

Restoration comprises a multitude of actions, with various goals across very different landscapes. Many choices and priorities occur when making land use decisions, with the monitoring system being based on similar choices. A variety of stakeholders need to be engaged to select the best indicators and align them with existing tools. In the context of AFR100, countries should look to devise partnerships that fit with their national restoration strategies as well as broader development plans, ultimately supporting the goal of achieving the restoration of 100 million ha of African land by 2030.

Image: Andrea Borgarello and TerrAfrica Partnership

Above and below: landscape and restoration projects in Chad

Image: Andrea Borgarello and TerrAfrica Partnership

The Khawa community-led ecotourism project — demonstrating an ecosystem approach to land and water resources management

Neil Fitt, Chief Executive Officer, Kalahari Conservation Society (KCS)

Botswana is home to globally important populations of many vulnerable species of fauna and flora that live within the vast and unique wildernesses of the Kalahari Desert and the Okavango Delta. Botswana has also been identified as a country that is likely to suffer the consequences of climate change more severely, on average, than other countries. Approximately two-thirds of the country's surface consists of sandy, infertile soils, most of it of the arenosols soil type, with a low moisture retention capacity. In areas of low rainfall the prevailing conditions have led to the formation of sand dunes.

Due to this semi-arid setting the productivity and sustainability of food systems are low, whereas there is increasing demand for food and land as the population grows. Reports indicate that the situation is worsened by both the country's dependence on conventional agriculture practices that promote overstocking, and the lack of prudent livestock management systems. Hence there is overgrazing of range land areas; bush encroachment in many areas; a loss of soil and nutrients into rivers passing out of the ecosystem; and a consequent decrease in the overall productivity of the habitat.

The development of Botswana's National Action Plan (NAP) for the Orange Senqu river basin was supported by the Global Environment Facility and United Nations Development Programme, and implemented, in 2013, by the United Nations Office for Programmes.

The Kalahari Conservation Society (KCS) collaborated with the International Union for Conservation of Nature (IUCN) to undertake a transboundary project — A Water Secure Future for Southern Africa: Applying the Ecosystem Approach in the Orange Senqu Basin — funded by the United States Agency for International Development (USAID). This was a regional project, with local implementation partners at country level, developed as a holistic approach to supporting implementation of the respective country NAPs for the basin — Botswana, Lesotho, Namibia and South Africa. The Botswana NAP had identified four key thematic areas: increasing water demand; declining water resources quality; land degradation and sustainable land-use practices for the improvement of livelihoods; and suggested interventions.

There were several efforts to pilot interventions as identified by the NAP in Botswana. Among these were: sand dune stabilisation in Boravast and Khawa; mapping of degraded areas for rehabilitation; installation of rainwater harvesting systems in households; management of the invasive alien species, specifically the *Prosopis* in the Boravast areas; assessments to improve rangeland management and land use plans; and exploration of alternative livelihoods and activities for communities.

Also, in the village of Khawa in the Kgalagadi District of Botswana, the KCS was responsible for piloting an ecosystem approach to integrated water resources management through community-led ecotourism. The area is characterized by low and erratic rainfall, coupled with poor soils. There is therefore no surface water, and only limited groundwater for livestock watering and domestic purposes. The economic status of the Khawa community is very low, and the community relies on natural and range-based resources for sustenance; an important source of livelihood being small stock in the form of goats and sheep. Although the village historically relied on wildlife, the progressive evolution of wildlife legislation has reduced the availability of game meat to the community. In addition to these hardships, the water obtained from boreholes is often saline and needs treatment. Also, the proximity of the village to the Kgalagardi Transfrontier Park (KTP) now represents a threat as predators such as lions are able to leave the park and kill livestock. However, with help from the KTP, an opportunity for Khawa village has been opened through tourism, reducing the reliance on livestock and therefore demand on water in the area.

Over the past four years, the Botswana Tourism Organisation has invested in promoting non-wildlife tourism in Khawa village, based primarily on the spectacular sand dunes and the scenery in general. The annual Khawa Dune Challenge and Cultural Festival, that includes a motor sport event, takes place during the early months of the winter, usually May, and lasts for three days. The event attracts over 5,000 people annually, creating a boost to the area's economy.

This pilot project commenced in 2014 with the intention of finding solutions to the following environmental issues:

- Overstocking and overgrazing, resulting in the decline of pasture and overall biodiversity in the study area
- Land degradation caused by overstocking, as inhabitants gained goats, feed, and veterinary services through government subsidy programmes, with limited consideration of the ecology and economics of livestock farming in the arid environment.

Image: Kalahari Conservation Society

Sand dunes in the region of Khawa village have become the site of the annual Khawa Dune Challenge and Cultural Festival, helping to promote non-wildlife tourism in the area

- Unique landscape attractions such as the Khawa Dune Challenge, marketed within a tourism diversification drive.

The project was structured around two objectives and activities:
- To demonstrate enhanced social and ecological resilience in Khawa through ecotourism
- To improve knowledge, awareness and guidance of and on the ecosystem approach in Khawa, thereby improving biodiversity conservation.

The pilot demonstration project began with establishing a management centre and gatehouse constructed to facilitate controlled access into the fragile ecosystem of the 62 ha campsite that has been allocated to the Khawa Kopanelo Development Trust and is structured around the Community Based Natural Resource Management (CBNRM) policy.

The project not only facilitates the management of the area, but aims to develop the tourism potential of this underdeveloped part of Botswana. It was important that the project adopted ecosystems approach principles to underpin its credibility. Below is a summary of how the project was implemented against each principle.

Objectives of ecosystem management as a matter of societal choice

During its inception, the project invested much effort in sensitising the stakeholders and building ownership. Following the participatory approach that was deployed during the development of the NAP, the pilot project team conducted consultative workshops and smaller meetings to educate stakeholders in the linkage between the NAP and the pilot projects. An ecosystem approach was defined at the meetings so that it was fully understood by all stakeholders. The project site was chosen on the basis of majority stakeholder opinion at a consultative workshop, and the process was assisted through the evaluation of a SWOT analysis for all potential sites. Government officials, civil society organisations and Kgalagadi community leadership were given full opportunity to participate and take part in the decision on project scope and activities. Additionally, communities at the chosen site — Khawa village — were given the opportunity to suggest and select the project activities they felt should be undertaken.

Decentralizing management to the lowest appropriate level

The project coordinator employed to oversee implementation was recruited locally and had worked on a similar project in the area before. He had a good understanding with the local communities and was based at the project site under direct supervision of two trust board members appointed to directly monitor and act as a backstop for the project work plan. The project was implemented as a CBNRM initiative.

The Botswana CBNRM policy states that all activities undertaken at community level should be directly supervised by the office of the District Commissioner, who is responsible for development in the district. Therefore, the District Development Committee acting under the District Commissioner's Office, was given full responsibility to implement the project.

Image: Kalahari Conservation Society

Khawa village management centre and gatehouse constructed to facilitate controlled access into the fragile ecosystem of the 62 ha campsite

Considering the effects, actual or potential, on and of adjacent and other ecosystems

Land degradation is probably an underlying problem for all other thematic areas identified by the Botswana NAP for the Orange Senqu river basin. Considering the soils and land characteristics found in the project area and the common community livelihoods' activities, the project realised that, unless something was to change, land degradation would progressively worsen and could lead to the collapse of the ecosystem. The project, through consultations and back and forth negotiations, led to a consensus to identify and demonstrate an alternative livelihood activity that would safeguard the future of the area and support its rehabilitation and recovery.

Following the identification of the opportunity to align with a community-led ecotourism project, through the annual Khawa Dune Challenge and Cultural Festival, it was understood that ecotourism, unlike conventional livelihood activities such as agriculture, can take several years to become sustainable and therefore might require up-front capital investment. The 62 ha plot allocated to the community was therefore zoned to allow multipurpose use. The Khawa event, being very large and quite well established, had a significant influence on activities, but the zoning was not limited to this. It was observed that, due to the proximity of the site to the Kalagadi Transformer Park, there were opportunities for several other types of activity throughout the year, and not just for a short period.

Various activity proposals have been evaluated with some already having been implemented and others still being considered, including a filling station and shops that will not only benefit tourists, but also the local communities. It is hoped that the wider community will appreciate the potential of ecotourism in the area and will also look to see how they can diversify rather than being fully reliant on agriculture. This will greatly benefit the soils and allow the land to recover and assist in the stabilisation of the water quality and availability.

Understanding and managing ecosystems in an economic context

The construction of the management centre and gatehouse, has assisted the Trust in managing the human-induced land degradation taking place at times other than during events. The developing of the facility will enable the Trust to collect camping fees from tourists, as opposed to the past when tourists camped in the area without being controlled. The facility is also open all year round, with the camping fees benefiting the community economically.

The Trust employs full time staff to operate the gatehouse, thus earning a living directly from the project. Some local community members have also been employed on a temporary basis during the construction of the gatehouse, not only gaining from direct employment, but also developing their skills for the future.

Conserving ecosystem structures and functions to maintain ecosystem services

The project legacy is the leased 62 ha plot for use as a campsite, and this will assist in controlling the campers within a confined area, thereby reducing impact on other parts of the ecosystem structure.

Managing ecosystems within the limits of their function on a spatial and temporal scale

As ecotourism becomes better established and understood in the area, there will be more opportunity for the community of Khawa to establish cooperatives within the area where community members will be able to sell their small stock. With this model, community members will also be able to viably reduce their livestock numbers, which will address the overstocking within this fragile ecosystem. The project has confined those activities that could be detrimental to the environment to a controlled area. This allows for management and control on sustainable grounds, activities that directly benefit the local communities.

Setting management objectives for the long term

The Trust has set itself the objective of managing the area in a sustainable way, working hand in hand with all community members and other stakeholders.

Considering all forms of relevant information, including the traditional

Information on the tourism potential of the area was used to reach a consensus on the project, with which it was decided to allow space to build a curio shop where traditional crafts will be sold, thus enhancing local knowledge systems of traditions. Firewood is also sustainably collected and sold at the entrance, eliminating the uncontrolled gathering of firewood by tourists, which would otherwise not be done in a sustainable way.

Involving relevant sectors of society and scientific disciplines

During project inception, the relevant stakeholders such as the community, Trust board members, the local Technical Advisory Committee, and national stakeholders including scientific researchers, were consulted and involved. These and other stakeholders are free to visit the project at any time

and inform the project team of any problem issues that have been observed during the visit.

Key achievements and successes

The project's key achievements and successes include, but are not limited to:

- Management centre, entrance gate and curio shop constructed for tourism within Khawa village
- Baseline survey conducted to assess the status of sanitation in the village, subsequently establishing that it is generally well maintained
- The Project assisted the Khawa Kopanelo Development Trust to acquire a 62 ha plot, being used as a camp site to extract revenue from tourist activities in and around the village. With the plot allocated to the Trust, it has the capacity to negotiate with any potential partner for possible collaboration on future developments for the benefit of the community
- The project demonstrated the implementation of the CBNRM principles of community engagement in natural resources management. This reinforces the principle of devolution of power to the community such that it is able to manage the project though the allocated area in an environmentally sound manner
- The Trust and Village Development Committee members, including 13 females and 15 males, have been trained on financial management, governance and environmental conservation.

Key lessons learned

The project team and the KCS have learned much from this exercise, of which some of the key lessons are that:

- Stakeholder engagement during planning, and ensuring constant updates during implementation are essential. If properly informed and engaged, stakeholders will assist even when encountering challenges. The Technical Advisory Committee played an instrumental role to ensure that land was acquired for the Trust before they lost USAID/IUCN funding. Consistent updating of the Tribal Authority was also helpful as it supported and lobbied government officials that visited the village, with the need for land to be allocated
- A community project must be driven by the community. It needs to establish a formal body that can lead the process from its own point of view, like a Trust
- Where land is needed for a community project, it is essential to first establish the legal documents of land ownership, otherwise delays will occur if no such documents are available from the land authority.

Summary

This project demonstrated the success of CBNRM principles of community engagement in natural resources management. It has also demonstrated that the activities that contribute to land degradation and water pollution can be managed in partnership with local communities. Projects of this nature are not the sole responsibility of government departments.

Image: Kalahari Conservation Society

Meeting between the Kalahari Conservation Society and local stakeholders to discuss the ecotourism possibilities around Khawa village

A stepping stone towards sustainable financing in Africa through the experience of Groupe Crédit Agricole du Maroc

Hind Sourat, Cooperation and Partnerships Coordinator; Mariem Dkhil, Head of Cooperation and Sustainable Development; Mustapha Chehhar, Head of Agricultural Financing, Groupe Crédit Agricole du Maroc

Soil degradation is undoubtedly the dominant issue to face the world over the coming decade. Land is deteriorating severely, with fertile soil being lost at a rate of 24 billion tonnes per year.[1] Africa, consisting largely of desert or semi-arid land, is one of the areas most affected by soil degradation. This is certainly true of Morocco where, for more than half a century, Groupe Crédit Agricole du Maroc (GCAM) has developed expertise in financing agriculture.

GCAM is a profit-driven institution endowed with a public service mission to finance agriculture and activities regarding the economic and social development of the rural sector. Its approach is based on a balanced portfolio between agricultural and other economic activities. These dual objectives are symbiotic. That is, the bank's commercial activities offset costs from the bank's commitment to providing low-rate agricultural loans, taking into consideration that agriculture represents more than 50 per cent of the bank's overall portfolio. The GCAM model is proven, having evolved through innovation to provide Moroccan agriculture with financing solutions that are sustainable from economic, social and environmental points of view.

Groupe Crédit Agricole du Maroc

Created in 1961 as a specialized finance institution in agriculture, Groupe Crédit Agricole du Maroc (GCAM) underwent a structural transformation in 2003, becoming a commercial bank with a public service mission for the promotion of the agricultural sector. As such, it is the financial partner of the national agricultural strategy "Plan Maroc Vert".

Today, GCAM is the fourth bank in Morocco, with over 833 branches and 4,000 employees. It serves 2 million clients with a total credit portfolio of US$ 7.8 billion and total deposits of US$ 8.2 billion.

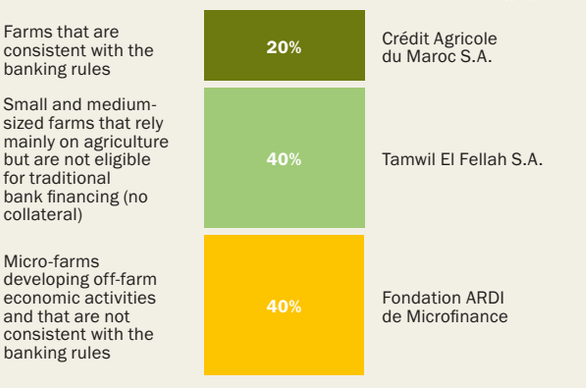
Through its inclusive model, GCAM has managed to serve hundreds of thousands of small farmers, channeling large amounts of capital, including international funding, to priority areas. The Group has thus developed a real expertise in the conversion of great amounts of money from donors into aid for great numbers of beneficiary farmers, helping them adopt practices that enhance soil fertility and combat land degradation.

Given the exposure and sensitivity of agro-ecosystems in Morocco to climate change, and the importance of agriculture for the well-being of the population, it is estimated that the anticipated impacts of change threaten the bases of development in each region. Adaptation to soil degradation is an activity closely linked to the reduction of the vulnerability of communities, regions or activities. Therefore, as a financial institution, GCAM adapts to current and future challenges by providing local communities with the appropriate financial products that will allow them to mitigate the risks of soil degradation.

There are various types of adaptation in GCAM that can be promoted through financial products and services for all types of clients, especially local communities. However, this requires training, technical assistance, dissemination of knowledge and a variety of adapted and sustainable products focusing on the needs of the clients. GCAM therefore offers strategic partnerships that promote sustainable adaptation processes and establish alliances to strengthen the sector.

GCAM serves both the agricultural sector financing and inclusive financing through a specific organizational setup of dedicated channels. In order to get closer to the real and

Moroccan farms typology — 1.5 million units



Thanks to its organization where each farmer can access credit through a specific channel, GCAM ensures that all viable projects are funded, enabling long-term, sustainable growth for agricultural entrepreneurs

Image: Groupe Crédit Agricole du Maroc

Investors' Forum organized by GCAM during the International dates fair of Erfoud

variable needs of the entire agricultural and rural population, the GCAM financing system has been refined and categorized into three subsystems resulting from a segmentation of Moroccan farms into three groups:

- Firstly, farms that are consistent with the prudential banking rules (Basel 3). They represent 20 per cent of Moroccan farms and are financed by the Group's parent bank, Crédit Agricole du Maroc (CAM). Standard bank financing is marketed thanks to a specialized distribution network, whose strength lies in the proximity and quality of the human resources, including confirmed agricultural and agri-food expertise.
- Secondly, micro-farms that are excluded from the traditional banking system (40 per cent of Moroccan farms). They are financed by another subsidiary of the Group, ARDI, a microcredit foundation especially active in rural areas. Created in 2006 by GCAM, the ARDI Foundation is a non-profit association, and results from the Group's willingness to fight against poverty and exclusion in the rural area.
- Thirdly, small and medium size farmers (40 per cent of Moroccan farms) that do not respond to a traditional default banking method with real collateral and whose needs are not covered by microcredit. For these, GCAM has created a dedicated subsidiary, Tamwil El Fellah (TEF), an innovative agricultural finance model for smallholder families with specific prudential rules negotiated with the Moroccan Central Bank. Developed by GCAM in cooperation with the Ministries of Agriculture and Finance, TEF aims at promoting inclusive rural and agricultural development through the provision of short and long term loans to farmers that have no collateral. Backed by a prudential stabilization fund, it allows financing to be opened up to this large group of agricultural producers and fills the 'missing middle' finance gap in agriculture. Tamwil El Fellah is considered by several international organizations and donors to be a unique model and the subject of inspiration for other development countries, especially in Africa where 80 per cent of farmers belong to the 'missing middle' category.

The entire system enables each farmer to access credit through a specific channel, with GCAM ensuring that all viable projects are funded, giving agricultural entrepreneurs long-term, sustainable growth.

Additionally, through its research and development programme, GCAM is able to anticipate the needs of all key agricultural value chains, from seeds to harvest to market, so as to support clients in expanding their businesses. Some are targeted to finance sustainable projects such as date palm plantation (see following page) or localized irrigation systems in a country where effective and efficient irrigation system management is crucial.

The rationale behind GCAM financing is that each offer has to be adapted to the specific needs of the farmer in terms of:

- Amount — under- or over-financing should be avoided. To this end, GCAM relies on financing standards that estimate the production costs for more than 112 crops, or for animal farming, at various levels of intensity — rain fed versus irrigated for crop production; intensive versus extensive for animal production.
- Payment plan — a farmer cannot pay before his produce is ready. Therefore, a payment schedule is agreed based on the harvest frequency or production dates.
- Reimbursement capacity — the farmer's activity should generate a benefit that covers the instalment amount as well as living expenses. GCAM uses an agricultural scoring system that calculates the farm's margin, compares it to the instalment amount and, together with other criteria such as client history or availability of water on the farm, gives a risk rate for the client, with a subsequent loan possibility.

With this comprehensive approach, sustainable financing is provided to farmers with limited risk for the bank.

Case Study — Financing the restoration of the Moroccan oasis through the value chain approach

The Moroccan oasis agro-ecosystem covers more than 50,000 ha, or approximately 15 per cent of the country. Due to its important biodiversity, the oasis ecosystem provides important economic and environmental services. In many oases, date palms form the upper layer, protecting fruit trees and arable crops from excessive insolation, and contributing to the formation of a mild microclimate. However, Morocco has lost more than two-thirds of its palm trees over the last century because of successive seasons of drought and the onset of bayoud disease (*fusarium oxysporum*).

To mitigate these conditions, the Moroccan Ministry of Agriculture initiated, in 2017, a programme to promote the planting of palm trees in the oases of the Souss-Massa, Drâa-Tafilalet, Oriental, and Guelmim-Oued Noun regions. As part of the programme, GCAM has designed a new loan product specifically to finance palm planting over a period of 15 years, with a six-year grace period, corresponding to the first date harvests. The loan includes the maintenance costs of the young plantations as well as the operational costs for intercropping. The programme was tailored to encourage smallholder farmers to adopt an agroforestry system where date palms are grown together with other crops such as cereals, alfalfa or melon. The loans are distributed through both CAM (traditional banking) and Tamwil El Fellah (meso-finance) in order to benefit all farmers, whatever their size or risk profile.

In addition, GCAM finances the date farming cooperatives and storage and valorization units, thus increasing the product's added value and therefore the farmers' revenues. GCAM grants short-term loans as advance on goods for dates, a cash facility to cover employees' salaries, and investment loans for transportation, mechanization or harvesting equipment.

This comprehensive value chain financing serves several objectives. Firstly, it addresses the issue of access to market for smallholder farmers — indeed, poor access to financing leads many farmers to borrow from intermediaries who provide seasonal input credit but dictate the farm gate prices. Secondly, it improves the farmers' organization, as the cooperatives have a higher bargaining power on the market which ensures lower input costs and higher prices for the produce. Thirdly, value chain financing is a risk mitigation approach as it gives the bank an overview of the financial flows between the various stakeholders, and generates more value for the date producers who, in turn, are able to pay back their loans.

Besides its high social and economic impact, the project actively contributes to land restoration in the pre-Saharan area, as well as to the preservation of sustainable oases that act as ramparts against desertification.

Enabling stability into the future through LDN projects

Importantly, as land degradation neutrality requires the mobilization of large financial resources, and as 95 per cent of African farmers cannot access the financing they need to grow their business and adopt new sustainable practices, GCAM cooperates with African financial partners by sharing knowledge and expertise on inclusive agricultural financing in order to help the integration of smallholder farmers into the financial sector.

Image: Groupe Crédit Agricole du Maroc

Young date palms with drip irrigation — a project financed by GCAM in Boudnib, Drâa-Tafilalet region

In addition, GCAM, through its partnership with Mirova (a subsidiary of the French company Natixis), enables sustainable land management projects involving small and medium-sized farmers to access the Land Degradation Neutrality Fund. GCAM thus helps its partners in sourcing and structuring projects that can demonstrate various benefits such as land rehabilitation, social impact on local communities, and financial returns.

As most of the restoration or rehabilitation initiatives involve a high degree of innovation, there is significant risk of failure. For small scale farmers, this may lead to a dramatic loss or even starvation for their families. By applying its skills and agricultural value chain approach in Morocco, and elsewhere in Africa, GCAM ensures that farmers are given the financial support they need to take that risk and engage in new cropping methods or practices while minimizing the risk of failure.

In summary, Groupe Crédit Agricole du Maroc offers a key selling proposition in financing risky but profitable projects, consequently enabling those with ecological benefits to boost their return on investment in a sustainable way. Moreover, GCAM has developed an organizational model, together with risk mitigation tools and appropriate products, to boost both financial inclusion and smart-agriculture financing. This business model allows small and medium-sized farms access to adequate financing to implement the fundamentals of good soil management.

Are the outcomes that are vital for the survival of mankind achievable in an era of global warming?

Gabriel Haros, Corresponding Author, Managing Director and Founder of PundaZoie Company Pty Ltd.; John Leake, Director, The Institute for International Development Ltd. and NyPa Australia Ltd. and Associate Professor, University of Adelaide

According to the United Nations, unless soil decline is addressed the world has less than 60 growing seasons left.[1] Additionally, it is estimated that the global population will reach almost 10 billion by 2050.[2] Given this perfect storm, the United Nations Decade for Deserts (2010–2020) and the fight against desertification[3] is especially relevant as more and more land around the world faces increasing deterioration and degradation.

The intensive nature of agriculture in today's world has degraded the vegetative cover and biodiversity of vast areas of the Earth's surface. This, coupled with soil surface temperature rises, is resulting in a major reduction of above- and below-ground carbon, and therefore soil biological resources, leading to erosion together with chemical, nutrient and pesticide run-off into river systems, estuaries and oceans.

These and other natural factors have damaged the capacity of the land and oceans to absorb (excess) carbon dioxide (CO_2) via the natural process of photosynthesis, reducing agricultural productivity. This is accompanied by increased salination, soil erosion, desertification and, in some important marginal irrigation areas, the production of huge amounts of saline water, depressing the effect of usually productive plants.

Micro-climates are increasingly unable to perform the function of keeping farmers' fields moist, cool and healthy, resulting in diminishing food quality, and giving rise to new evidence of rising public physical and emotional health issues and costs.[4] Prof. Robin Batterham, former Chief Scientist for Australia (1999–2006), states that current intensive land practices are not sustainable and will lead to losses in farmland productivity and profitability. He says a move towards regenerative farming can stem this undesirable trend without any long-term loss in farming outcomes, issuing instead an increase in productivity, profitability and sustainability.[5]

Does the world have sufficient land to grow food to feed 10 billion people?

From 2005 to 2050 the food requirement for rising populations is estimated to increase by between 70 and 110 per cent[6] as income from emerging middle classes drives a demand for farm-based produce, such as grains and meat for largely urban populations which already exceed 50 per cent of the total, and are expected to exceed 75 per cent by 2050.[7]

However, the area of land considered even marginally suitable for agriculture is predicted to rise from only 33.2 million km^2 today to just 34.1 million km^2 by the end of this century.[8] As some 50 per cent of grain production today is fed to livestock, substituting some of this grain by new livestock feeds grown in degraded areas is commonly suggested as a practical solution, utilizing proven techniques that also reverse soil degradation and allow for climate variability.[9]

Much of this degraded land exists in mixed farming zones fringing the deserts on each continent. These areas are mostly inhabited by poor, often marginalized people, who would be able to participate in this solution if they could be shown how their livelihoods might be improved as a result of their efforts in these farming proposals.[10]

The question: "Will the world have sufficient capacity to feed 10 billion people by 2050?" should be rephrased as: "Does the world have the necessary land resources to meet its future requirements for food?" A further question would be: "How can we equip the people who live in these degraded areas to become part of a solution that benefits all?"

Turning straw into gold: a new paradigm of regenerative agriculture

There is a solution to these questions but it requires international collaboration, global and local partnerships, widespread education and ways to involve the people who live in degraded areas to participate every step of the way.

Image: PZC

Greening the Earth trials in Australia demonstrating the development of a saltbush plantation grown in hedgerows suitable for the dual purpose of harvesting and livestock cell grazing between the rows

Most importantly, a solution requires the ability to foresee and appreciate events over the long term, and the development and maintenance of a narrative for change that can inspire the range of stakeholders required for the period of time needed to achieve sustained, beneficial change. This change requires local leaders to be mobilized in each area, the action of key opinion and policymakers and leaders at both national and international levels, and appropriate partnerships across many levels.[11]

The solution would deliver a range of profitable and socially beneficial outcomes that address economic, environmental and agricultural concerns, and public health and social and emotional issues, to increase many fold the scale of land area available for productive agriculture while addressing land degradation. This solution is regenerative agriculture[12] which is a production system that will long outlast the investment phase.

Carbon sinks and organic carbon

A characteristic of most degraded soils is a loss of organic matter and a changed soil structure, often associated with heightened salinity of different types and reduced hydraulic conductivity (drainage). Such soils have potential as carbon sinks[13] whereby increased photosynthesis — possible with plants more adapted to such soils — transfers new carbon to soil as soil organic carbon (SOC) in the form of roots and soil flora and fauna that can become fixed with decomposition into more recalcitrant carbon materials that will last indefinitely.[14]

This activity gradually addresses structural and biological problems within soil, leading to improved drainage and productivity. Some plants that can do this also provide grazing as well as material for feed pellets and various valuable by-products.[15] It follows that the Earth's soils act not only as major storage systems for CO_2[16] but, in doing so,[17] can deliver the greatest opportunity for increasing productive land mass to address food security.

The solution becomes one of finding the means for the desert and under-productive marginal agricultural landscapes to be rehabilitated for the productive cultivation of food, thus addressing global food security while simultaneously creating the biggest and most efficient land-based carbon sink in the world for the capture of CO_2 to combat climate change.

An Australian solution

The land remediation/carbon credit initiative of the PundaZoie Company (PZC) and its Greening the Earth (GTE) programme commenced in Tasmania in 1989. The word PundaZoie, from Greek, means "always living."

The company began researching, trialling and developing agricultural species and systems to address the global issues of SOC as a solution for climate change and diminishing food security by engaging in a university research partnership in Tasmania (UTas) and conducting field trials in southern Europe, the UAE and across a number of states of Australia.

PZC has been researching the possibility of integrating drought and saline resistant species, including saltbush, into rotational grazing, harvesting, food processing and milling techniques, as well as the creation of bio-energy and flavonoids from halophytes to be used as anti-oxidants for the wellness and pharmaceutical industries. The company has also collaborated with the Institute for International Development (IID) in examining other halophyte plants important for inclusion in various degraded land areas in Australia and internationally. IID has also developed the capacity to engage remote communities under a wide range of biophysical and cultural circumstances in development activities.

Regenerative farming and carbon drawdown

Regenerative farming creates SOC whereby the soil's carbon content is increased using photosynthesis (a natural CO_2 pump), drawing down carbon dioxide from the atmosphere and converting it into carbon in the soil at the proportion of 3.75:1. The capture of 3.75 tonnes of atmospheric CO_2 thus converts to one tonne of SOC. This process not only revives and remediates marginal and depleted landscapes for agricultural use, but the resultant SOC can be measured and applied as accredited Australian Carbon Credit Units (ACCUs) for sale to Australia's Clean Energy Regulator (CER) by way of the reverse bidding mechanism of the Carbon Farming Initiative's (CFI) Emissions Reduction Fund (ERF).

Acceptance by CER and United Nations of the methodologies for SOC

In 2017 the CER accepted PZC's GTE regenerative farming carbon capture methodology using SOC whereby PZC

Image: PZC

Greening the Earth plantations trialled at Gayathi in western Abu Dhabi on land owned by the UAE Environmental Agency to test maximum moisture capabilities necessary for positive plant establishment purposes. Saltbush and local companionship species were successfully grown from encased seed pellets and irrigated using saline groundwater for five minutes overnight

Image: PZC

Prime Minister of Australia, Hon. Malcolm Turnbull MP, and Scotdesco CEO, Robert Larking, discuss the progress of the Scotdesco project, October 2017

Image: PZC

PZC's invitro tissue culture consultant and expert Dr. Jitendra Prakash of Invitro International, Bangalore, India, teaches Scotdesco community members the benefits of in vitro tissue culture propagation techniques

aims to create around 20 tonnes of CO_2 equivalent per ha per annum[18] through the use of integrated saltbush planting, rotational grazing, and the harvesting and milling of high protein powder for both human consumption and the production of livestock feed pellets.

Saltbush, one of the many halophytes that grow wild in diverse parts of Australia that are suitable as a C4 species for the capture of SOC, was not only accepted by the CER for this purpose but has been identified by the United Nations Carbon Emission Trading Scheme as a species that assists the fight against global greenhouse warming by the sequestration of atmospheric carbon back into the soil.

The United Nations estimates that the Australian native, *old man saltbush*, once it has reached three years of age, converts approximately 15–20 tonnes of carbon per ha annually.

Different plants are important to various parts of the landscape and for differing climatic conditions and soil types. For example, *Distichlis spicata* Var. Yensen 4a PbR (NyPa Forage™) is adapted for waterlogged saline lands to enhance both the grazing and harvesting values of saltbush while restoring soils and fixing carbon in a similar way.[20]

Reversing the impact of climate change

It is predicted that sequestering new SOC on a year-to-year basis and on a sufficient scale will not only halt the continuing effects of climate change but can put the concentration of atmospheric greenhouse gases into decline.[21]

The financial returns

The benefit of GTE is that it turns the obligation of emissions reduction from that of being a cost to one of creating profits.

Financial modelling conducted by PZC is based on establishing field plantations of 10,000 ha sites for both cropping and grazing, each with its own in vitro tissue culture propagation nursery and feedstock processing plant. Appropriate sites are secured by way of partnership, lease and/or purchase. These can be adapted for smallholder and patchy situations that exist in many degraded areas associated with ongoing food production.

The cost, calculated for each plantation area of 10,000 ha, inclusive of the cost for providing an in vitro tissue culture propagation nursery and processing plant, is approximately AU$ 39 million (once only). The pre-tax profit generated from the activities described above for the life of the project, which is estimated to be a minimum period of 60 years, is approximately AU$ 21 million (annually).

The financial modelling outcomes are impacted in a positive manner in cases where GTE plantations are conducted over much larger areas due to savings afforded by economies of scale caused by centralizing assets.

Profit is also derived from the broad base of flow-on effects and the beneficial consequences derived from the plethora of downstream jobs and business opportunities that arise in addition to a range of social, emotional and environmental benefits of GTE. This is especially relevant for rural and indigenous communities where employment opportunities are scarce and the consequential reliance on government welfare systems is intense.

Increased farmland productivity and land values

GTE plantations not only capture carbon dioxide in the soil to reduce greenhouse gas emissions, they can also increase the carrying capacity of farmland by as much as twenty-fold; reduce the mortality rate of newborn lambs as the plants offer shelter from cold winds and adverse climatic conditions; improve productivity in terms of yield and quality; increase land values and consequentially encourage a return to the land.[22, 23]

Both the direct and indirect benefits of maintaining healthy soil systems are highly visible and measurable in terms of positive economic, environmental, social and food security outcomes[24] whereby regenerative farming practices,[25] thus restoring the carbon content of the soil, result in preserving the natural capital of the land; biological diversity; increased farmland productivity and improved land values. This is in contrast to common land practices in conventional agriculture.[26]

Social and humanitarian outcomes

The many compelling public health and social welfare reasons for change in these landscapes have made it possible to attract prominent spokespersons at national and international levels to develop and maintain the narrative for change. This is reflected in a high level, forward-thinking report by Australia's national advocate for soil health, Major General Michael Jeffery, a former governor general of Australia, who has made 10 strategic recommendations on how to preserve farming practices sustainably and profitably. Major General Jeffery is an enthusiastic supporter of global collaboration.

The Scotdesco experience — turning words into action

In the tiny Aboriginal township of Bookabie on the edge of Australia's Nullarbor Plain, the members of the Scotdesco Aboriginal community are demonstrating their vision as a solution for the rest of the world. Australia is the driest inhabited continent in the world with 70 per cent of its land either arid or semi-arid, receiving 250mm to 350mm of rainfall a year, or less. Approximately 81 per cent of Australia is broadly defined as rangelands, known to most Australians as 'the outback' which is the natural home to many of Australia's indigenous peoples and culturally very important for most Australians.

Theory becomes practice —
Scotdesco, the Aboriginal gateway for a global solution

The Scotdesco initiative, run in partnership with PZC, is implementing the GTE programme to establish a new business paradigm whereby the Scotdesco/PZC relationship is incorporated into a vital and equal corporate partnership conducted in the name Bunyuru Pty Ltd. (Bunyuru being the local Aboriginal word for saltbush).

Scotdesco CEO, Robert Larking, says: "The Greening the Earth partnership between PZC and the Scotdesco Aboriginal community is a vision of health and prosperity for the future well-being of our country and its people. It draws from spiritual, physical, social and cultural connections and the natural affinity and knowledge that Aboriginal Australians have of the land going back some 60,000 years, as the world's oldest living culture. The cropping and manufacturing programmes foster new employment, business, mentoring and training opportunities for Scotdesco and for the regional community which, over time, will deliver improved skills, profitable returns and economic self-sufficiency in a manner that is dignified and respectful of Aboriginal history, culture and traditions".[27]

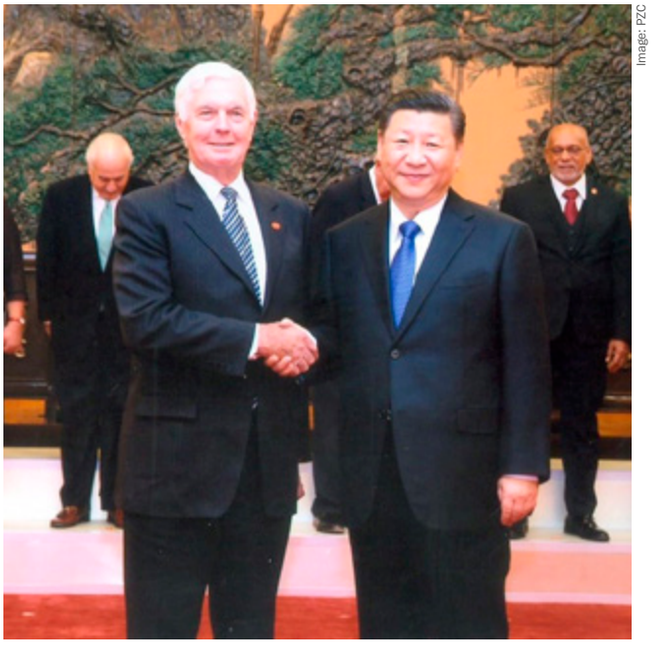


Image: PZC

Major General Jeffery emphasizes the need for international collaboration by exchanging views with President Xi Jinping of China on mutual opportunities for Australia and China in regenerative agriculture, linked to China's climate change policy

Image: NyPa Australia Limited

Commercial application of halophyte *Distichlis spicate* Var. 4a (NyPa Forage™) growing on saline aquaculture effluent in the central wheat belt of Western Australia. This sets an example for the valuable use of a resource common in many degraded areas of the world

The big picture for Australia and the world

Foreseeing and accepting the enormous potential of sequestering SOC is fundamental to universal success whereby international cooperation and widespread teaching and training action are vital.

Given that GTE plantations can sequester approximately 20t of CO_2 per ha, it follows that, if a country such as Australia was to create 500 plantations comprising 10,000 ha each (5 million ha) across its vast rangelands and Aboriginal holdings, the drawdown would be 200 million tonnes of atmospheric CO_2 per annum or more than one third of Australia's total greenhouse gas emissions.

This process would reverse salination and desertification trends, create beneficial micro-climates with increased biological diversity (both in the soil and above-ground), and reduce run-off and erosion — all without the need for intensive irrigation and chemical applications — resulting in regional job and business opportunities, healthier food, healthier animals, and healthier farmers and communities

Should this claim seem fanciful, it should be remembered that this land size is equal to just 13 per cent of the 10 largest landholdings in Australia[28] while 14.22 per cent of the country's 7.7 million km^2 (1,094,00 km^2) is held under Aboriginal Torres Strait Islander organizations as freehold, leasehold and reserve.[29]

Applied in collaboration over several continents, the GTE programme would catalyze many other regenerative agriculture techniques that could collectively draw down up to 20 billion tonnes of carbon worldwide per annum and make a major contribution to removing excess atmospheric CO_2 to help avoid the predicted devastating effects of climate change as well as providing healthy food and satisfying jobs for the increasing population of the world.[30]

The potential of agroforestry to enhance Land Degradation Neutrality

Judith Nzyoka, Assistant Scientist, Landscapes Governance Theme, World Agroforestry Centre and ASB Partnership for the Tropical Forest Margins; Peter A. Minang, Leader, Landscapes Governance Theme; Global Coordinator, ASB Partnership for the Tropical Forest Margins; and Flagship Leader, Landscapes – Forest Trees and Agroforestry (FTA) Research Programme of the CGIAR; Ruth Ogendi, Communications Assistant, World Agroforestry Centre and ASB Partnership for the Tropical Forest Margins; Lalisa Duguma, Scientist, Sustainable Landscapes and Integrated Climate Actions, Landscapes Governance Theme, World Agroforestry Centre and ASB Partnership for the Tropical Forest Margins

Since the adoption of the 2030 Agenda in 2015, Land Degradation Neutrality (LDN) embodies targets set by countries to conserve, sustainably manage and restore land designated within their land use planning agenda. LDN has been identified as an important pathway for securing sustainable global development, with targets implemented at local, national and regional scales, to propel comprehensive national, institutional and corporate strategies that embrace complementary activities. These can include the adoption of sustainable land management and holistic land-use planning, the rehabilitation of degraded land for production, as well as the restoration of natural and semi-natural ecosystems that provide valuable functions and benefits.[1]

So far, 110 countries have set LDN targets. In the last 25 years, 25 per cent of global lands have either been highly degraded or are subject to high rates of degradation, with a significant impact on the livelihoods of 1.5 billion people. This trend is still mounting at a rapid pace, with approximately 12 million ha of land degraded globally each year. Additionally, in Africa, 65 per cent of arable land, 30 per cent of grazing land and 20 per cent of forests are degraded.[2]

Despite its causes, extent and severity being contested, there is a consensus. Land degradation can be defined as a long-term loss of ecosystem function and productivity caused by disturbances from which land cannot recover unaided. With agricultural lands being severely affected by degradation, net primary productivity continues to decline as the human population and demand for food and goods grows. It is estimated that land degradation costs between US$ 6.3 trillion and US$ 10.6 trillion annually, worldwide.[3]

Agroforestry can provide many ecosystem services and is widely recognized as a suitable tool for land restoration. With the land area under agroforestry close to 1 billion ha, it comprises 43 per cent of all agricultural land with at least 10 per cent tree cover, as of 2010.[4] Defined as the integration of trees into farmlands and their management in agricultural landscapes, agroforestry can aid in achieving the LDN targets in several ways:

- Trees can fix nitrogen and stabilize the soil, boosting the crop nutrient supply and so land productivity
- Roots improve the structure of the soil, thereby controlling erosion and improving water availability
- Agroforestry can diversify and increase agricultural production while providing land users with other economic, social and environmental benefits that can increase food and nutrition security while generating income
- Communities' resilience to shocks, including drought and food shortages, is increased, enhancing food security
- Permanent tree cover is provided which can be valuable for forest and landscape restoration options.

The Food and Agriculture Organization estimates that land potentially available for landscape restoration is 2.2 billion ha. Of this, 1.5 billion ha are best suited to mosaic restoration, in which forests and trees are combined with other land uses, such as agroforestry. Additionally, 1 billion ha of croplands and densely populated rural areas on former forestlands would gain from the establishment and strategic placement of trees to protect and enhance agricultural productivity and other ecosystem functions. As such, agroforestry is one of a wide range of approaches for restoring degraded areas such as forests and agricultural lands, thereby contributing to LDN.[5]

Critical aspects for agroforestry in driving the achievement of LDN

In order for agroforestry to meet LDN targets in achieving sustainable land management and holistic land-use planning, some considerations should be set in place:

- An enabling legal and policy environment that guarantees rights to, and ownership of, trees and land, to enable equitable LDN outcomes. This includes a working national-scale coordination that can be incorporated into existing local and regional governance structures and governance by resource users at a local level; governance by the state at local and national levels; and international agreements to govern issues at transboundary, regional and global levels. In many developing countries, land

Image: Peter Minang

A restored landscape in the Ngitili system of Shinyanga Region, Tanzania

tenure is insecure, and trees are not always the property of land users. Therefore, as such, investment in agroforestry is, at times, risky.

- Agroforestry should be built in line with other conservation targets so as to provide resource users with incentives and diversified investment. Access to planting material infrastructure at the right time, in the right quantities and of high quality but with limited knowledge of agroforestry systems, can hinder the contribution of agroforestry to LDN and is seen as an additional burden, rather than an opportunity to add greater value. Agroforestry systems can be complex to implement, and therefore the requirement is for training and extension services that use participatory methods to teach resource users how to implement and manage agroforestry systems compatibly with the aim of restoring their lands and increasing agricultural production in the short and long terms.
- Since agroforestry takes 3–5 years to deliver its benefits, innovative funding mechanisms to buffer the challenges of delayed returns on investment are required to develop markets and improve value chains for agroforestry products. LDN actions can be financed through national and international financial flows, justified by ecosystem benefits that accrue to society at national and global levels.
- Agroforestry actions should be monitored and assessed for their impact on biodiversity and on social outcomes to track LDN progress and avoid unwanted eventualities. Recognition of existing local knowledge of agroforestry systems should also be taken into account and can be incorporated into integrated sustainable land management.

The Ngitili system

Ngitili — a local name for dry-season fodder reserves among the Wasukuma agropastoralists of Shinyanga, Tanzania — is an enclosure system where farmers conserve or plant trees in grazing lands which then provide livestock feed and wood for energy and construction. The system comprises two components: vegetation and animals. The animal component encompasses mostly goats, cattle, sheep and donkeys. Two distinct vegetation strata are identifiable, an upper stratum dominated by *Acacia tortilis*, *Acacia nilotica*, *Acacia polyacantha* and *Acacia seyal*, and a lower stratum of grasses, herbs and forbs. The structure and composition of Ngitili is highly influenced by location, age, management practices and intensity of use. Therefore, the interaction of livestock with vegetation has a significant role in the management and sustainability of the system. The site selection for the Ngitili establishment has been largely influenced by land availability, proximity to homesteads and ease of protection. Responsibility of the area lies with the head of household but, in the case of private or communal Ngitili, a group of elders becomes responsible. At the beginning of the programme, approximately 611 ha of such schemes existed, but that number grew significantly. In 2005, there were approximately 378,000 ha under the system, blended with other agroforestry practices such as woodlots instrumental in range management and forest restoration in 833 villages.[6] The Ngitili area remains closed to livestock at the beginning of the wet season but is opened up for grazing at the peak of dry season. Hence, the system alleviates dry season fodder shortages, prevents environmental degradation such as soil erosion, and helps conserve biodiversity.

The HASHI programme

In 1986, the Tanzanian government devised a programme called the Shinyanga Soil Conservation initiative (HASHI), that relied on the traditional local practice of Ngitili. The Shinyanga region is home to Wasukuma people and covers approximately 5.4 per cent of the total land area of Tanzania at its pre-2005 extent but hosts over 80 per cent of the country's livestock. Between 1980 and 2003 the region's population doubled, reaching approximately 2.8 million.[7] The Wasukuma are agropastoral communities dependent on mixed livestock rearing and, predominantly, sedentary agriculture. The area is semi-arid, and the vegetation type is mostly acacia and miombo woodlands.[8]

The Shinyanga region has undergone a number of processes in terms of the land use characteristics and associated practices. The period before the 1930s, referred to as the reference state, was when the landscapes in the region were considered sustainably managed, before becoming intensely degraded during the period between the 1930s and 1980s due to a number of drivers indicated in the degradation phase. The degradation created huge social and ecological problems requiring restoration measures. As such, the restoration effort through the HASHI programme received considerable political support, at national level in particular, with the government making a number of policy provisions such as revisions of land tenure policies and mobilization of financial resources to support the restoration effort.[9] Although the programme officially closed in 2004, the project activities continued to be carried out by the Natural Forest Resources and Agroforestry Management Centre (NAFRAC) as well as community members.

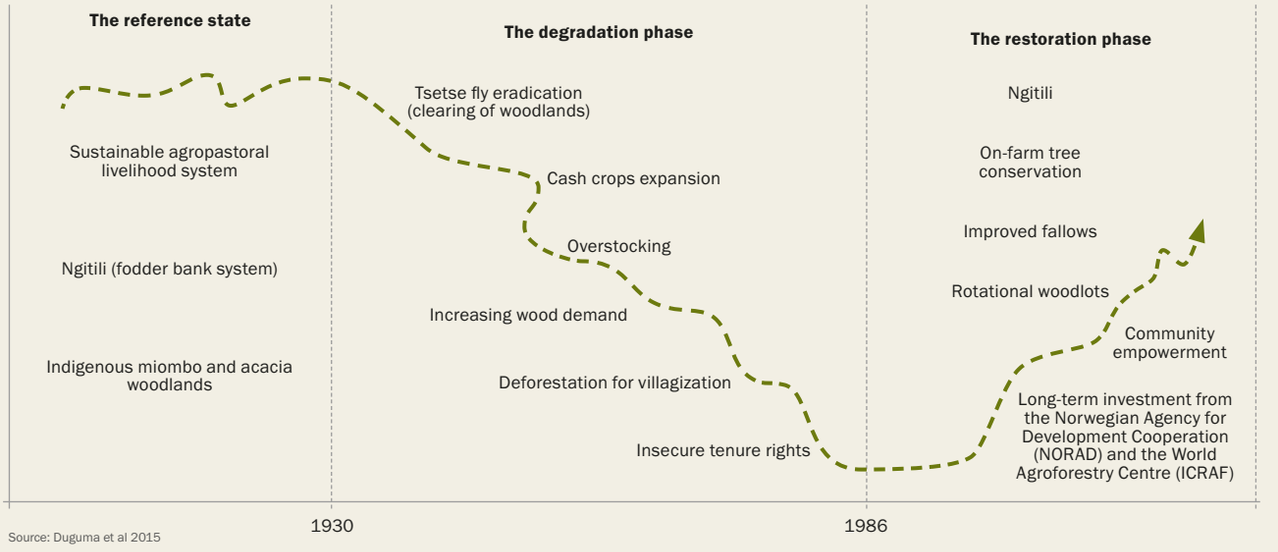
Land Degradation Neutrality in Ngitili

LDN is a flexible target with actions that can be implemented at local, regional or national scales. It recognizes the sovereignty of nations to manage trade-offs and to capitalize on the synergies between biological and economic productivity. It aims to maintain and increase the amount of healthy and productive land resources in line with national development priorities. In the case of the communal Ngitili, there are specific rules and regulations put in place by local leaders and the village government to ensure that it is only those who engage in the specific management activities that benefit from it. This Ngitili system is managed by groups of communities, and therefore includes a number of strong, self-organizing activities. For those not involved in the restoration process, there is an option of paying for the services or products collected from the Ngitili. However, as expressed by the village environmental committees, there are cases of illegal use, although the majority of the community respects the local norms and values.

The village environmental committee and local leaders determine the level of harvest for different users, and the village government (Dagashida) and community policing (Sungusungu) make sure that this decision is properly implemented on the ground. The communities have rules and regulations on how much of the products are to be harvested, by whom and under what circumstances. This is a strong indicator to avoid overharvesting which later affects the sustainability of the system.[10] The programme ensures fair and equitable sharing of the benefits among group members engaged in managing parcels of land, as such adhering to the principles of LDN. Often the benefits go to public infrastructure such as schools and roads, and whenever there is remaining cash, it is shared among the members.

The importance of traditional institutions is underestimated in natural resource management. The institutional responsibilities of the management of Ngitilis are as important as the technical aspects. There may be a wide range of institutions concerned with issues such as access, control and responsibilities within a community, as evidenced by the role of the Sungusungu in Ngitili conservation. To the outsider they may not be obvious, and their role may be underrated with respect to traditional natural resource management,[11] but these institutions have been used as the basis for Ngitili restoration,

Representation of elements characterizing the gradual changes in the Shinyanga region, Tanzania



Source: Duguma et al 2015

and HASHI has made determined attempts to locate control over the Ngitili in the village itself.[12] Traditional sanction mechanisms and fines (mchenya) have been the basis for enforcement. This maintenance of a range of informal organizational mechanisms for dealing with land use matters, which may often operate in near isolation from formal government, is an important feature.[13] The blending of the traditional and modern has clearly been an important factor in the success of Ngitili restoration.

Many more individuals now make their own Ngitili and noticeably, there is more vegetation now than in 1988. The in-situ conservation programme has had a positive impact on the environment in the Shinyanga region,[14] an improvement made by both direct and indirect HASHI intervention. Farmers are reclaiming previously owned Ngitilis, while others plan to establish new ones.

Reflections

In the context of Ngitili, agropastoralism — a form of agroforestry practiced with livestock, crops and trees — has transformed the Shinyanga landscape from almost a desert to a thriving ecosystem. In this case, agroforestry presents a clear pathway for addressing land degradation. By devolving the governing structures of Shinyanga, it has contributed to increased tenure security at individual and village levels and has played a significant role in the rapid restoration of Ngitili. Hence, the provision of the appropriate conditions of decentralization, increased tenure security, and the empowering approaches of HASHI, combined with the adoption of traditional knowledge of Ngitili management, has enabled agropastoralism to meet the restoration goals.

Ngitili also demonstrates that rural resource users play a key role in restoration and, as such, necessitate the appropriate incentives. The individual areas restored may not be large, but the number of people who individually or jointly own Ngitili is great and spread widely over the region, transforming the once degraded area. Agroforestry, an important restoration instrument, can be useful as an entry point to meet LDN targets and, subsequently, the Sustainable Development Goals.

Image: Peter Minang

Livestock grazing in the restored Ngitili, Tanzania

Image: Peter Minang

Community meeting in Shinyanga, Tanzania

Productive forests — an untapped and underused resource for addressing some of humanity's biggest challenges

Gerhard Dieterle, Executive Director, International Tropical Timber Organization (ITTO);
Ramon Carrillo, Communication and Outreach Officer, ITTO

Continuing degradation and loss of forests poses major risks to billions of people, especially the rural poor, who use forests for shelter, food, energy, medicines and income. Demand for forest products, especially wood, will escalate in the coming decades as populations grow and become wealthier and as certain non-renewable resources are replaced because of their negative climate impacts. There could be a resources crunch, but forestry can help avert this by producing more wood sustainably while also providing crucial ecosystem services such as those associated with clean water supply and the mitigation of climate change.

Sustainable Development Goal 15: Life on Land, captures one of humanity's biggest challenges: to protect, restore and promote the sustainable use of forests. As a matter of urgency, forests need to be at the forefront of global sustainable development efforts. They can play a major role, for example, in mitigating climate change, such that combining forest conservation, sustainable forest management (SFM) and forest restoration could close the global mitigation gap by 8 $GtCO_2$ per year, or approximately 20 per cent of total emissions. Forestry could achieve this while also generating employment and income and providing social and environmental benefits.

Forest conservation and production are not mutually exclusive. A multipronged, integrated approach is required, comprising:

- Creating an enabling framework for forest production and conservation, including good forest governance, the rule of law, and equitable rights to land
- Protecting high conservation value forests, especially remaining primary tropical forests, as a global public good
- Restoring degraded multipurpose forest landscapes for productive use to reduce pressure on forests with high conservation and environmental values
- Investing in productive forests for timber, pulp and energy and managing them sustainably
- Reducing the production footprint of all agricultural and forestry commodities by managing and using resources sustainably and efficiently
- Establishing verified degradation-free and deforestation-free supply chains and trade across the land-use spectrum in both domestic and international markets.

The International Tropical Timber Organization (ITTO) has been promoting SFM and supply chain approaches, encompassing all of these aspects, in the tropics for more than 30 years. ITTO members understand the importance of considering entire product life cycles — from the tree in the forest, to the finished product, to its eventual disposal — in order to ensure that the climatic, environmental, social, cultural and economic benefits are real and sustainable. ITTO has developed a suite of international policies on the conservation, management and use of tropical forest resources, and it has funded more than 1,000 projects to assist tropical timber-producing countries in adapting such policies to suit local circumstances and applying them in the field.

Lasting, mutually successful outcomes will be achieved only through collaboration between governmental and non-governmental actors in the value chains. ITTO-financed projects are implemented largely by local partners in the tropics, thus helping to unlock the potential of communities, smallholders and governments and to bring far-reaching changes beyond the project areas. The following case studies show how relatively small-scale interventions, if properly targeted, can act as catalysts for larger-scale change, improving livelihoods while encouraging forest conservation, SFM and green supply chains.

Conservation and communities

Many indigenous peoples and local communities rely on forests for a range of products and services, but the establishment of protected areas can deny them access to these. Buffer zones around protected areas are crucial for ensuring that local communities have access to resources so that they can maintain and improve their livelihoods while also generating positive conservation outcomes.

An ITTO project has helped improve the management of the buffer zone of the Pulong Tau National Park in Sarawak, Malaysia. The buffer zone, encompassing approximately 6,000 ha of forest, is composed of several ecosystems characterized by differences in soil and altitude — riparian and alluvial forests on low flat ground; and kerangas, mixed dipterocarp and montane forests at higher elevations. The buffer zone includes three sub-catchments that ultimately serve 300,000 people living downstream in numerous

villages, longhouses and towns along the Batang Baram River. Two timber concessions partially overlap with the buffer zone.

Several hundred species of flora were recorded over the course of the project, and camera trapping revealed more than 28 mammal species in the buffer zone, of which 25 species have some kind of protected status, as well as 18 frog and toad species, of which seven are endemic to Borneo.

The Penan people in the buffer zone live in four villages, comprising 52 families and approximately 250 individuals. The Penan roamed the forests in the upper Baram before the Pulong Tau National Park was constituted in 2005 but, under Sarawak law, they were not granted user rights to the forest because of their nomadic existence. Nevertheless, the people are culturally attached to the forests on which they depend for energy, food, construction materials, handicrafts and medicine. It is therefore crucial for their culture that they remain in the area.

The traditions of the Penan are strongly compatible with sustainability. For example, starch obtained from the wild sago palm (*Eugeissona utilis*) is an important staple food, especially among older people. The Penan communities in the buffer zone have disallowed logging in certain areas to protect their water catchments and plant and animal resources, including sago palms.

The communities lack modern education and employment, however, and they have struggled to develop new livelihoods to suit their changed circumstances. The project helped build the capacity of the Penan to grow fruit crops, create fisheries, make handicrafts and carpentry products for sale, engage in ecotourism, and improve their water supply infrastructure. The project also identified three communal forests to be managed for the longterm supply of forest products.

The project demonstrated the multiple functions of the Pulong Tau National Park buffer zone. Crucially, it worked closely with local people to develop sustainable livelihoods that would enable them to safeguard and sustainably manage the zone. Achieving SFM is a long-term endeavour; the process is well underway in the Pulong Tau buffer zone, but more work is needed to ensure enduring success.

Supporting women

A small grant from ITTO in 2009 provided the stimulus for a women's association in the Republic of Côte d'Ivoire to improve charcoal production using efficient, eco-friendly processing techniques, thereby increasing the standard of living in the community and raising awareness of the importance of forest conservation. Now, the MALEBI women's association is implementing a larger ITTO project in the nearby Ahua gazetted forest to ensure a continuous supply of wood for charcoal production.

Nearly three-quarters of households in the Republic of Côte d'Ivoire use charcoal or firewood to meet their daily

Image: G. Dieterle/ITTO

Globally, demand for wood, such as this Togo teak (*Tectona grandis*), is expected to continue growing rapidly, making sustainable forest management an urgent necessity

Image: © W. Cluny

An ITTO project helped to build the capacity of Penan communities to pursue new livelihood options while continuing to use the Pulong Tau buffer zone for traditional purposes

energy needs. Charcoal production in the country increased by 22 per cent in the ten years to 2012 and firewood production increased by 4 per cent. The Ahua forest supplies wood for charcoal to meet the cooking and heating needs of the citizens of nearby Dimbokro and Abidjan, and the charcoal business is a significant employer of women and youths.

With ITTO support, and an awareness of the ecological impacts of the charcoal business, the MALEBI women made the decision to reforest and restore part of the 4,500 ha Ahua forest using species such as kassod (*Cassia siamea*), samba (*Triplochiton scleroxylon*) and teak (*Tectona grandis*), and they are also growing cash crops within the plantation. The project has helped strengthen MALEBI as an institution, and it has built the capacity of its members in order to establish tree nurseries, produce seedlings, and create and manage forest plantations and agroforestry plots. The women are meeting the subsistence needs of their families for food and wood fuel while rehabilitating the forest to ensure its longterm sustainability.

Among the benefits of the project is an increase in income for the women involved in the charcoal business, which has translated into a higher quality of life for their families. In the village of Tromambo, this income enabled women to fund the construction of a water pump, which now provides fresh water for the whole village.

The MALEBI women's association has helped shift attitudes at local and national levels towards accepting the role of rural women in forestry. The prime minister of Côte d'Ivoire endowed the project with the third National Award of Excellence for the best promoter of community development. The project also has considerable potential for replication elsewhere in the country and beyond, as recognized by a recent mission to the project site by the World Bank's Forest Investment Programme.

Building transparent and legal supply chains

Like many other timber-producing countries, Guatemala has difficulty in proving the legality of its forest products. Part of the problem is that many monitoring and verification actions are carried out manually and are subject to the discretion and bureaucracy of regulatory institutions. However, the ability to demonstrate the legality — the green credentials — of forest products is crucial if those products are to be accepted and valued by global markets.

In order to provide a solution to this problem, two ITTO projects have been set up to help create the Guatemala Forest Statistical Information System (SIFGUA). The aim is to increase the quality and timeliness of forest-related information, thereby increasing market transparency and trade and improving decision-making in the forest sector.

SIFGUA consists of three information systems: the Electronic Forest Enterprises Information System (SEINEF); the Electronic Forest Administration System in Protected Areas; and the Electronic Forest Management System, for forests outside protected areas.

SEINEF is, in effect, a timber traceability system, enabling the registration, monitoring and control of forest products as they move across the country. But its implementation

Image: R. Carrillo/ITTO

Women from the MALEBI association gather to conduct maintenance operations in a reforested area of the Ahua gazetted forest, Republic of Côte d'Ivoire

would not be possible without suitable revisions, updates and amendments to the regulatory framework. An important step was therefore to introduce two controls — the Forest Enterprise Monitoring Regulation and the Regulation for Forest Products Transport and Legal Sourcing — making SEINEF mandatory for forest enterprises.

SEINEF is an innovative tool designed for use by enterprises of all sizes, from the small — for instance, carpentry workshops, furniture factories and timber warehouses — to the very large — forest corporations and exporters. SEINEF provides users with a wide range of services, such as the digitization and review of their regular reports (carried out automatically by the system); the verification of supporting documentation on inventory entries and exits; and analyses of yields and internal flows.

SEINEF also enables the standardization of timber transport documentation as the Company Bill of Transport. These are numbered and have unique QR barcodes (machine-readable optical labels), and are printed on special paper that minimizes the potential for falsification.

The main objective of SIFGUA is to automate processes and approvals for forest stakeholders and to collect, process and analyse information that can then be disseminated to the public via a website. SIFGUA involves the real-time collection of standardized, high-quality data to strengthen the purview of the forest sector and increase its efficiency. It also reduces illegality, enables the increased collection of taxes by the government (which can be reinvested in forests), and improves access to markets for indigenous communities and small and medium-sized enterprises.

Image: INAB/ITTO

An officer from Guatemala's National Environmental Police checks a timber consignment at Izabal, Guatemala

There is no doubt that the world needs more forests and trees to provide goods and services for a rapidly growing population. Wood and wood-based energy should be considered in the same way in which we view food. We need, therefore, to strive for both food and wood security. Although we continue to learn how best to do this in the forest sector, there is sufficient knowledge to take a major step forward in the next decade. What is needed now is substantial investment, a concerted effort to build capacity in forest management, wood processing and green supply chains, and education to ensure that the world's people fully understand the importance of productive forests for a sustainable future.

Land degradation and forest restoration in the Pacific Islands

Easter Galuvao, Director, Environment Monitoring and Governance; David Moverley, Invasive Species Adviser; Gregory Barbara, Environment Assessment and Planning Officer; Jope Davetanivalu, Environment Planning Adviser, Secretariat of the Pacific Regional Environment Programme

Unsustainable harvesting of natural resources, and the destruction and modification of habitats and ecosystems continue to threaten the integrity and health of the vulnerable natural systems on which Pacific island life depends. Invasive alien species are recognized as one of the main causes of biodiversity erosion in island ecosystems. The Secretariat of the Pacific Regional Environment Programme (SPREP) has been working with member countries and other partners in delivering efforts to manage these environmental issues and contributing to the protection, restoration and sustainable use of terrestrial ecosystems in order to halt and reverse land degradation and biodiversity loss.

The SPREP strategic plan 2017–2026 is a continuation of the commitment by SPREP and its members and partners to address four core priorities areas — climate change resilience; waste management and pollution control; environmental governance; and ecosystems and biodiversity protection. These areas are aligned to Sustainable Development Goal 15 on the preservation of terrestrial ecosystems and associated species.

Many programmes and activities have been run by SPREP, aimed at sustainably managing forests and protecting areas that are important for biodiversity.

Image: Jope Davetanivalu

There is a continuing programme of native tree planting in the Toloa Rainforest Reserve to improve the structure and shape of the forest

Restoration of the Toloa rainforest on the island Kingdom of Tonga

The Toloa Forest is the largest remaining area of lowland tropical forest on Tongatapu, Tonga's main island. The forest is now under the care of Tupou College and utilized by Tongan schools as an educational site. But, due to threats from harvesting and invasive alien species, the 23 ha forest is degraded and not functioning well as an ecosystem.

In 2014, SPREP, in partnership with the Tonga Ministries of Environment, Energy, Climate Change, Disaster Management, Information and Communications, and together with Tupou College and other partners under the Global Environment Facility Pacific Alliance for Sustainability (GEF-PAS), funded the "Prevention, control and management of invasive alien species in the Pacific Islands" project. An operation plan for the restoration of the Toloa rainforest was thus developed. It was chosen as a priority site by both the Tongan government and stakeholders through their enthusiasm in wanting to preserve the only native forest left on Tongatapu, as described in their National Invasive Species Strategy and Action Plan (NISSAP). An operational plan was drawn to outline the major elements of the restoration work from 2014 to 2020 and provide guidance to protect natural resources and livelihoods from the negative impacts of invasive species.

Image: Stuart Chape

The Robert Louis Stevenson Museum, Vailima on Mt Vaea, Apia, Upolu, Samoa

Image: Jope Davetanivalu

Tree planting coordinated by the Samoa Conservation Society and joined by staff, families and friends of Secretariat of the Pacific Regional Environment Programme, the Samoa Forestry Division, and the Ministry of Natural Resources, along with nearby communities

Tupou College, as steward of the Toloa Rainforest Reserve, has the primary responsibility of implementing the plan with the support of government and partners. The plan includes a summary of the invasive plants in the reserve as well as a description of the implementation approach to be followed, including the invasive plant and mammal management techniques to be used. A detailed work plan, planting plan, and annual budget were prepared to operationalize the work. The Toloa Rainforest is one of six pilot sites focused on the managing of invasive species such as rats (*Rattus exulans*), and invasive plants such as the cordia tree (*Cordia alliodora*), which outcompetes the native forest and its natural habitat.

The Tongan government provided support by funding the establishment of the Toloa Rainforest Nursery. In the 2015 Environment Week, themed "Healthy Nature – Happy Tonga", the Tonga Department of Environment continued its commitment to the action plan on the restoration of the rainforest by joining Tupou College, partners and communities in a continuing programme of native tree planting in the reserve to improve the structure and shape of the forest.

Mt. Vaea ecological restoration project, island of Upolu, Samoa

Mt. Vaea is the most visited of all Samoan reserve areas and is a popular recreational spot, only ten minutes' drive from Apia, the capital city of Samoa. The reserve is also an important historical site, being the resting place for the celebrated Scottish author, Robert Louis Stevenson. However, the reserve is heavily impacted by invasive weeds that are slowly spreading, a characteristic that has accelerated during post-cyclone periods. One of the impacts of the spread of invasive weeds is a reduction in diversity of native birds, plants, reptiles and other native species due to the loss of natural habitats and ecosystems.

In 2008, SPREP supported a project proposal, the Mt. Vaea Ecological Restoration Project, to promote biodiversity conservation and invasive species management, endorsed by the Ministry of Natural Resources and Environment and its various partners and collaborators from international, regional, and civil society organizations, including the Robert Louis Stevenson Foundation. The two main objectives of the project were to restore the Mt. Vaea reserve forested area to its former state with the appropriate native rainforest tree species, and to use Mt. Vaea as a demonstration site of invasive species management and habitat restoration for the benefit of Samoa and the rest of the Pacific island region.

The project's two main elements were the selective removal of invasive weeds from the reserve and the replacement of the weeds with selected native species as part of forest restoration. The project received sustained and continuous effort over five years in two main phases. Phase 1 covered field surveys and plant inventory work. The surveys provided much valuable information, revealing that the entire project area had been severely affected by invasive species as well as by human related impacts such as agricultural and forestry, and natural calamities such as cyclones and severe weather events. Invasive species constituted over 60 per cent of total species, of which over 50 per cent comprised only five target species. The initial survey highlighted the extent of the problem, informing the five-year operational plan, created under the GEF-PAS-funded "Prevention, Control and Management of Invasive Alien Species in the Pacific Islands" project.

The GEF-PAS project enabled the implementation of Phase 2, involving significant physical effort, equipment and knowledge sharing. This included the raising of public awareness on invasive species, on invasive species management, and on forest conservation and restoration, and determining the costs for weed management in the Samoan context, which can then be used for other project proposals. Also trialled were a variety of invasive species management techniques for key invasive weeds. Training was given to the Ministry of

Image: Samoa Conservation Society

Forestry experts demonstrating the importance of soil preparation for the reforestation of O le Pupu Pu'e National Park, Samoa

Image: Stuart Chape

The forested western escarpment of Mt. Vaea, Upolu, Samoa

Environment staff, the Samoa National Invasive Task Team (SNITT), and others involved in the process of designing and implementing the management project.

Parts of the Mt. Vaea Reserve have now been restored to a more natural state with benefits for native biodiversity and recreational potential. The project is on-going.

O le Pupu Pu'e National Park restoration project, Samoa

The O Le Pupu Pu'e National Park (OLPP) was the first national park to be established in the South Pacific. Located on the Island of Upolu, approximately 15 km south of Apia, it currently measures 5,019 ha (12,396 acres). While the OLPP provides a large area of protected forest, over one-quarter of that has required effective management of invasive species.

In 2015, SPREP, in partnership with the Samoan Ministry of Natural Resources and Environment (MNRE), and the Forestry Division, undertook preparation of the restoration plan for the OLPP, with the plan consultation funded under the GEF-PAS Regional Invasive Species Management Project. The plan calls for a multi-year project until at least 2020, with a focus on effective control of invasive species to promote forest restoration. A key element of the plan is community consultation as well as invasive species surveys for mapping the extent, impacts and numbers. The MNRE provides the core support for the implementation of the multi-phased project.

Community consultation included workshops with various village groups — village chiefs (*Alii ma Faipule*); official government representatives (*Sui o le malo/Pulenuu*), government representatives for women (*Sui Tamaitai*), women's committee (*Komiti o Tina*), and youth group (*Tupulaga talavou*) from each of three villages adjacent to the OLPP: Sa'aga, Saleilua and Poutasi. Owners of beach huts and village hotels have also been involved. This level of involvement by the affected stakeholders has assisted in information gathering on the invasive species as well as in monitoring and running the restoration plan itself.

The surveys and community consultation has documented the high extent of impact suffered by OLPP from invasive species of many taxonomic groups including plants, birds, mammals and invertebrates. The park is bordered on three sides by land, making the re-introduction of any managed invasive species from surrounding areas a high risk. Attempting to manage all invasive species throughout the park was therefore not a viable option. A prioritization process was followed to identify: a) species with high ecological impacts and the type of management, whether control or eradication, required; and b) the particular areas within the park that warrant invasive species management to protect valuable biodiversity. Based on the knowledge gathered from the consultation and surveys, the highest priority for invasive species management in the park at the time of survey was Fue Lautetele (*Merremia peltata*). Management of the species was carried out with its removal and replanting with native species to form a dense, dark canopy. This operation was of relatively low cost. Future management of invasive animals, such as rats and cats in particular, may be warranted in particular sites to protect threatened fauna such as Manumea and Maomao, two threatened Samoan birds.

Participatory restoration of degraded forest landscapes by tribal village clusters in Madhya Pradesh, India

Dr. Pankaj Srivastava, Director, Indian Institute of Forest Management, Bhopal

Community participation in the protection, management and restoration of degraded forest lands has generated a new hope in many parts of India and catalyzed grassroots level collective action for a more effective protection of common property resources. Such stories of improvement in forest health under a participatory framework and collaborative institutions indicate that, despite immense biotic pressure on natural resources, when local communities realize the gravity of the conditions decisions are made to create better local environments. An excellent example is that of the participatory restoration of a highly degraded and eroded forest landscape by a few clusters of predominantly tribal villages in the Barwani district of the Nimar region of Madhya Pradesh. This example underlines the significance of social capital in large scale ecological transformation.

Barwani is a district in the western part of the centrally located Madhya Pradesh province of India. The district is infamous for massive encroachments of forest lands by local tribal communities since the early 1960s. The total geographical area of the district is 427,055 ha, of which 192,622 ha (45 per cent) are forest lands. The district is predominantly inhabited by the Barala community, which is a sub-tribe of the Bhilala. According to the 2011 census, the population density in the district is 255 per km^2, and approximately 70 per cent is tribal. The district's forest landscape has suffered mostly from forest encroachments due to a rapidly increasing population and a predominantly agrarian economy. The population of the district in the year 1901 was 30,647, rising to 1,385,881 in 2011 according to the census, an increase of 450 per cent over a century. The impact of such rapid growth, coupled with the tendency of encroachment, has been huge.

Image: Dr. Pankaj Srivastava

Village meeting at Ajgariya

The demand for agricultural land has also increased exponentially, resulting in tremendous biotic pressure on natural forests. A politically motivated regional movement in the 1950 and 60s in the Nimar region also led to encroachment of forest lands en-masse for agricultural purposes, a trend that continued unabated until recently. The official working plans of the Forest Department reveal that as much as 74,744 ha (39 per cent) of the district's total forest area was under encroachment until 2010–11. This historical account is the backdrop against which this unique forest restoration initiative, carried out by the same community, is to be seen and evaluated.

It is also essential to understand the new policy environment and its impact on the consolidation of strong social capital in a few clusters of villages which ultimately resulted in the effective restoration of degraded forest lands in the area. Forestry in India is embedded in the constitution, empowering both central government and the separate states to make laws. The National Forest Policy of India, 1988, paved the way for involving local communities in the protection and management of state-owned forests. The policy aimed to create a massive people's movement, with the involvement of women, to achieve its objectives. The policy also treated the bona fide needs of local tribal populations for fuel, fodder, minor forest produce and construction timber as the principal claim on forest produce.

The 1988 policy states that the holders of customary rights and concessions in the forest area should be motivated to identify themselves with the protection and development of forests from which they derive benefits. Pursuant to the policy, the Ministry of Environment and Forests issued, in June 1990, a letter to all Indian states and union territories to involve local communities in the protection of state-owned degraded forest lands. These instructions led to the emergence of Joint Forest Management (JFM) where village level institutions, created for the protection and management of forests, were designated by the respective state and union territory governments, mostly through notified government resolutions (GR). The first JFM GR was given by the government of Madhya Pradesh in December 1991 which laid the foundation of three types of village level JFM

Khadikham in 2006 (top) and in 2016 (above) showing the difference in biomass coverage

committee, namely Forest Protection Committees (FPCs) for the protection of dense forests; Village Forest Committees (VFCs) for the restoration of degraded forest lands; and Eco-development Committees (EDCs) for involving people in the management of wildlife and protected areas. Dialogue with local communities concerning their involvement in forest protection under the new policy directives was initiated in Barwani district by the Forest Department in 1992.

The process of restoration of the degraded Barwani forest landscape has been spread over several fragmented clusters. The total area of all clusters is approximately 20,000 ha. The process began at the village of Wadiapani in the Warla range in 1993, under the leadership of Shri Mangilal Barela, chairman of Wadiapani VFC, who was extremely passionate about restoring the degraded forests under his jurisdiction with the participatory mechanism offered by JFM. The Wadiapani VFC was very effective in controlling illicit tree felling, preventing forest fires, arresting new encroachments and regulating cattle grazing, although its impact remained localized for several years.

The foundation of a new success story was meanwhile being laid in a nearby cluster of approximately ten villages around Ajgariya and Khapada. The forest area of this cluster is spread over 93 compartments in ten beats of two forest ranges — Warla and Dhavli. Although the area officially allotted to seven VFCs in the cluster is only 4,996 ha of 20

Image: Dr. Pankaj Srivastava

Nagalwadi in 2005 showing the extent of deforestation across a large area

Image: Dr. Pankaj Srivastava

Restored forest at Nagalwadi in 2015

Examples of regeneration improvement in Ajgariya-Khapada cluster compartments

VFC	Compart. No.	Area (ha)	Base regeneration 2006	Current regeneration 2014
Ajgariya	471	210.67	380	982
Khapada	459	135.52	380	678
	461	224.96	380	866
Dokalyapani	494	235.85	380	1013
	491	227.12	380	1578

Areas allotted to VFCs

Sl. No.	Name of VFC	Compart. Nos. allotted to VFC	Area allotted to VFC (ha)
1	Kolkheda	1155, 1157, 1161	937.13
2	Peeparkheda	1162	288.37
3	Nagalwadi	1163	284.56
4	Padla	1164	213.35

compartments of reserve forest, the villagers, enthused by the potential outcome of their own initiative, began protecting 5,549 ha of additional area of 23 further compartments, without official attachment of the forest area to their villages.

The area under protection of local communities in the cluster of ten villages, which was mostly devoid of vegetation at the turn of the millennium, has now improved tremendously and started generating benefits for the local population. In order to quantify the improvement in regeneration status, 46 sample plots of 50m x 50m were laid down in 16 compartments and a valid vegetation survey was conducted, revealing a vast improvement over the baseline information available in Forest Working Plan of the area. For example, compared to the average baseline figure of 380, the current regeneration in compartment 494 was found to be 1,093; in compartment 459 it was recorded at 678; for compartment 471 it was found to be 982; compartment 491 was reported as 1,578; and compartment 461 was recorded as 866, all of which illustrates the significant improvement in regeneration status. Similarly, the number of trees/pole crop per ha has also increased, indicating overall improvement in the health of the forest.

The number of bamboo clumps was found to be 18 per ha and teak saplings under 20cm girth at breast height (gbh) was found to be 149 per ha, whereas teak trees above 20cm gbh were 106 per ha. Miscellaneous trees above 20cm gbh were found to be 30 per ha, and the average girth of established saplings was 30 cm. The average of trees per ha was 315 and, with a predominance of young saplings, this is an indication of the improving health of the crop. Satellite images of the area on different timelines clearly show remarkable improvement in the condition of the forests over last 10–15 years.

The average regeneration in these compartments was found to be 645 per ha, compared to 380 per ha as shown in the working plan data.

A participatory appraisal in the Ajgariya-Khapada cluster revealed that the increasing scarcity of fuel, fodder and water in the area was a key motivation for villages to become proactive in the protection of their degraded landscape. The realisation of scarcity facilitated the consolidation of social capital that contributed to the process of rehabilitation of the forest areas in many neighbouring villages as well.

Another cluster of villages in the same district with remarkable results of community participation in forest restoration, albeit with a slightly different perspective, was the Nagalwadi area in Rajpur taluk, Barwani district. Here, six forest compartments, together measuring approximately 1,725 ha, were allotted to four VFCs. The area is famous locally for a temple where the serpent deity, Bhilatdev is worshipped. The area was inspected by the author twice, firstly in 2005 and then in 2015. During the first visit there was hardly any vegetation and the entire tract was highly degraded, with a severely hacked, malformed forest crop. The second visit, however revealed a miracle. In this cluster too, community participation in degraded forest restoration was the key element, but the sentiment was slightly different. Here, a local priest popularised a belief that the area around the temple was a sacred forest under protection of the serpent deity. Coupled with the community initiative of four adjoining VFCs, the religious sentiment played a crucial role in restoring the lost glory of jungle in the tract.

Effective protection soon resulted in a remarkable improvement to the area where the previous average of 84 trees per ha increased to a level of more than 1,300 per ha, a success story in a highly encroachment-ridden district. The crop density in forest compartments allotted to VFCs improved tremendously and the moisture regime of the area also increased to a significant extent. This unique restoration experiment in JFM was acclaimed by Madhya Pradesh's chief minister.

Stories of restoration of large chunks of degraded forest lands in the clusters of Sendhwa seem miraculous, testament to the success of natural resource management. The precise extent of the area is, according to a rough estimate, no less than 20,000 ha over several scattered clusters.

Image: Dr. Pankaj Srivastava

Members of Hingwa VFC, including forest guard (right) and restored teak crop

Image: Dr. Pankaj Srivastava

Image: Dr. Pankaj Srivastava

The degraded Ajgariya landscape of 2005 (above), pictured in contrast to the restored landscape of 2016 (below). Ajgariya, the village that acted as a nucleus of this restoration of degraded forests over a period of more than a decade, was visited by the author several times between 1992 and 2016. He witnessed the extreme degradation of these dense forests, followed by a phase of impressive revival. Scarcity of fuel wood and other timber, coupled with the early drying of perennial streams, motivated residents of Ajgariya and an adjoining village to protect the forest area adjacent to their farmlands

Rejuvenating soil health through organic farming

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The sustainability of crop production with a high yield and consistent quality is dependent on several factors including the quality of the soil. Fertile, healthy soil is a vital prerequisite to planting, and a harmonious interaction between soil, water and biodiversity is essential in order to create and maintain a peaceful coexistence in the ecosphere. It is estimated that 95 per cent of food is grown on soil, emphasizing its importance in food security However, current statistics indicate that one-third of the world's soil is becoming degraded, turning from living soil to dead dirt. This, in turn, is responsible for the huge loss of biological diversity as well as the downturn in the economic, productive capacity of the land.

A healthy soil is full of decaying organic matter, minerals, water, air, bacteria, fungi and microorganisms and is very much alive; while compacted, eroded land and polluted waterways are examples of dead matter. Living soil can easily become dead when excessive chemical fertilizers, pesticides or herbicides are applied. Over time, repeated applications of chemical substances to the soil and crop ecosystem can result in degraded soil, increased plant weakness, and reduced pest resistance. Rejuvenating the soil through natural processes is a sustainable way to restore its fertility.

Land conditions and suitability for agriculture in Malaysia

The total land area of Malaysia is approximately 33 million ha, with 10 million ha (33 per cent) used for agriculture. In Peninsular Malaysia, the distribution of suitable land for crop cultivation is approximately 7 million ha (53 per cent). Marginal and unsuitable land such as peat, acid sulphate, sandy beach ridges, sand tailing and steep land covers approximately 6.2 million ha (47 per cent). Sarawak consists of 3.4 million ha (28 per cent) suitable for agriculture cultivation, and 8.8 million ha (72 per cent) of unsuitable land, including swamp and areas too steep for agriculture. Land suitable for agriculture in Sabah covers approximately 2.2 million ha (30 per cent), with unsuitable land about 5.1 million ha (70 per cent).[1]

There are three types of problematic soils in Malaysia, namely peat, acid sulphate, and sandy beach ridges (BRIS). These types of soil are considered unsuitable because of their physicochemical and biological properties. Peat and organic soil in Malaysia covers approximately 2.7 million ha, with a low soil pH range from 3.0 to 4.5. Acid sulphate soil has an even lower pH of less than 3.5 and contains aluminium and iron that are present at a level too toxic for crop production.[2]

For acidic soil, the largest agronomic problem is the non-availability of nutrients for crop uptake, especially phosphorus due to iron toxicity.[3] In Malaysia, acid sulphate soil (Sulfaquepts) is scattered along the west coast plains of Semenanjung and in the Sarawak river, covering approximately 100,000 ha of land. The sandy spodosols of greater than 85 per cent sand are considered problematic due to their excessive water drainage as well as low organic matter content, clay content, cation exchange capacities (CEC) and nutrient content. Water and nutrients can easily leach out of the soil due to the low field capacity and CEC respectively, and thus water and nutrient stress is common.[4] BRIS covers approximately 155,400 ha along the coastal plain in Peninsular Malaysia and 40,400 ha in Sabah.[5]

The main soil threats in Malaysia began because of development on environmentally sensitive areas such as marginal land, steep slopes, swamps and highlands, causing landslides and soil erosion. Cameron Highlands, over 1,000m above sea level, is the main vegetable producer, followed by Kundasang, Sabah. Both of these highlands are utilized for agricultural activity mainly for temperate vegetables and cut flower production. Excessive cutting of the slopes for crop cultivation has caused soil erosion and siltation in the lakes.[6] Agriculture production that uses excessive chemical inputs under netted structures causes high saline soil and requires a new soil topping after a period of time. Agriculture development on marginal soil such as acidic soil requires very efficient water management and intensive liming as the soil is too acidic for crop cultivation. The long term use of excessive amounts of liming materials may cause an increase of hydroxide in soil, a condition that affects crop root development due to hydrolysis, and potentially leads to poor uptake of certain micronutrients such as zinc and boron.[7]

Soil management through organic farming

Organic farming practices use green manures, compost and specific manure applications to increase the fertility of the soil. Many studies have shown that organic farming practices improve soil fertility, increase microbial activity and biological processes that enhance the health of the soil.[8] Organic farming in Malaysia has been promoted since the mid-1990s, with research focused mainly on soil health, nutrient management, pest and disease control and the crop production system. This is to ensure that a holistic and sustainable farming model is developed by integrating various organic farming technologies through research and development and making those available for farmers to learn and train themselves.

Image: MARDI

Application of biochar-based compost in acid sulphate soil for rice cultivation

Organic farming can restore and protect the living soil and this translates into helping the world to increase food productivity by up to 80 per cent.[9] In addition, organic farming practices can also reduce the effects of global warming by minimizing the use of chemical fertilizers.[10]

Natural resources to improve soil mineral availability

One of the important concepts in organic farming is to adopt natural input practices. To help improve soil productivity and fertility, on-farm natural inputs are mainly used with additions of off-farm inputs such as indigenous micro-organisms (IMO), composts, fermented fruit and plant juices, fish amino acids and other home-made fertilizers. The regular addition of organic supplements to the soil can improve soil productivity and fertility. An empirical study was carried out to evaluate the changes in the soil's chemical properties after the application of IMO and a combination of various homemade fertilizers such as Fermented Plant Juice (FPJ), and Oriental Herbal Nutrient (OHN), under a natural farming system for long bean production in the two locations of Air Kuning in Negeri Sembilan, and Serdang in Selangor. The table opposite shows the differences in chemical and physical properties when organic amendments to soil and crops are made

Soil chemical and physical properties at the Air Kuning site

Soil Properties	Organic (NF)		Conventional (CF)	
	Before	After	Before	After
pH	4.48	4.95	4.07	4.35
Conductivity	37.1	40.8	24.2	30.5
Organic carbon (%)	1.95	3.20	1.82	2.05
Total N (%)	0.15	1.85	0.21	0.45
Available P (ppm)	38.2	45.9	37.4	35.9
CEC (meq 100g–1 soil)	4.55	6.25	3.78	4.21
Exchanged cations (meq 100g–1 soil)				
Potassium (K)	0.10	1.25	0.35	0.45
Calcium (Ca)	1.04	1.45	0.77	1.23
Magnesium (Mg)	0.18	0.26	0.15	0.10
Sodium (Na)	0.15	0.41	0.10	1.25
Bulk density (g/cm^3)	1.30	1.01	1.35	1.25

Source: Zulkefli, M et al., 2004

Soil chemical and physical properties at the Serdang site

Soil Properties	Organic (NF)		Conventional (CF)	
	Before	After	Before	After
pH	4.85	5.04	4.98	4.75
Conductivity	39.11	45.20	40.05	43.12
Organic carbon (%)	2.42	1.95	2.57	2.19
Total N (%)	0.16	1.25	0.15	0.09
Available P (ppm)	13.68	15.30	12.80	10.32
CEC (meq 100g–1 soil)	11.03	14.04	12.25	11.55
Exchanged cations (meq 100g–1 soil)				
Potassium (K)	0.10	0.25	0.14	0.16
Calcium (Ca)	1.15	3.30	1.35	1.09
Magnesium (Mg)	0.48	0.65	0.55	0.63
Sodium (Na)	0.10	0.86	0.13	0.15
Bulk density (g/cm^3)	1.28	1.25	1.30	1.27

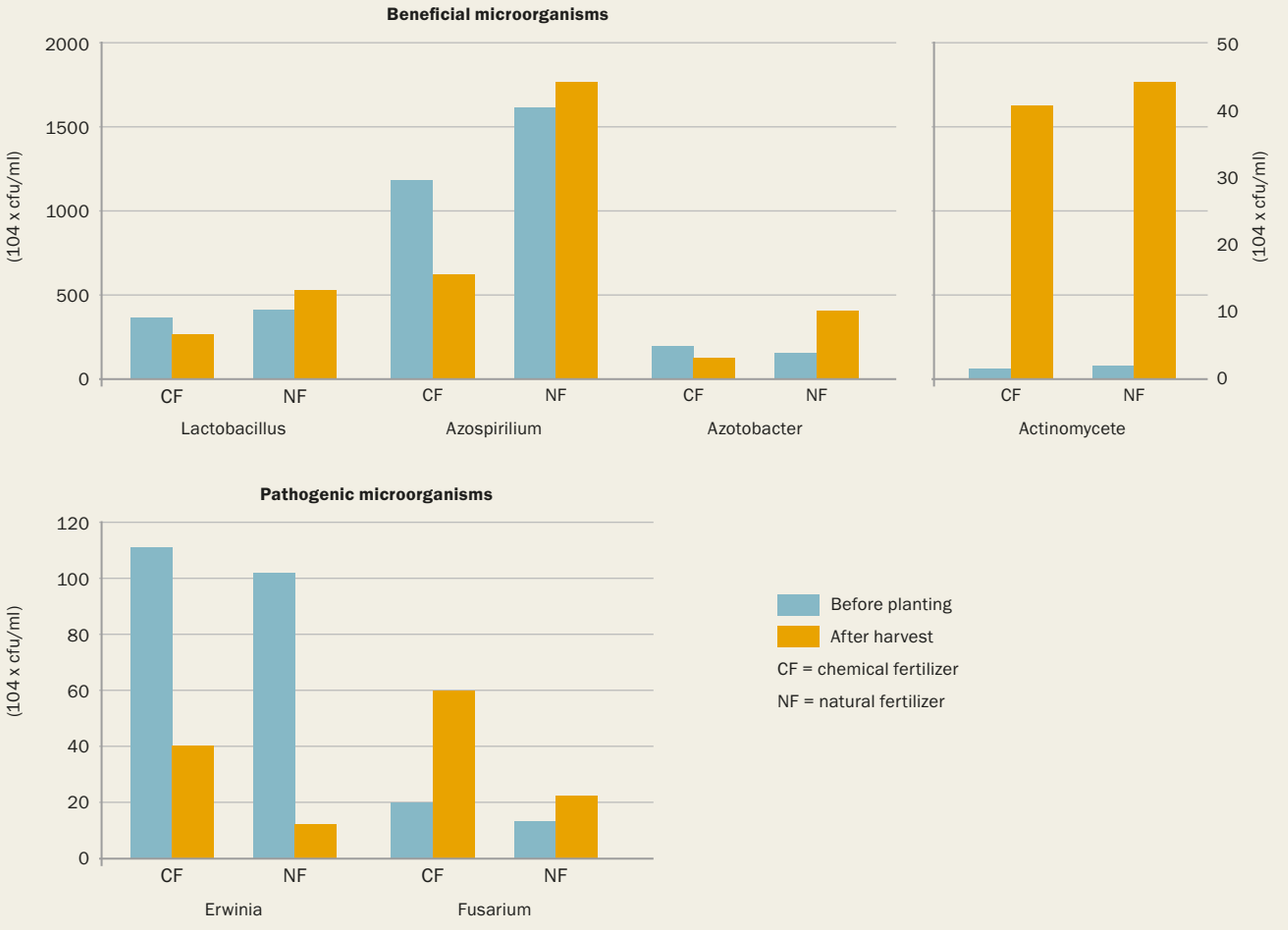
Source: Zulkefli, M et al., 2004

compared to conventional practices using chemical fertilizers. The results revealed that the soil's chemical properties improved after planting under natural farming practices at Air Kuning where the soil organic carbon increased from 1.95 to 3.20 per cent, and the available phosphorus and CEC increased by 20 and 37 per cent respectively. After a period two years, there was a substantial improvement in soil properties at the Air Kuning site under the organic amendment practices, a strong indication of the enhancement of soil nutrient status through organic matter application which, in turn, provides long-term benefits to soil fertility.

Enhancing the soil's microbial ecosystem

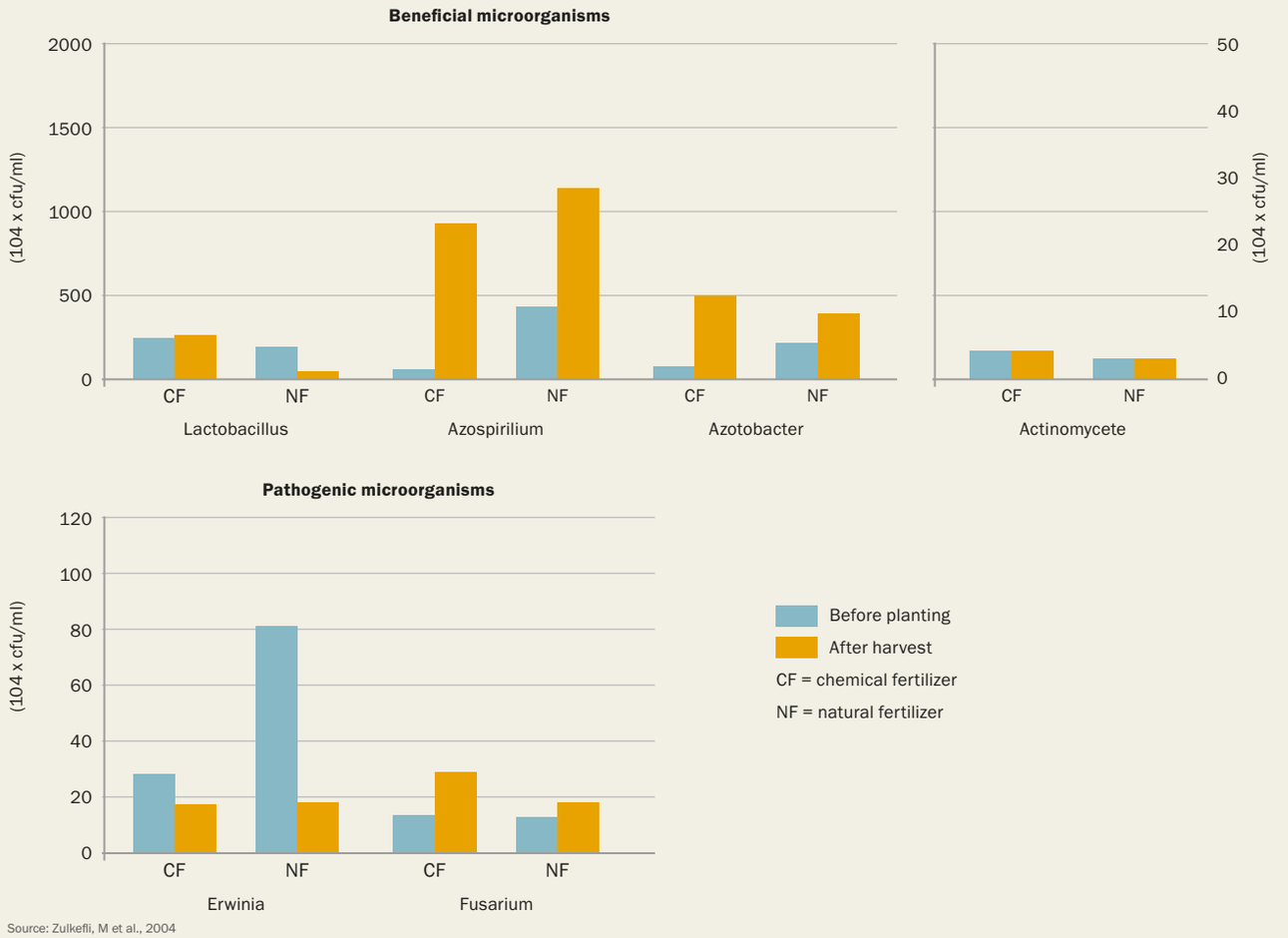
Chemical inputs can reduce pathogenic and parasitic nematodes but also decrease the fertility of soil.[11] Organic farming has been shown to increase the population of beneficial microbes such as the vesicular-arbuscular mycorrhizal fungi, known to enhance phosphorus absorption by host roots when compared to conventional farming.[12] The same study was carried out in Air Kuning and Serdang, where the two locations, using both organic as well as conventional practices with chemical inputs, indicated higher populations of soil microbial populations (either beneficial or pathogenic

Soil microbial population changes at the Air Kuning experimental site



Source: Zulkefli, M et al., 2004

Soil microbial populations at the Serdang experimental plot



Source: Zulkefli, M et al., 2004

Image: MARDI

Vermicompost production using rice husk waste

microbes) in plots applied with organic substances. At the organic plot on the Air Kuning site, the activities of beneficial microbes was found to be higher than that of the conventional farming site. The total population of two families of pathogens, Erwinia and Fusarium, is much lower in the organic farming site compared to the conventional farming site. This provides further evidence on the advantages and practicability of applying natural farming practices in sustaining and improving soil fertility, as higher levels of beneficial soil microbes are directly related to soil fertility.

The utilization of organic practices could improve the physical and chemical properties of the soil which then increases the activity of beneficial microorganisms.[13] The combination of organic matters and IMO can provide greater amounts of newly formed and readily decomposed nutrient fractions needed for the growth of more microorganisms,[14] which in turn results in higher amounts of soil microbial biomass and soil enzymes.[15] Repeated application of organic matter and IMO into soil helps maintain the microbial populations,[16] and effectively suppresses a wide range of soil-borne plant pathogens.[17] The application rate or concentration, frequencies, and timing seem to play an important role in the survival of beneficial microorganisms.

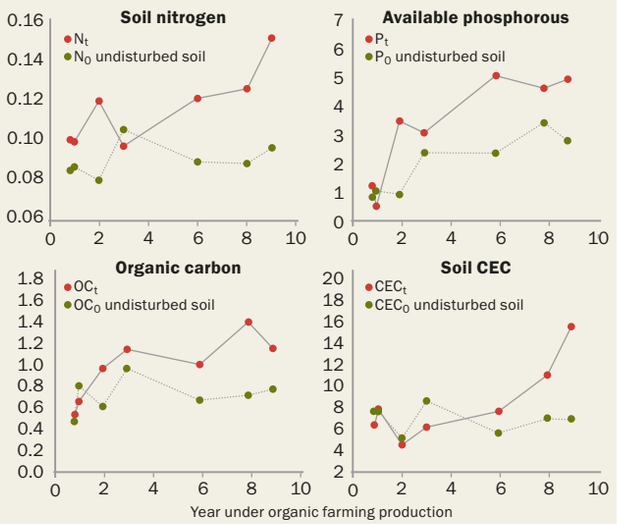
Increasing organic matter for healthy soil

In Malaysia, a long-term study on the soil fertility status of organic farming was carried out on soils collected from farms of varying ages of development. The study aims to discover the trends and the changes in the fertility of these soils. Topsoils were collected from seven sites that have been developed for organic farming over various periods of time. The farms are: Lojing, Cameron Highlands (10 months); Kenaboi,

Kuala Pilah (12 months); Zenxin Farm, Kluang (24 months); Zenxin Farm, Cameron Highlands (36 months); Loh Organic Farm, Semenyih (six and eight years); and Manson Valley, Cameron Highlands (nine years). An increase was observed in soil fertility status between the newer and the older farms in the organic production system over time. A low nutrient content, especially nitrogen, is observed in the early years of organic farming practices, but this increases significantly over time. Important increases in soil organic carbon, available phosphorous and exchangeable cations were observed in the nine-year-old farms, indicating that organic management practices have contributed to relative stability in soil electrical conductivity. In addition, the exchangeable potassium, carbon, magnesium and sodium in the soil also increased significantly with time.

In an attempt to improve soil fertility in problematic soils in Malaysia, the application of organic matter through biochar, compost and organic fertilizer was investigated on BRIS and acid sulphate soil in the Kelantan region on the country's east coast. Rice husk biochar produced via a gasification process in a local rice mill was used as it has physico-chemical properties that are able to neutralize the acidic nature of soils and contribute positively to the retention of water for the sandy soils. The positive effects of the organic amendments for corn and rice crop production under sandy and acid sulphate soils respectively are mainly due to acidity alleviation and increased availability of nutrients and water. These improvements also affect the biology of the system, offering a favourable habitat for microorganisms.[18] The application of biochar-based bio organic fertilizer in acid sulphate soil for rice cultivation increased the physico-chemical and biological properties of the soil. The initial soil pH in the study location was below 3.8, with a calcium/aluminium ratio of 1.2, indicating active aluminium in the soil which can be a major factor affecting the efficient supply of soil nutrients to crops. The changes in soil properties showed that plots treated with biochar organic matter were particularly able to improve soil pH, CEC, total microbial count and calcium/aluminium activities, with sustained positive effects until the harvest period.[16]

Levels of nitrogen, organic carbon, available P and exchangeable cations in nine-year-old farms



Source: Zulkefli, M et al., 2004

Image: MARDI

Biochar compost production using oil palm empty fruit bunch (EFB), palm oil mill effluent (POME) and biochar in the fertilizer processing factory

Image: MARDI

Application of biochar-based compost to sandy soil for cabbage cultivation

Conclusion

Organic approaches and the application of organic matter such as compost, biochar and bio fertilizer not only rejuvenates depleted soil but keeps it healthier by enriching microbial biodiversity. Studies carried out for organic farming practices in Malaysia highlight the fact that the sustainable use of soil and preservation of environmental sustainability are key factors in obtaining food security for future generations. There has been a focus on organic farming in the country for many years but there is still room for expansion. Current research and development activities undertaken by MARDI are looking at many aspects of the organic farming approach and its successful application by farmers.

To ensure sustainability in organic farming, knowledge transfer through seminars and hands-on training, especially on soil and nutrient management, is being carried out for the benefit of Malaysian organic farmers. The commercialization of technical research products carried out by MARDI for local fertilizer manufacturing companies is also altering the requirements of organic fertilizers for sustainable crop production in the country. Enhancing the use and application of organic fertilizer will reduce the import of chemical fertilizers into the country which will be positive to Malaysia's balance of trade as well as preserving the environment for future generations.

The power of collective action among water vulnerable communities in rural India

Dr. P.M. Ghole, Chief General Manager; Dr. A.R. Khan, General Manager,
National Bank for Agriculture and Rural Development

Water, one of the most necessary resources for the sustenance of life, is central to the socio-economic development of mankind. India, with 2.4 per cent of the world's total geographical area and 18 per cent of the world's population, has only 4 per cent of the world's total fresh water resources. Of the 4,000 billion cubic metres (bcm) of annual rainfall within the country, the estimated utilizable resources are only 1,123 bcm, or 28 per cent of the total, due mainly to hydrological, topographic and other physical constraints. Sources include 690 bcm of surface water and 433 bcm of groundwater. As of 2010, the cumulative water utilization by all sectors of the economy was 702 bcm, of which the agriculture sector alone consumed around 78 per cent. Given that more than 55 per cent of agriculture in India is rainfed, resources still depend on the variabilities of the monsoon.

With rapid population growth, urbanization and improvement in living standards, water requirements are increasing in all sectors, posing a challenge for fair allocation. The national per capita annual water resource in India during 2001 was 1,816 m^3, falling to 1,544 m^3 in 2010[1]. According to international standards, conditions that dictate less than 1,000 m^3 per capita create the official designation of water scarcity. It is estimated that, by 2050, the total water demand from all sub-sectors, of 1,180 bcm, will surpass the total utilizable water resource of the country[1] and the share of irrigation will reduce to 68 per cent. Climate change is likely to further aggravate the availability of fresh water due to extreme weather conditions and reduced recharge, adversely impacting agricultural productivity. Hence, improving water use efficiency is one of Indian agriculture's key priorities. As of 2018, the average efficiency of surface water irrigation is 35–40 per cent, and approximately 55 per cent in the case of groundwater irrigation.

Each year, large swathes of India are forced to combat acute water shortage due to changing weather conditions, unsustainable water use, deteriorating water quality and the ever increasing demand by both industry and agriculture. Also affecting the nation's delicate water ecosystem balance are a debilitating mix of other factors such as over-exploitation of groundwater, disproportionate use of chemical fertilizers and pesticides in agriculture and unsafe disposal of industrial wastes into fresh water. While several schemes have been initiated to reduce water scarcity issues at government level, problems continue to expand in the face of changing demand patterns and climate variability.

Given these hardships, the National Bank for Agriculture and Rural Development (NABARD), an apex-level develop-

Image: NABARD

School children on a campaign rally, Khatoli Talli Village, Champawat District, Uttarakhand

Image: NABARD

Digging a well, Gogharpura village, Mandsaur district, Madhya Pradesh

Image: NABARD

Pond desilting in Paladi village, Nagaur district, Rajasthan

ment finance institution in India, felt that the precariousness of the conditions demanded a strategic shift in approach, from supply-driven to demand-based and community-led initiatives along with stakeholders' sponsored programmes. So, following over three decades of collaboration with multiple stakeholders on transformational initiatives, including watershed development activities and community mobilization programmes for microfinance activities, NABARD decided that a water conservation campaign should be initiated. The initiative became perhaps the largest ever such campaign undertaken by an institution in India.

The Water Conservation Campaign

NABARD launched its Water Conservation Campaign in March 2017, aiming to cover 100,000 villages in the most vulnerable and water stressed areas, including those with over exploited groundwater blocks, across 250 of the most vulnerable districts in the country. The areas were identified based on a vulnerability assessment report made by the Central Research Institute for Dryland Agriculture. One of the distinctive features of the campaign was the active participation of political leaders, ministers and senior bureaucrats from central and state governments, banking and academic institutions, and extension agencies together with local water experts and scientists, civil society organisations, NGOs and farmers' organisations.

The broad objectives of the campaign were to create awareness of the various techniques of water conservation, preservation, judicious utilization, and efficient management; the adoption of available technologies for enhancing water productivity; promoting investments in water efficient technologies; rainwater harvesting and improved water conservation and management practices; increasing the adaptive capacity of farmers against the adverse impact of climate change; promoting climate-resilient agriculture; and ensuring the improved availability of water, thus contributing to enhancing agricultural productivity and farmers' incomes. In line with these objectives, appropriate messages set in local languages were created in the form of posters, pamphlets and banners depicting the technical specifications of various water conservation and management structures together with their field applications. These materials were used during village level events as aids to sensitize villagers to various technological and cost-effective crop management options for addressing the water issues.

In its early stages, the campaign focused on creating awareness among the rural community of various methods of water conservation, preservation and efficient utilization at different levels. The campaign highlighted the benefits of adopting an improved package of agronomic practices, modern technologies such as micro irrigation (more crop per drop) and embracing traditional water management practices with a focus on voluntary initiatives for the village communities.

The frontrunners of the campaign comprised 8,000 water ambassadors (Krishi Jal Doots) and 200 master trainers, who were identified and trained for localized and personal engagement at field level. These individuals, who were trained in effective communication strategies, technical inputs on water management through community actions, and networking strategies, were deployed to run the campaign at village level from April to July 2017, a critical period of water shortage in large parts of the country. A team of two Krishi Jal Doots were deployed to cover a cluster of 25 villages along with officials of the local panchayat, bank branches, extension agencies and water activists. Approximately 500 villages were covered under the campaign in each district.

An exciting feature of the campaign, and something that brought together the young and the old, was the "A day in

Image: NABARD

Village resource mapping exercise, Paladi village, Nagaur District, Rajasthan

the village" programme, comprising activities such as walkathons, water resources mapping, discussions on water related issues, voluntary community actions and identification of village level volunteers for follow-up. The water resource mapping activity received an overwhelming response, and the participatory nature of its preparation and presentation facilitated an important visualisation of the available resources in a village. The mapping captured information on existing, as well as projected, water-related structures in the villages, and identified roles and responsibilities for the village community and the delivery system for enabling the structures to function effectively. It also focused on the possible areas of support through credit interventions and convergence strategies. The resource maps and action plans prepared during the campaign, together with the profile of village volunteers, were uploaded to a web portal specially designed to monitor the activities on a real-time basis.

As a result of the campaign, village communities in many parts of the country undertook long term investment activities such as desilting and the deepening of village ponds, tanks, drains, and streams, the clearing of water courses, construction of bunds, recharging pits and farm ponds, reviving traditional water bodies and tree plantation, all through the voluntary contribution of labour. This was most pronounced in the states of Telangana, Himachal Pradesh, Rajasthan, Uttar Pradesh and Chhattisgarh. Further, the self-realization of the effectiveness of simple farm-based interventions and technologies among the villagers, and the activation of the voluntary spirit to adopt these technologies, has been one of the most impressive outcomes of the campaign.

Following the village level campaign, district and state level debriefing sessions were organized with the participation of state government departments, senior bank officials and other major stakeholders to expand the vision and outreach of the initiative at both district and state levels. The feedback received in these sessions, together with the action plans that evolved during the campaign, consolidated the major achievements, important lessons learned, and possible areas of development interventions for improving the socio-economic status of the rural space. These action plans were shared with state government departments, banks, corporations and other development partners for integrating with their own development plans, making it a truly meaningful and collaborative initiative as well as creating the desired impact on the ground. Further, the area development credit plans, prepared as a sequel to the campaign in various districts, were integrated with the district credit plans for facilitating a flow of bank credit to irrigation and water management activities.

Summary

The water conservation campaign eventually went on to cover 101,569 villages across 250 districts in 21 states. During the rollout of this pan-India programme, the master trainers and water ambassadors motivated and energized village communities to undertake water conservation meas-

ures on a voluntary basis. Its voluntary nature became the essence of the entire programme, creating much needed awareness of the various cost-effective techniques and farm practices for water conservation and its efficient management of recharging groundwater, rain water harvesting and recycling of waste water. It created a demand for adoption of a range of proven technologies such as micro irrigation, farm ponds, check bunds and dams, mulching and climate-smart agriculture on individual farmers' fields.

The campaign was at its most palpable at village level where the connection with the state level system operation was understood. This awareness has created pressure on the existing delivery systems to perform more efficiently and promote greater flow of public resources for creating efficient rural infrastructure, including irrigation and water resources. The campaign reinforced the importance of community participation and mass mobilization efforts in disseminating knowledge of simple techniques in irrigation efficiency improvement, better crop planning and the efficient use of local resources through voluntary individual and collective action. The key lessons emerging from the campaign, are now being crystallised by NABARD to introduce suitable policy guidelines for more focussed and targeted interventions to achieve its long term objectives.

Image: NABARD

Awareness engagement, water conservation campaign, Uttar Pradesh

Image: NABARD

Digging a new pond, Kirbil village, Sonebhadra District, Uttar Pradesh

Image: NABARD

Mulching process at a NABARD wadi (orchard) project, Billage Kanadar village, Sabarkantha District, Gujarat

Awarding scientific innovation in water research to secure our quality of life on land

Abdulmalek A. Al Alshaikh, General Secretary, Prince Sultan Bin Abdulaziz International Prize for Water

The Prince Sultan Bin Abdulaziz International Prize for Water (PSIPW) is a leading scientific award, offered every two years, that focuses on innovation. Since its establishment in 2002 by HRH Prince Sultan Bin Abdulaziz (1930–2011), PSIPW had given recognition to scientists, researchers and inventors around the world for pioneering work that addresses the problem of water scarcity in creative and effective ways.

To this end, PSIPW offers a suite of five prizes, covering the entire water research landscape. First, there is the Creativity Prize, worth US$ 266,000, which is awarded for cutting-edge interdisciplinary work that can rightly be considered a breakthrough in any water-related field. Then there are four specialized prizes, each worth US$ 133,000: the Surface Water Prize, the Groundwater Prize, the Alternative Water Resources Prize, and the Water Management and Protection Prize.

Nominations are evaluated by an international panel of distinguished scientists who serve on various committees for each of the five prizes. Nominations undergo a rigorous three-tiered evaluation process, starting with a preliminary evaluation committee, followed by a referee committee, and ending with a final selection committee.

Even though PSIPW is a prize dedicated to water, much of the award-winning work is directly relevant to United Nations Sustainable Development Goal 15, which is to "protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss". Many of the prizewinners have made substantial contributions to the understanding of desertification, soil erosion, biodiversity loss, and how to better preserve terrestrial ecosystems.

The official announcement of the winners of PSIPW's eighth award was made by PSIPW Chairman HRH Prince Khaled Bin Sultan Bin Abdulaziz on 20 June 2018 at the opening ceremony of UNISPACE+50. PSIPW has a close relationship, and a memorandum of understanding, with the United Nations Office for Outer Space Affairs (UNOOSA) and a substantial number of PSIPW's prizewinners throughout the years have relied heavily on space technologies to achieve their innovative water management solutions. PSIPW also has special consultative status with the United Nations Economic and Social Council (ECOSOC) and is an observing member of the UN Committee for the Peaceful Uses of Outer Space (UN COPUOS).

People, water resources, and the land

Dr. Günter Blöschl of the Vienna University of Technology and Dr. Murugesu Sivapalan of the University of Illinois at Urbana-Champaign were awarded the 2018 Creativity Prize for launching a groundbreaking new paradigm to understand the emergent anthropocene. Named sociohydrology, this new approach focuses on the dynamic interactions and bi-directional feedback between water systems and people by studying the effects of societal actions on hydrology and the effects of hydrological phenomena on societal development. Through their joint efforts, Dr. Blöschl and Dr. Sivapalan have demonstrated the power of this approach for predicting long-term human–flood dynamics and agricultural land degradation, as well as for addressing many vexing challenges posed by population growth and climate change.

Understanding evaporation from the natural landscape

Dr. Wilfried Brutsaert of Cornell University won the Surface Water Prize in 2018 for developing a method using the nonlinear complementary principle to generate unprecedented and accurate estimates of evaporation from the natural landscape that can be applied over a large-scale in various types of terrain. His work illustrates the power of the underlying complementary principle to resolve the question of global evaporation trends under climate change conditions.

Predicting floods and protecting coastal populations

Dr. Peter J. Webster of the Georgia Institute of Technology won the Creativity Prize in 2016 for applying his extensive work on ocean-atmosphere interactions and their effects on monsoon strength to provide one- to two-week lead time forecasts of monsoonal floods that often provoke catastrophic inundations in highly populated coastal regions. By combining weather forecasts from the European Centre for Medium Range Forecasting (ECMWF) with a river runoff model to forecast river flow as well as the inundation following the flood front, he was able to predict, with remarkable accuracy, the floods that have devastated Bangladesh, Pakistan, Thailand, and India over the past several years.

Deepening our understanding of soils

Dr. Martinus Theodorus van Genuchten of the Federal University of Rio de Janeiro won the 2018 Groundwater Prize for the development and application of key theoretical and software tools that describe water flow and contami-

Winners of the Prince Sultan Bin Abdulaziz International Prize for Water, 2018

The award winners of the Prince Sultan Bin Abdulaziz International Prize for Water, 2018 were announced on 20 June 2018 at the opening ceremony of UNISPACE+50.

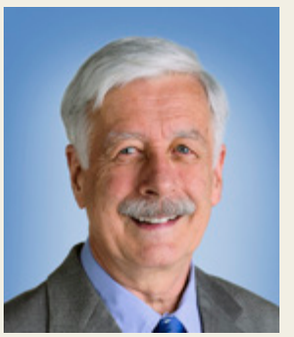
Source: PSIPW

Creativity Prize
Dr. Andre Geim and Dr. Rahul Nair (National Graphene Institute, Manchester University) for developing novel graphene oxide membranes that promise to enable energy-efficient and high-volume water filtration and desalination.

Surface Water Prize
Dr. Wilfried Brutsaert (Cornell University) for developing, demonstrating, and validating a new theory that can generate unprecedented estimates of evaporation from the natural landscape.

Creativity Prize
Dr. Günter Blöschl (Vienna University of Technology) and **Dr. Murugesu Sivapalan** (University of Illinois at Urbana-Champaign) for developing the new field of sociohydrology, a groundbreaking paradigm for water management and a new validated approach for studying the dynamic interactions and bi-directional feedback between water systems and people.

Alternative Water Resources Prize
Dr. Omar Yaghi (University of California, Berkeley) and **Dr. Evelyn Wang** (MIT) for creating a solar-powered device that uses an innovative porous metal-organic framework (MOF) to capture water from the atmosphere.



Groundwater Prize
Dr. Martinus Theodorus van Genuchten (Federal University of Rio de Janeiro) for the development and application of key theoretical and software tools that describe water flow and contaminant transport in the subsurface.

Water Management and Protection Prize
Dr. Jim W. Hall and Dr. Edoardo Borgomeo (Environmental Change Institute, University of Oxford) for developing and applying a new risk-based framework to assess water security and plan water supply infrastructure in times of climate change.

nant transport in soil. Software tools include RETC, CXTFIT, STANMOD and especially the HYDRUS codes. The HYDRUS family of codes are now the industry standard for modelling variably saturated flow and solute transport problems of all types. He also developed the van Genuchten functions, which are the standard for quantitative descriptions of the hydraulic properties of unsaturated porous media, including hydraulic conductivity. In addition, he developed the concept of mobile and immobile fluids to describe flow and transport processes in structured soils and fractured rock. Taken together, this work shows him to be one of the most influential vadose zone hydrologists in the world today.

River systems and land management

Dr. Gary Parker of the University of Illinois Urbana-Champaign, one of the world's premier river geomorphologists, won the surface water prize in 2016 for clarifying the problem of meandering rivers, a field that has long been an uncharted territory of geomorphology and sediment transport. His work contributes to our understanding of the shapes that rivers take and how they change themselves and their floodplains as they migrate, eroding the sediment of which old land is composed, and creating new land by emplacing fresh sediment. His research provides models and effective tools for understanding the processes of meandering and predicting width variation patterns in river systems. On a practical level, the work enables knowing what is going to happen in a reconfigured watershed before observing it.

Climate change and desertification

In 2012, Dr. Kevin Trenberth and Dr. Aiguo Dai from the National Centre for Atmospheric Research in the US won the Surface Water Prize for their groundbreaking work that provides a powerful estimate of the effects of climate change on the global hydrological cycle, with a clear explanation of the global water budget. Their work provides powerful predictions about how hydrologic variability brought on by climate change will affect patterns of desertification in the twenty-first century.

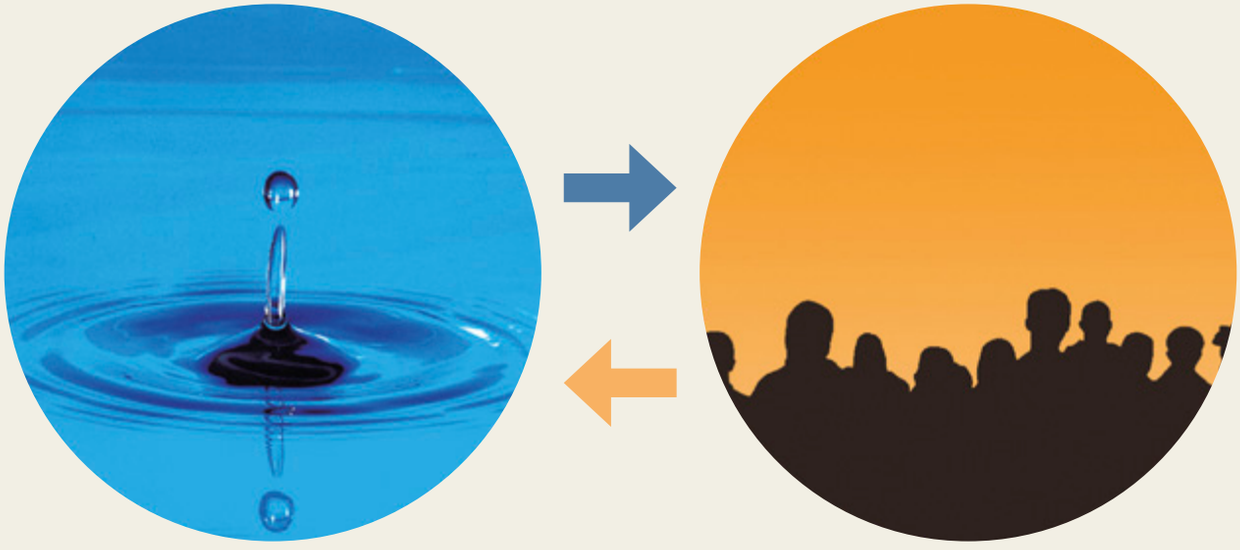
Human activity and desertification

In 2010, Dr. Ignacio Rodriguez-Iturbe of Princeton University and Dr. Andrea Rinaldo of the École Polytechnique Fédérale de Lausanne in Switzerland won the Creativity Prize for their invention and development of the new field of ecohydrology that bridges the gap between the physical and life sciences. Ecohydrology is a multidisciplinary research field that draws from the physical sciences and life sciences to provide a unified picture of water-supported biological dispersion. In practical terms, the new research field presents itself as a comprehensive blend of theory (mathematical modelling), interpretation of past and present biological records, and field experimentation. Ecohydrology is a powerful tool in combating desertification, since human activities alter the linkages between climate, ecosystem functioning and water availability in arid lands. Dryland ecohydrology directly tackles the crucial question of whether human beings cause deserts.

Other PSIPW initiatives

Besides awarding its suite of prizes every two years, PSIPW is active in numerous water-related projects, some of which focus on combating desertification, community development and sustainable agriculture through the restoration and rehabilitation of degraded land. Among the joint initiatives between PSIW and UNOOSA is the International Conference on the Use of Space Technology for Water Management, held every three years in various countries around the world, and the UN Space and Water Portal, an online hub for professionals and organizations working with space technology applications for water-related activities.

Sociohydrology — an interdisciplinary field studying the dynamic interactions and feedback between water and people



Source: PSIPW

Caribbean Small Island Developing States — a response to sustainable land management

Calvin James, Executive Director, Partnership Initiative for Sustainable Land Management

Land degradation is a serious and significant problem in the Caribbean Small Island Developing States (SIDS). The types and causes are essentially the same throughout the sub-region but the extent and severity differs from one island state to the next.

The United Nations Convention to Combat Desertification (UNCCD) provides the global framework for addressing land degradation and sustainable land management issues in the SIDS. Given the scope of this initiative, if used effectively it could contribute significantly to the attainment of the Sustainable Development Goals' (SDGs) objectives of poverty eradication and food security.

To enable the Caribbean SIDS to respond to these challenges, a Partnership Initiative on Sustainable Land Management (PISLM) was initiated. The PISLM was formulated as an integral and technical part of the Caribbean SIDS Programme, mandated by The Forum of Ministers of Environment for Latin America and the Caribbean at their fourteenth meeting in 2003, with a view to providing a framework for the implementation of the UNCCD and the land management components of the Barbados Programme of Action (BPOA) and the Mauritius for the Further Implementation of the BPOA (MS/BPOA) initiative in the Caribbean SIDS.

At the Caribbean Sub-regional Workshop on Land Degradation of 2004, where the PISLM was inaugurated, a partnership declaration of Caribbean small island developing and low-lying coastal states was adopted. It called for the establishment of an interim sub-regional task force comprising country parties represented by the respective national focal points of the UNCCD, GM/UNCCD, UNCCD Secretariat, UNEP and other strategic partners.

The first meeting of the sub-regional task force, together with the extended task force meeting of participating agencies and Latin American countries for enhancing South-South cooperation between Latin American and Caribbean SIDS, was held in 2005 and focused on the following main areas:

- Formalizing the institutional arrangements and relations of the partnership initiative
- Drafting operational guidelines for a PISLM support office
- Reviewing the components of the initiative, in particular the implementation of targeted Global Environment Facility (GEF) projects
- South-South cooperation between Latin America countries and Caribbean SIDS in land management.

The task force suggested the establishment of a support unit to coordinate the activities of the PISLM, for which the government of the Republic of Trinidad and Tobago has been nominated. More specifically, the task force identified the Caribbean Network for Integrated Rural Development (CNIRD) located in Trinidad and Tobago as being the best possible unit for hosting the support unit for the PISLM.

At the 25th special meeting of the Council for Trade and Economic Development (COTED) held in 2008, it was decided that the PISLM should be used as the framework for the implementation of the UNCCD initiatives, and the land management components of the BPOA and MSI/BPOA in the Caribbean SIDS, to all practicable purposes. All Member States and relevant regional and international organizations were urged to support and participate actively in this initiative, particularly as it seeks to address issues relating to rural development and poverty alleviation in the Caribbean SIDS rural sector.

Today, the PISLM of the Caribbean SIDS is an independent inter-government organization with the PISLM Support Office acting as its secretariat.

SDG 15.3

The twelfth session of the Conference of Parties (COP) of the UNCCD, held in Ankara, Turkey in 2015, endorsed SDG target 15.3 and the concept of land degradation neutrality (LDN) as a strong vehicle for driving the implementation of the convention. It invited all UNCCD country parties to formulate voluntary targets to achieve LDN and requested UNCCD bodies to provide guidance for formulating national LDN targets and initiatives and to facilitate the use of the

The PISLM parties

The Caribbean parties
Antigua and Barbuda, Bahamas, Barbados, Cuba, Commonwealth of Dominica, Dominican Republic, Grenada, Guyana, Haiti, Jamaica, Saint Kitts and Nevis, Saint Lucia, Saint Vincent and the Grenadines, Suriname, and Trinidad and Tobago.

Civil Society Organizations
The UNCCD Secretariat, The Global Mechanism of the UNCCD (GM/UNCCD), UN Environment/Regional Office for Latin America and the Caribbean, the UN Food and Agriculture Organization Caribbean sub-regional office, the Caribbean Community (CARICOM) Secretariat, and The University of the West Indies.

Image: PISLM

Open pit mining, Guyana

UNCCD indicator framework as a contribution to the monitoring, evaluation and communication of progress towards the national LDN targets.

Decisions 2 and 3 of COP12 stated that:

- Striving to achieve SDG target 15.3 is a strong vehicle for driving implementation of the UNCCD
- LDN is defined as a state whereby the amount and quality of land resources necessary to support ecosystem functions and services and enhance food security remain stable or increase within specified temporal and spatial scales and ecosystems
- Countries are invited to formulate (national) voluntary targets to achieve LDN
- UNCCD bodies are requested to i) provide guidance for formulating national LDN targets and initiatives; and ii) facilitate the use of the UNCCD indicator framework as a contribution to the monitoring, evaluation and communication of progress towards the national LDN targets.

In response to these decisions, the Global Mechanism and the UNCCD Secretariat have jointly established a global programme in support of a national voluntary target setting for LDN. The main objective of the programme (LDN-TSP) is to enable country parties to define national baselines and to identify targets and measures to achieve LDN by 2030.

The Caribbean's response

The PISLM support office was contracted through its executive director, Mr Calvin James, in his capacity as the national expert, to support the implementation of the LDN-TSP by providing technical backstopping to the national LDN target-setting process in selected countries.

Country parties from the Caribbean (Annex III) that have committed to setting LDN targets

1 Antigua and Barbuda
2 Belize
3 Dominica
4 Guyana
5 Haiti
6 Jamaica
7 St. Kitts and Nevis
8 St. Lucia
9 St. Vincent and the Grenadines
10 Suriname
11 Trinidad and Tobago

As national expert, the PISLM support office backed the national focal point of the UNCCD throughout the implementation of the LDN target-setting process at national level, including:

- Drafting a country-specific work plan and detailed budget
- Supporting the establishment and functioning of the LDN national working group
- Leading the country analysis (desk review) to assess the UNCCD implementation enabling environment, linking to other relevant processes including UNCCD's NAP SWOT analysis and alignment process; Integrated Investment Frameworks for Sustainable Land Management; National Development Plans; UNFCCC's NDC; CBD's NBSAPs, and national DRR; FIP; PPCR and FLR portfolios; and mainstreaming LDN into the national SDG agenda
- Effectively supporting the
  – Technical data processing unit in charge of standardizing the LDN country database

  - Extraction of data from global and national databases, and the identification of higher resolution data needs, as appropriate
  - Establishment of LDN baselines at national and subnational levels in order to enable the LDN target-setting process
- Identifying priority areas for immediate LDN actions, covering all land degradation processes significantly present in the country
- Articulating, as appropriate, national voluntary targets and associated measures for review and validation by the LDN National Working Group.

Image: PISLM

Land degradation issues resulting from an abandoned mine, Guyana

Image: PISLM

Survey of damage after Hurricane Maria, Dominica

Climate change impacts and responses

The case of the Commonwealth of Dominica

Dominica is a small volcanic Island state with one of the lowest population densities and the most intact forest cover in the Caribbean. This nature island with its eight active volcanoes and the only boiling lake in the Western Hemisphere, possesses tremendous terrestrial and marine biodiversity and exhibits a high level of endemism. Situated in the Caribbean Sea, south of Guadeloupe and north of Martinique, Dominica is very mountainous, being of volcanic origin, and measures 47 km by 22 km, covering 751 km^2.

The relief is extraordinarily abrupt with highly dissected terrain, numerous steep or precipitous slopes and with relatively little flat land. Estimates of land slope classes as a percentage of the total area indicate that 85 per cent of the land is very steep or mountainous, 13 per cent is steeply undulating and 2 per cent is flat or gently undulating.[1]

Land use in Dominica can be classified into three broad categories: arable land (land cultivated for crops that are replanted after each harvest) 8 per cent; permanent crops (land cultivated for crops such as citrus, coconut, coffee and cocoa) 24 per cent; other (any land not arable or under permanent crops, including permanent meadows and pastures, forests and woodlands, built-on areas, roads, and barren land) 68 per cent.

Hurricanes and other extreme weather events have historically imposed significant costs on the Dominican economy, leading to major declines in GDP growth and general productivity. The Commonwealth Vulnerability Index rates Dominica as having the sixth (out of 111 countries evaluated) most vulnerable economy (to external shocks and natural hazards) in the world, and the most vulnerable in the Caribbean. Average annual economic losses associated with extreme hydro-meteorological events are equivalent to approximately 7.4 per cent of GDP.

Dominica's agricultural sector remains painfully vulnerable to natural disasters and climate variability. Every year, farmers lose a significant portion of their crops and livestock during the six-month hurricane season, and the World Bank reports that agriculture's share of GDP in Dominica has fallen consistently with each major natural disaster, with the sector failing to recover previous levels of relative importance.

The past ten years have produced a repeated series of highly destructive storm impacts to the island. Hurricane Dean in 2007 caused extensive damage, estimated at 58 per cent of GDP, or US$ 162 million, with significant damage to buildings and infrastructure; and in 2015 tropical storm Erika produced an extraordinary rainfall event and high intensity winds that resulted in damage and losses of US$ 483 million, equivalent to over 90 per cent of Dominica's GDP. Most recently, Hurricane Maria, which made landfall in Dominica in September 2017 as a Category 5 hurricane with maximum sustained winds of 160 mph (260 km/h), devastated the country's infrastructure, ecosystems, and economic production. The storm's winds, which were the most extreme to ever impact the island, defoliated nearly all vegetation, splintering or uprooting thousands of trees and decimating the island's lush rainforests. The agricultural sector was almost completely wiped out, with 100 per cent of banana

and coconut plantations lost; vast numbers of farm animals killed; large amounts of farm equipment destroyed; and all of the country's agricultural and forestry stations and nurseries either destroyed or severely damaged. The Agriculture Division and Forestry Department also lost much of its equipment and computer and paper records. Estimates of the total damage to the agriculture sector are around US$ 500 million, including US$ 20 million for infrastructure.

In response, the Prime Minister of the Commonwealth of Dominica, The Honourable Roosevelt Skerrit noted that Dominica now has no choice but to pursue a climate resilience strategy. As a result, two initiatives were put into effect to meet this new policy mandate — the creation of the Climate Resilient Execution Agency of Dominica (CREAD) and the creation of a new body, the Ministry for the Environment, Climate Resilience, Disaster Management and Urban Renewal.

The PISLM has partnered with the Ministry for the Environment, Climate Resilience, Disaster Management and Urban Renewal, through the Environmental Coordinating Unit (ECU), to develop and implement, in collaboration with UN Environment, a GEF-funded project entitled "Strengthening resilience of agricultural lands and forests in Dominica in the aftermath of Hurricane Maria". The objective of the project is the landscape surrounding Morne Trois Pitons National Park, focusing on participatory forest rehabilitation and restoration, sustainable agricultural practices, and the development of livelihoods options. This project is officially slated for implementation in 2019.

However, in June 2018, the PISLM commenced a GEF-funded project entitled "Sustainable Land Management in the Commonwealth of Dominica", with the objective to develop an integrated land management model that includes agriculture, forestry and natural resources management practices to generate development and critical environmental benefits in tandem.

Image: PISLM

Denuded forests, exposing soil on the hillside, Dominica

Image: PISLM

Extensive damage caused by Hurricane Maria, Dominica

Ecological restoration of forest ecosystems through the Chilean National Strategy on Climate Change and Vegetation Resources

José A. Prado and Wilfredo Alfaro, National Forestry Commission (CONAF), Ministry of Agriculture of Chile

The Atacama Desert in the northern part of Chile is the driest and oldest desert in the world, but it is advancing south, covering more areas of the country. The Coquimbo Region in the centre of Chile is on the border between the northern, hyper-arid zone and the southern, Mediterranean zone, and is within one of five priority Mediterranean areas of global significance for biodiversity conservation. The region has become an icon of the fight against desertification in Chile.

The region contains three main river basins — the Elqui in the north; the Limarí in the centre; and the Choapa in the south. The region is home to 176 agricultural communities, of which there are 178 in the entire country, where the peasants are landholders of a total area close to one million ha. In the Limarí River Basin at the region's core, agricultural communities at Peñablanca (White Rock), Cerro Blanco (White Mountain) and Rinconada de Punitaqui (Punitaqui's Corner) have developed an initiative to reverse climate change, desertification, land degradation, drought and biodiversity losses by integrating strategic activities of ecological restoration in forest ecosystems as a means to improve the land conditions for food production.

The National Strategy on Climate Change and Vegetation Resources 2017–2025, and the National Action Programme to Combat Desertification in Chile 2016–2030, both have the prime objectives of reducing the advance of the desert and reversing the impact on livelihoods from climate change, desertification, land degradation and drought.[1,2] During 2015, with the participation of more than 3,600 people throughout the country, a full set of measures was agreed for action at all levels in the Coquimbo Region. These activities, encompassed within the national strategy, set out to coherently combat the impacts and drivers of change. As a result, a partnership between local communities, national organizations and international cooperation agencies began initiatives in the region to recreate the former conditions of food production by the restoration of forest ecosystems.[3]

Agricultural communities have implemented those initiatives with the support of the Chilean government as part of its commitment to multilateral agreements with the United Nations Framework Convention on Climate Change (UNFCCC), the Convention on Biological Diversity (CBD), United Nations Forum on Forests (UNFF), and United Nations Convention to Combat Desertification (UNCCD). These activities are also included as an integral part of the nationally determined contributions of Chile to the Paris Agreement of the UNFCCC, as well as contributing to Sustainable Development Goal (SDG) 13 on climate change, and SDG 15 on living land, especially targeting SDG 15.3 on working to achieve a land degradation-neutral world.

Pilot projects run within these agricultural communities have been funded by international organizations such as CBD, European Union, Global Environment Facility, United Nations Collaborative Programme on Reducing Emissions from Deforestation and Forest Degradation in Developing Countries, United Nations Development Programme, United Nations Environment Programme, World Bank, the governments of Chile, Korea, and Switzerland, and private companies, with a total investment close to US$ 3 million.

The Agricultural Community, *Comunidad Agrícola*, is a special legal designation for land tenancy in Chile. The communities in the Coquimbo Region are characteristic of those governed by this tenancy agreement, which was established mostly by a process of agrarian reform in the last half of the twentieth century on substantial areas of land inherited from the Spanish colonial period. Large areas are held as common ground by these communities, with each of its members holding a very

Image: CONAF

Schematic representation of the ecological restoration of a forest ecosystem, created for community education in the Peñablanca Agricultural Community, Coquimbo Region, Chile

Image: CONAF

Ecological enrichment of a relic cloud forest, carried out during the desert bloom (*Desierto Florido*) phenomenon caused by unusually high rainfall, Peñablanca Agricultural Community, Coquimbo Region, Chile

small area as a private asset. There are rain-fed tracts of common ground in the slopes, the use of which is annually assigned by the entire community to some of its members for crop cultivation. This activity began a process of land degradation that has continued over the past two centuries.[4]

During the present century, climate conditions have worsened and an unusually long period of drought — one without precedent over the last millennium — has affected the communities, threatening survival, causing migration, and leaving the remaining people to fight to reverse land degradation and restore land capacity. Sustainable land management practices such as afforestation, soil reclamation, water harvesting, and fog collection have therefore been implemented to reverse the land degradation processes.

Peñablanca is one of the most characterful of the Coquimbo peasant communities. With a total area of 6.587 ha, it is located at the centre of the region, on the Limarí River Basin and within a biological corridor that connects relic cloud forests along the coastal range. The population of the community is around 100 people, one-third of that of 1978. During the first half of the last century, Peñablanca was a supply centre for the regional and national production of wheat and sheep, despite the herds of goats that were emblematic of the poverty of the region. However, at the beginning of the 1930s, Chile was the country most affected by the global crisis, due especially to the collapse of nitrate mining in the northern part of the country, with the economy and livelihood of the Peñablanca community severely affected, leading to intensive use and eventual exhaustion of land capacity. By the end of the century, none of the traditional crops could be produced in the area, at which point support for the community was provided by the National Forestry Commission (CONAF) to aid restoration of vegetation cover, with scope to restore the environmental conditions enjoyed at the beginning of the twentieth century as a sustainable centre of food production.

In a long series of efforts to reverse land degradation, the community was selected as a focus for the demonstration of ecological restoration in forest ecosystems. The project, titled "Development of a model for social and environmental investment for restoration of semi-arid lands in Chile," is an initiative led by CONAF, as the National Focal Point to the UNCCD, funded by CDB and the Korean government, and co-funded by most of the agencies that support implementation of the National Strategy on Climate Change and Vegetation Resources.

One of the project's primary community activities has been afforestation, using indigenous species consistent with the remnant patches of cloud forest, where the vegetation types are distributed in the temperate zone, but not in the arid zone, 2,000 km south. The main species planted under the direction of the project is *Aextoxicon punctatum*, known locally as Tiké, and one of the Berberopsidales family. It is the dominant tree in the nearby Fray Jorge National Park, and is typical of a Chilean cloud forest. Its origins have been found in Patagonian fossils from the start of the Paleogene period, 56 million years ago.

Over the past 50 years, the local communities have also been innovating with water harvesting, using netting devices for collecting fog. Products are created from this activity such as the local beer, *Atrapaniebla* (Fog Collector).

Soil and water conservation is also performed in these communities for the ecological restoration of severely degraded drylands, reversing soil erosion and harvesting water. Typical practices are the digging of infiltration trenches and ditches, and the construction of derivation channels and low check dams.

The region's other agricultural communities, Cerro Blanco and Rinconada de Punitaqui, have developed similar approaches to restoring their capabilities of food production, reversing climate change, desertification, land degradation and drought.

The projects developed in support of this ecoregion aim to improve carbon stocks and restore degraded land. The role of forests in producing rainfall in drylands — forming condensation nuclei for cloud generation, influencing humidity, and changing albedo and its effect on the local energy balance — is a key part of the strategy to reverse climate change, desertification, land degradation and drought, and to foster the production potential of these agricultural communities. However, a wide range of needs are still to be met to secure full land degradation neutrality in the region, but the initial results are cause for hope in the communities.

A valuable perspective has been achieved from ground surveys made with the communities involved in assessing results from the activities.[5] Don Daniel Rojas, president of the Agricultural Community of Peñablanca, draws attention to the closeness to environmental issues felt by residents, as well as their awareness of desertification and climate change. Formerly, more than 3,500 ha of wheat were cultivated in what are now degraded soils, and all of the water springs that once existed have disappeared.

Maritza Segovia, secretary of the Cerro Blanco Agricultural Community, acknowledges that more training is required on agricultural and environmental issues and, above all, on informatics, in order to successfully access the supporting programmes and projects offered by public institutions. However, the community is proud that the work is bearing fruit. "Thanks to these projects we have been able to see a very important change in the surroundings of our community, where the trees we have planted begin to grow," says Ms. Segovia. President of the community, Don Domingo Cortés, adds that the level of vegetation cover has increased with the work done so far, but he is also concerned with the need for more training on informatics so that future projects can be applied for from public institutions, highlighting the fact that an agricultural community lacks the appropriate level of knowledge to make proposals in the formats required for funding, especially from public institutions.

Finally, Javier Varas, member of the Board of the Agricultural Community Rinconada de Punitaqui, states that vegetation has recovered considerably since the start of the interventions, even increasing the community's water supply. Goat herds are now not allowed to graze in the protected area of the community, which has been extremely difficult to protect, especially during the period of the long drought.[6,7]

Image: CONAF

Ground preparation for ecological restoration of a relic cloud forest amidst the desert. Peñablanca Agricultural Community, Coquimbo Region, Chile

Image: CONAF

Community reforestation using Tiké (*Aextoxicon punctatum*), the dominant tree of the relic cloud forest that is usually found 2,000 km south of the Coquimbo Region within the evergreen temperate rainforest

Enhancing rural development through the conservation and management of ecosystem services' resilience — a land use model in Costa Rica

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Globally, ecosystem services are vital for the livelihoods of rural communities. Ecosystems, however, suffer various pressures such as the loss of wildlife habitat, aquifer contamination, and soil loss, and the increasing overexploitation of natural resources continues to diminish an ecosystem's capacity to generate such services. The synergy between these pressures and changes in climate patterns contributes to a progressive reduction in the provision and quality of ecosystem services. Given these challenges, local communities require new approaches that increase their ability to adapt. To do so, we need to move away from normative ways of thinking and acting. A paradigm shift, based on frameworks such as the Earth Charter, and specific action-oriented goals and targets, like the Sustainable Development Goals (SDGs) are required. The SDGs propose targets linked to climate action, risk management, and the sustainable use of biodiversity.

Ethical principles and values embodied in the Earth Charter seek to inspire in all people a new sense of global interdependence and shared responsibility for the well-being of the entire human family, including future generations. Offering an integral vision for development, the Charter is the result of a global dialogue that started during the Earth Summit in Rio de Janeiro (1992), where the summit's Secretary General, Maurice Strong, proposed that governments identify and commit to principles that would guide humanity's vision of a sustainable world. It was not possible for the governments' representatives of the time to agree on a common ethical framework for sustainable development, but civil society followed up on the proposal, generating a largely participatory global dialogue process to identify shared values and ethical principles for sustainability in the twenty-first century. This dialogue involved people from various sectors — politicians, scientists, indigenous representatives, religious leaders and youth, among others, from all regions of the world. The drafting process began in 1994, and the Charter was launched in 2000. Since then, thousands of people and organizations have endorsed it and are seeking ways to put the vision into practice.

The Foundation for the Development of the Central Volcanic Mountain Range (Fundecor) is a non-governmental organization dedicated to sustainable development, and has incorporated the Earth Charter's ethical principles into its vision and general policy. Fundecor has been implementing local development models based on forest ecosystems services for over two decades. One such programme is the Sarapiquí Resilience Initiative (SRI), a local landscape-scale development strategy, whose principal objective is to strengthen community and socio-ecological system capacities to prepare for, and react to, global threats such as climate change, deforestation, and land degradation. Using forest ecosystem services as an organizing concept for various development sectors, the SRI generates improved social and economic benefits based on sustainable management of these services.

SRI works in the Huetar Norte region of Costa Rica where the average annual temperature is 27°C and rainfall is 4,000 mm, covering 370,000 ha in 11 counties, of which Sarapiquí (Heredia Province) constitutes approximately 70 per cent of SRI's total area of influence. Around 78,000 people live in these counties with low indices of social development. The economy is based on small- and large-scale agriculture and livestock production accounting for approximately 40 per cent of the area, with a concentration of services in the District of Puerto Viejo; and with nature tourism as one of these important activities. Tropical moist forest covers some 60 per cent of the territory. Recent studies report that Sarapiquí is highly vulnerable to climate change and extreme weather events which, when combined with deficient social development, demand the reinforcement of resilience development models.

SRI combines management strategies at both the farm and landscape scales. The benefits from sustainable forest management and ecosystem services for farm owners as well as for society have been well documented. Now, sustainable forest management and ecosystem payment schemes are used across development sectors and at scale. Such investments include public–private strategies for water conservation; extreme weather events risk management; participatory rural development planning; poverty reduction through farm-based

Image: Fundecor

The high socio-ecological vulnerability to extreme weather events and the climate change of the forests and agroecosystems within the Sarapiquí Resilience Initiative require integrated landscape models that enhance local capacities to design and implement adaptation measures

climate change adaptation pilot projects that can be replicated at landscape scale; governance strengthening; and the development of decision-making information systems.

For the past two decades, Fundecor has provided technical assistance in sustainable forest management to 105 families, owning 7,075 ha between them, and generating important income by increasing forest value. Evidence to date indicates that these managed forests have maintained canopy cover and have not lost biodiversity at landscape scale.

Fundecor has also developed financial mechanisms for other services that forests generate for society, such as carbon sequestration, water production, and sediment retention, in addition to timber production. Fundecor's ecosystem services models were adopted into forest law in 1996, serving as the basis for Costa Rica's environmental services payments programme. Between 2010 and 2017, Fundecor has managed and transferred a total of US$ 12,200,000, benefiting 994 families and conserving 140,000 ha of tropical forests. According to studies conducted by researchers from numerous universities, the payment for the ecosystem services policy has contributed to a moderate reduction in deforestation in just over 20 years since it began in the late 1990s. Public recognition of forest ecosystem-based benefits and their sustainable management, together with supportive public policy have so far minimized deforestation in the region.

Currently, the forestry sector endeavours to increase sustainable timber production and transform this activity into a defining feature of rural development. Fundecor does this by generating value chains that differ from those production chains in which links remain isolated. Its efforts help stakeholders to develop products based on market demand and to offer the products at the quality and quantity required by the markets.

Given such opportunity, new business models have emerged to manage short-cycle forest plantations for pallet production; forest plantations that supply timber for furniture; and sustainable primary forests to produce timber for construction and high-value-added products such as floors. These models will be complemented by technical assistance for different actors in the value chains to generate an attractive business for impact investors.

Within SRI's region, livestock and agriculture play key roles in the economy. To design strategies that increase resilience, Fundecor has been facilitating a planning process with the agricultural and forestry sectors to identify vulnerabilities of livelihoods and ecosystem services in the face of climate change and implement corresponding adaptation countermeasures. A select number of such measures are being implemented on farms which serve as demonstration projects. Fundecor will then use this portfolio to transfer knowledge and experiences among regional farms, whose impact will also be monitored by Fundecor.

Fundecor further promotes ecological restoration to diversify farm productivity. Such techniques recreate the structural complexity of a tropical forest, but also integrate production of timber and non-timber forest products. This diversification benefits the farm economically as well as restoring ecological processes. To increase farmer income and distribute benefits more widely, Fundecor studies value chains for select products, such as pepper and vanilla.

Water production constitutes a fundamental ecosystem service on which multiple communities depend. Fundecor designed and implemented the first water fund in Costa Rica, named Agua Tica. This public–private partnership jointly invests in sustainable watershed management and compensates forest owners for the service. Payments come from a

Image: Fundecor

Training farmers on restoration techniques, as well as on the identification of production options that recreate the structural complexity of tropical forests, is pivotal for increasing socio-ecological resilience

trust administered by a third-party financial entity. Within the SRI framework, Fundecor also explores similar financial mechanisms that can be used jointly by the Administrative Associations for Aqueducts and Sanitary Sewer Systems (ASADAS) — local entities that manage and distribute water — and private local enterprises that are key resource users interested in responsible environmental cooperative practices. This partnership will build the ASADASs' ability to supply water securely, using a citizen science programme to monitor efforts.

The SRI model benefits from investments in public protected areas, critical for biodiversity conservation and environmental welfare. Nature-based tourism is an especially important input to the Costa Rican economy, and so Fundecor has contributed to visitor management in highly popular national parks.

Participation, transparency, accountability, conflict management, and capacity building are fundamental aspects of governance that need strengthening in integrated landscape management models. Fundecor conducts training and environmental education in SRI communities. For example, farmers are trained in climate-smart agriculture and management of agroforestry farms. Likewise, Fundecor carries out environmental education in high schools.

Inter-institutional coordination is a basic step to achieving landscape-scale integrated management. For this purpose, the Regional Agricultural Sectorial Committee (COSER) is a planning, coordination, and consultation body within the Costa Rican Planning Ministry, composed of regional directors representing agricultural sector institutions such as the Ministry of Agriculture and Livestock; Institute of Rural Development; National Institute of Learning; and National System of Conservation Areas. COSER members work together to increase adaptation and resilience of the agricultural and forestry sectors. Also, Fundecor works on multisectoral platforms that conserve and restore ecological connectivity, fundamental to landscape resilience. An action plan has been set to prioritize investments in promoting that resilience.

Decision-making platforms complement these strategies. The information that they produce has been prioritized for use in designing adaptation and resilience strategies in the agroforestry sector.

In future, field staff and farmers will use mobile apps to better access information that reduces technical assistance costs and improves productivity. This information system includes an investigation component for short-, medium-, and long-term research on integrated landscape management and socio-ecological resilience. The platform on which this research takes place is called the Breathing Lab. The findings will strengthen the management model and stakeholders as well as the information system itself.

It is important to note that, throughout the tropics, there are locations with biophysical and socio-economic conditions similar to the site under study. SRI therefore has the potential to become a replicable model nationally and internationally. It is clear that landscape-scale approaches can achieve various objectives, both ecological and socio-economic as well as those of the various local stakeholders. In order to achieve this, one of the principal challenges for landscape management is the development of mechanisms that integrate results into decisions, an eventuality made possible due to the ethical principles that guide the design and implementation of strategies, such as those stipulated in the Earth Charter.

A transformative project to combat land degradation through the sustainable production of cocoa in the post conflict context of Colombia

Government of the Republic of Colombia[1]

Since November 2017, the Colombian government, with the support of the United Nations Convention to Combat Desertification, has been formulating a project aiming to achieve Land Degradation Neutrality (LDN) through the rehabilitation of degraded soils and the incorporation of sustainable cocoa production systems with small-scale farmers in the departments of Huila (Villavieja) and Magdalena (Aracataca and Santa Marta) in Colombia.

The project is designed to contribute to the achievement of Colombia's voluntary LDN targets, and is managed between various stakeholders, including the Ministry of Environment and Sustainable Development, the Alexander von Humboldt Biological Resources Research Institute, and the National Cacao Farmers Federation (Fedecacao), with the support of the Ministry of Foreign Affairs. It is aligned with the national post-conflict scenario where the improvement of rural conditions is a key component in tackling illicit crop growing, to ensure the livelihood of local communities and to deter the repetition of conflict.

The project seeks to halt and reverse land degradation through the implementation of soil rehabilitation actions and the improvement and incorporation of sustainable cocoa production systems by small-scale farmers. The expectations are of an increase in soil biodiversity and productivity, organic carbon storage and plant cover, as well as the enhancement of cocoa crop productivity and the strengthening of governance of small-scale farmers' associations. The project's implementation will contribute to the improvement of living conditions, the economic development of the regions, and to sustainable peace in the areas concerned. There is also special focus on the endangered ecosystem of a tropical dry forest.

Image: Colombia Ministry of Environment

Family production methods in Santa Marta, Magdalena Department

In line with Colombia's LDN targets, the project is expected to be implemented within a timeframe of ten years to contribute to the 2030 Agenda on Sustainable Development. It will also promote actions to implement existing commitments under the focal areas of the Rio Conventions, including not only land degradation and desertification but also biodiversity and climate change. The project is expected to impact around 400 families as beneficiaries and to restore approximately 1,750 ha of land, at a preliminary estimation. It also aims to provide 1,000 ha of tradable carbon certificates and strengthen cocoa production over approximately 400 ha through increasing farming capacity and processing in the target territories.

Context of the initiative

The formulation and implementation of the project is framed under Colombia's various international initiatives and commitments, including the 2030 Agenda for Sustainable Development and its Sustainable Development Goals (SDGs); the 20x20 Initiative; the biodiversity Aichi Targets; the ILAC indicators; the nationally determined contributions on climate change; and the LDN targets. At national level, its implementation is outlined by the Green Growth Strategy; the National Policy for Sustainable Soil Management; the National Policy for the Comprehensive Management of Biodiversity and its Ecosystem Services; the National Policy for Climate Change; the National Rehabilitation Plan; and the National Action Plan to Combat Desertification and Drought, among others.

According to national data, 24 per cent of Colombia's land is susceptible to desertification, and this is where the main cities, key irrigation districts, and the highest density of the population are located. Also, 85 per cent of the country's production systems are in areas vulnerable to desertification, and 48 per cent of the country is susceptible to erosion processes. The Caribbean region has 68 per cent of its area susceptible to degradation due to salinization, with 53,237 km^2 experiencing salinization and solidification processes. In Colombia, approximately 22 million ha are suitable for agriculture, 4 million ha for agroforestry, and 15 million ha for livestock. However,

Image: Colombia Ministry of Environment

Cocoa trees in Santa Marta, Magdalena Department, a region with 7,700 ha of priority areas for restoration and/or rehabilitation

currently only 5 million ha are used for agriculture and more than 34 million ha are used for livestock.

The original coverage of tropical dry forest is estimated to have been 8,146,597 ha, of which only 650,000 ha remain, equivalent to 8 per cent, making it one of the most threatened ecosystems in the country. Of the regions that were previously covered by tropical dry forest, 65 per cent are under some degree of desertification.

The production and transformation of cocoa in agroforestry schemes has been identified as an economic activity with positive effects to the environment. It preserves biodiversity, conserves or creates a favourable microclimate, mitigates the damaging effects of sun, wind and rain on soils, improves the recycling of nutrients, positively influences the management of pests, improves the fixation of nitrogen, helps improve the quality of the soil and prevents the increase of soil degradation. In economic terms, it increases plant productivity, diversifies production and reduces the risk of loss to the farmer.

Project components

The first component of the initiative is to strengthen the sustainable use of land in order to halt and reverse land degradation. Two subcomponents have been identified to address land degradation. These are the restoration of native species and cocoa planting, and the application of strategies for the sustainable use of biodiversity. Specific activities, implemented according to the baseline, include soil remediation by biomechanical works, irrigation and planting of native species, the establishment of nurseries with native species, physical and chemical soil treatment, irrigation, provision of green fertilizers, and the preservation of standing forests, among others.

The second component is the enhancement of the cocoa value chain in the prioritized areas, with the aim of improving collection and processing of the raw material. The first subcomponent is the improvement of production, and includes actions such as technical assistance with cocoa cultivation — training, advice on the technical management of crops, technical support for agroforestry, management of pruning and fertilizers, management of shade trees — and provision of infrastructure (individual and/or collective) for processing, including a collection centre, machinery, and transport. The second subcomponent is the enhancement of the national and international sale of cocoa, together with certification to give added value to the product, including technical advice for certification and quality labels.

The third main component of the project relates to the organizational and representative governance of cocoa associations and communities, taking into consideration gender aspects that strengthen the active participation of women within these organizations and communities. It includes the enhancement of the associations' capabilities for management and decision making; access to knowledge of markets, risks and mitigation strategies; the strengthening of abilities to plan production, harvesting, stocking and distribution to traders; support in the accounting, accountability and periodic production of financial statements; the provision of permanent managerial positions; and budget.

The promotion of productive economic alternatives based on sustainable biodiversity contributes to the social, economic and environmental dimensions of the project by strengthening local capacities for trading products, and by including activities compatible with cocoa agroforestry such as beekeeping, agritourism and the planting of timber and fruit species. The objective is to avoid deforestation through sustainable use of land to increase and diversify the farmer's income.

Another potential contribution is the creation and trade of carbon credits as a way of financing sustainable land use activities. A percentage of this income will go for restoration

and other productive activities around the sustainable uses of biodiversity. Additionally, alliances can be established for compensation of mining and infrastructure projects through investments in social responsibility schemes.

The International Union for the Conservation of Nature has joined the project through the appointment of two advisers to mainstream gender in its formulation process. They will support the preparation of workshops in the field with the target community to identify strategies to enhance the role of women in implementation.

Defining the prioritized areas

The areas prioritized for project implementation are those:

- Chosen for the Colombian LDN target-setting programme, which include lands in the Caribbean and the Andean region in semi-arid and dry, sub-humid areas
- With endangered ecosystems prioritized for restoration, in particular tropical dry forests
- With a moderate level of degraded lands due to erosion
- With existing cocoa farming activity and land suitability for cocoa production.

Other factors are considered such as basic access infrastructure and the presence of cooperation agencies. A combination of these criteria determined the prioritization of both the municipality of Aracataca and Santa Marta in the department of Magdalena, and the municipality of Villavieja in the department of Huila. Both Huila and Magdalena show erosion processes having affected more than 70 per cent of their area, making them the most affected in the country by the severity of erosion. These areas have dry forest ecosystems, prioritized by Colombia for their conservation since they currently have a low degree of representation in the national system of protected areas and have several loss drivers due to human activities.

Santa Marta and Aracataca, Magdalena Department

One of the key features of the project is the involvement of local communities and associations. There are three associations in this prioritized area that currently grow cocoa — Asoarhuacos in Troncal Caribe, between Santa Marta and Dibulla, with approximately 100 producers; the Association of Organic Producers of the Municipality of Dibulla, with approximately 40 producers; and Guardabosques de la Sierra with approximately 100 producers. Guardabosques de la Sierra has a collection centre where cocoa is processed and traded. It is estimated that 200 tons of cocoa can be produced annually, given the unification of sales by a single association.

A local project, *Cacao para la Paz*, led by the US Department of Agriculture (USDA) and the US Agency for International Development (USAID), reports a 400 per cent increase in crop productivity, with improvements in agricultural extension services, research, education and institutional technical assistance. Currently, productivity is 800 kg/ha of cocoa annually, but with technical improvements it can increase to 1,000 kg/ha. These crops began to be farmed in the area in the late 1990s as a strategy to replace illicit crops but were left without technical assistance. It is therefore in the area's interest to extend the USDA–USAID production model to increase the productivity of cocoa crops, obtain a constant volume of yield for export, facilitate access to certification for all producers, and enlarge the numbers of associates in the farmers' organizations.

In the municipality of Santa Marta, there are 7,700 ha of priority areas for restoration and/or rehabilitation, according to the Humboldt Institute. Aracataca is also an area with potential to strengthen cocoa crops, associations and their access to markets. Currently there are two small associations, Cuadriculac and Asodadruca, with approximately 15 associates each. However, there are more than 70 producers not yet associated and there are opportunities to explore collabora-

Image: Colombia Ministry of Environment

Cocoa producer in Aracataca, Magdalena Department, an area earmarked with potential to strengthen cocoa crops, associations and their access to markets

tive approaches to work. The productivity of cocoa crops in the area is approximately 300 kg per ha per year. Some farms are more productive, with between 600 and 1,300 kg per ha per year. However, drought and inadequate crop management lower productivity, so producers require technical and financial capacity to implement drip irrigation systems.

Villavieja, Huila Department

In the municipality of Villavieja there are approximately 88 ha of crops owned by 53 producers, and the local Association of Cocoa Producers of the Vereda del Doche (Asociación de Productores de la Vereda del Doche) has 25 members. It currently sells to the regional industry — Casa Luker and Nacional de Chocolates — with market prices that can be improved with higher production volumes. Cocoa in the area has recently been recognized for its high quality at the international chocolate trade show in Paris.

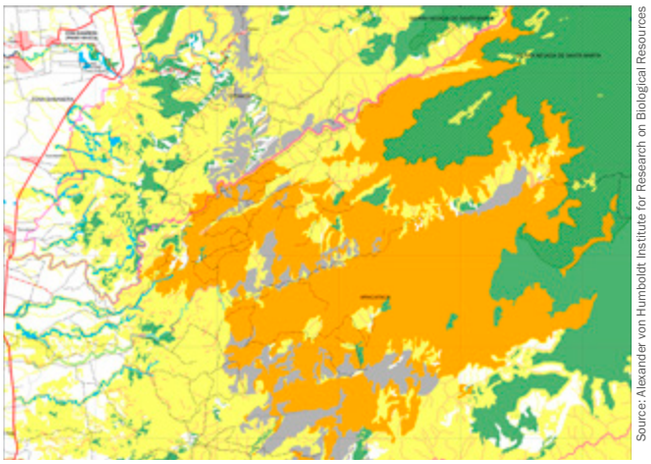
The productivity of cocoa in the area is approximately 500 kg per ha per year, but can rise to 1,000 kg per ha per year, or more, by improving irrigation, fertilization and pruning. Some farms currently produce 800 kg per ha per year. In the first two years of the project, alternatives for increasing the yield include the planting of banana and plantain, and raising goats for milk and dulce de leche. Local tourism also has great potential, with some producers acting as both tour guides and local speakers on issues related to cocoa cultivation.

The association is focused on enlarging the number of its members in order to consolidate productivity and enhance negotiation leverage through production volume. For this it requires investment in a cellar, fermenting boxes, scales, thermometers, guillotines, instruments for measuring grain moisture, canopies for drying the cocoa, and short-distance transport. Producers need more technical capacity to increase productivity while other plots will require rehabilitation. The added value of the cocoa could be raised by securing a designation of origin, "Chocolate del Desierto," as well as Colombian certification of good agricultural practices, which would increase the sale price by between 10 and 15 per cent.

In this, as in other areas of the country, cocoa is a family business, with everyone in the family helping in the cultivation, as it requires much labour — a daily wage is paid for 3 ha cultivated. Importantly, women play a decisive role in decision-making within the family nucleus. In the Vereda del Doche association, 9 of the 53 producers are female heads of household, and, in general, women participate in the management of the association.

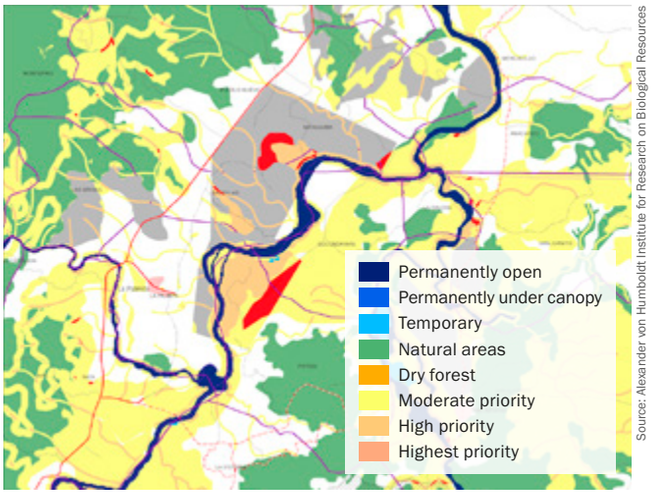
From an environmental perspective, in the municipality of Villavieja there are 2,600 ha of priority areas requiring restoration and/or rehabilitation, according to analysis made by the Humboldt Institute for the prioritization of degraded areas. The existing cocoa and potential timber crops play a strategic role in controlling the progress of desertification, and all properties have conservation potential. In Villavieja there are good conditions for allowing routes to irrigation by local rivers, and the area borders the Tatacoa Desert, unusually enabling access to water in a desert context.

The implementation of the projects will be positive for the territories that have been directly or indirectly affected by armed conflict. The cocoa crop has been related to conflict



Source: Alexander von Humboldt Institute for Research on Biological Resources

Prioritized areas between Santa Marta and Dibulla in the Caribbean Region



Source: Alexander von Humboldt Institute for Research on Biological Resources

Villavieja, in the surroundings of Tatacoa Desert

zones where a productive conversion of coca to cocoa has been made. In general, post-conflict Colombia represents a great challenge for rural development and for improving issues such as land tenure, rural emigration, low access to support services, transportation infrastructure and competition with other crops, both lawful and illicit. Cocoa provides a great opportunity for those areas that are emerging after the conflict.

Next steps

Some approaches have been made to engage potential private investors in the project, and formulating the terms of their participation is in progress. However, the initiative is open to assessing new options for financing from investors with a portfolio in sustainable development. Multilateral or bilateral cooperation funding is also envisaged for the first component of the project, namely restoration, soil rehabilitation and conservation measures; while private investment is expected to enable the second component of cocoa value chain enhancement and production improvement. The third component will benefit from both types of financing.

Colombia is also expecting developments from the LDN fund, managed by investment consultant Mirova, in order to submit the project proposal to investors and clients.

Allowing nature to recover without human interventions

Trevor Thompson, Land Use Officer, Ministry of Agriculture, Grenada

Grenada comprises three inhabited islands — Grenada, Carriacou and Petit Martinique — together with a number of uninhabited offshore islands. It is the most southerly of the Windward Islands in the Lesser Antilles and is located between St. Vincent to the north and Trinidad and Tobago to the south. Mainland Grenada has an approximate land area of 312 km², (34 km long, 20 km wide), while Carriacou and Petit Martinique are 34 km² and 2.3 km² respectively.

Geomorphology

Grenada is of predominantly volcanic origin — built from eruptions during the Tertiary and early Pleistocene periods — although some sedimentary rocks of the Tertiary and Quaternary periods are present. The soils are dominated by clay loams (84.5 per cent), clays (11.6 per cent), and sandy loams (2.9 per cent). Carriacou and Petit Martinique are also of volcanic origin and represent the exposed summits of peaks on a single narrow bank of submerged volcanic mountains. Approximately one-third of these islands are of fossiliferous limestone, mainly of the Miocene age.[1]

The main island geomorphology is characterized by a very mountainous terrain that runs north–south in two main sections, with ridges, spurs and peaks rising to 840m at Mt. St. Catherine which inclines steeply from the west coast and more gently from the east coast. Grenada has three old crater basins forming freshwater lakes: Grand Etang Lake (8 ha), Lake Antoine (17 ha) and Levera Pond (23 ha), and there are many other shallow ponds that fill with water in the rainy season but become dry during the dry season. Grenada has well defined watersheds and catchment systems that cut across the hills and valleys, transforming the landscape. The result is a very steep and hilly topography throughout most of the island, except in the southwest and northeast where it grades into low hills. The watersheds are small on the western side of the island, with sudden drops to the sea — in some places the distance from the top of the hills to the coast can be as little as one mile.

Carriacou comprises an axial range of hills and ridges with several low, gently sloping broad valleys that terminate in relatively sizeable coastal flats.

Climate

The Grenadian climate is best described as humid tropical maritime, within the Atlantic northeast trade wind belt. The seasonal shift in these winds give rise to a wet season from June to December, and a dry season from January to May, although there is little seasonal variation in relative humidity. The average annual rainfall for mainland Grenada ranges between 1,000 mm and 1,500 mm along the coastal zone, to approximately 4,000 mm in the interior, and supports surface stream flow and recharge of sub-surface aquifers. The marked spatial variation in rainfall pattern across the main island is due to differences in orthographic elevation. This rainfall

Image: Ministry of Agriculture, Grenada

Built up areas, 2005

Image: Ministry of Agriculture, Grenada

D' Arbeau Quarry, 2009

Image: Ministry of Agriculture, Grenada

D' Arbeau Quarry, 2011

pattern gives rise to the arid conditions experienced in the northern and southern extremes of the island.

The impacts of climate change have become more obvious, with the island experiencing increasing daily temperatures, changes in rainfall, flooding, a rise in sea level and the impact of two severe tropical hurricanes within 9 months between 2004 and 2005. The country is also vulnerable to other natural hazards such as tsunamis and there is an active submarine volcano, Kick 'em Jenny, located approximately 9 km off the north coast of Grenada, between the islands of Grenada and Carriacou. This is the most active volcano in the eastern Caribbean having erupted at least 12 times since its discovery in 1939.

Grenada is segregated into 71 watersheds, and Carriacou into 20 watersheds. Because of its size, Petit Martinique is considered as a single watershed. Grenada watersheds are characterized by a relatively dense network of permanent rivers, while the sister islands are dominated by intermittent streams. No permanent streams exist on Carriacou and Petit Martinique.

Land use

The watersheds cover an area of just over 1,200 ha of land. The topography ranges from 0 to 2 metres in elevation within the flood-prone areas close to the coastline, and 595 metres in the higher region. Approximately 99 per cent of the watershed is covered by slopes in excess of 10 deg.

Land use practices within Grenada's St. John's Watershed, located in the south western part of the island, had traditionally been environmentally friendly, comprising a forest reserve on steep slopes, and agriculture (mainly cocoa and other tree crops). There was also a low residential density except for the area of River Road that saw an increase in population with the construction of a housing scheme in the late 1960s. However, during the early 1970s, because of its close proximity to the capital city, the area began changing to an ad hoc type of mixed land use of residential, agricultural, industrial and commercial uses, residential being the most dominant. There was also the establishment of a new community within a portion of the former Mt. Parnassus forest reserve.

The expansion of quarrying and mining activities at the D'arbeau quarries resulted in a rapid increase in the land use trend but with no formal zoning or management plan for the watershed. Squatting around the mining and quarrying increased significantly. These combined activities resulted in significant changes to the landscape and an environmentally incompatible type of land use, with inadequate waste disposal and other services, together with associated problems.

Land degradation

When exposed to high rainfall levels, the inherent erodibility of the soils within the topography around St. John's Watershed renders them susceptible to degradation. Other causes of soil erosion — a common source of pollution of the St. John's River, which runs through the watershed — are poor agricultural practices, mining, deforestation and land clearing to facilitate construction of residential buildings and the establishment of new communities.

There are seven other communities within the watershed, all of which have experienced high levels of expansion in recent times, resulting in some of the watershed problems. Three of those communities, River Road, D'arbeau and the newly established community in Mt. Parnassus are of greater

Image: Ministry of Agriculture, Grenada

D' Arbeau Quarry, 2018

concern due mainly to the existing and potential environmental problems and proximity to the water course and river.

Land degradation is not new to Grenada. Some degradation is caused by natural processes such as rainfall and soil type relationships but, in general, the problem has been exacerbated by decades of bad land use practices. The problems at St. John's Watershed are a result of human activity, in the attempt to utilize a scarce resource on a small island to help build the nation, not realizing that overuse results in a scarring of the landscape.

Quarrying activities at D'arbeau resulted in many social and environmental problems including soil erosion, pollution of St. John's River and the consequent destruction of its aquatic life, dust pollution, and the resulting health problems for the community. The quarry was also an eyesore to the nation for many decades and, as it was located close to the national stadium, the scarring of the hillside was evident to anyone attending sporting or cultural activities being held at the venue.

The argument that the quarry was essential for national development was used as justification to continue using it without proper planning and forethought in the extraction of the resource. The quarried materials have been used as aggregates for the construction of roads, housing, and other projects such as retaining walls, and the backfilling of coastal areas to prevent coastal erosion. The result has been erosion of the hillside, and the pollution of the river and coastal waters, impacting the terrestrial environment. Heavy rain caused the river to run red.

To respond to this problem, the Grenadian government agreed to discontinue harvesting of the aggregates in the area and develop another site using proper mining techniques and with a structured development plan to harvest the resources in an organised manner. While this was welcomed, there was no plan to rehabilitate the old quarry. No plan was in place for work to be done on slope stabilization because of cost. Although people living in the surrounding communities continued to remove gravels and other aggregates illegally, mainly for their own use, the mining area became quiet and the professional work had stopped.

The 20-acre quarry was left abandoned, with old pieces of machinery and deserted buildings littering the landscape. And, in the absence of heavy machinery, trucks, and hundreds of staff removing the aggregates on the site, the natural process of regeneration began. After ten years of being left on its own, the entire hillside is once again covered with natural, lush and green vegetation, shrubs and grasses. Now, the scarring is hardly visible, with little evidence of a former quarry. Instead natural regeneration has created yet another of Grenada's green hillsides, left to be admired.

Image: Ministry of Agriculture, Grenada

St. John's Watershed looking north to south

Solar cookers — achieving sustainable solutions to land degradation

Caitlyn Hughes, Program Director, Solar Cookers International (SCI); Julie Greene, Executive Director, SCI; Alan Bigelow, PhD, Science Director and Main United Nations Representative, SCI

Solar thermal cooking technology is an ideal solution to land degradation. Solar cooking combats desertification, protects biodiversity, and prevents deforestation, because it provides a safe alternative to chopping down trees for cooking fuel. Solar cooking also protects ecosystems by reducing carbon dioxide emissions, because solar thermal cooking produces no emissions.

A solar cooker is a device that uses the energy of direct sunlight to heat, cook or to pasteurize water. The three most common types of solar cookers are box cookers, curved concentrators (parabolic) and reflective panel cookers. Solar cookers use only solar energy for fuel, and hence have no ongoing costs, environmentally or economically.

Solar Cookers International (SCI) is a US-based non-profit organization that connects partners in over 130 countries, with a mission to strengthen the solar cooking movement through advocacy and research, and to improve human and environmental health by supporting the expansion of effective carbon-free solar cooking in world regions of greatest need.

SCI has been able to identify more than 3.2 million solar cookers worldwide, and estimates that those solar cookers have directly, positively impacted over 11.5 million people, saved 16 million tons of wood, and reduced carbon dioxide emissions by 26 million tons. One solar cooker can save one ton of wood per year.

Solar cookers are especially beneficial in areas where wood, charcoal, and animal dung are traditionally used as fuel.

Image: Sperancea Gabone (front centre), Macedonia Ministry

Tanzanian women with their locally produced solar box cookers

When animal dung can be used as fertilizer instead of fuel, cereal crop production can increase by 20 billion tons per year. This prevents further land degradation, because existing land used for agriculture can be more productive. This prevents more land from being deforested for crop production.

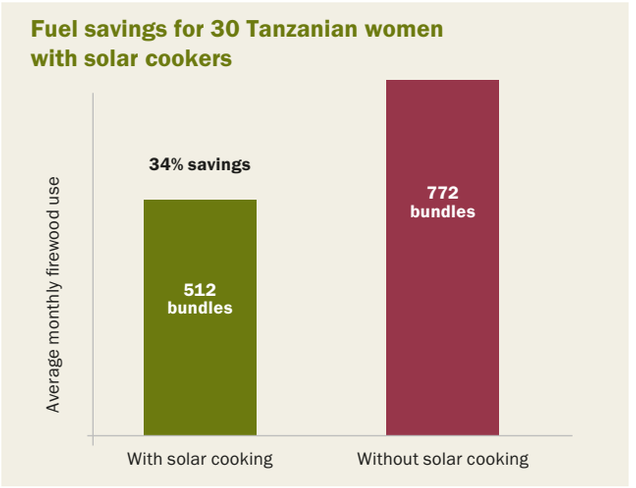
Government investment in solar cooking solutions has significant economic and environmental benefits. According to the World Bank and the Institute for Health Metrics and Evaluation, the total global cost of household air pollution is roughly US$ 1.6 trillion. Therefore, simple solutions such as solar thermal cooking that reduce air pollution can save billions of dollars for economies.

There are many examples of successful implementation, partnerships, and women's empowerment with solar cooking worldwide. Three case studies, in India, Nepal, and Tanzania, showcase some best practices and benefits of solar cooking.

Ms. Sperancea Gabone from Tanzania is a local and global champion of solar cooking, living in an area where 98 per cent of the wood used is for firewood and charcoal. The average Tanzanian household burns 4 tons of wood per year for heating and cooking, but solar cooking changes that. Ms. Gabone has taught thousands of people in her area about solar cooking. She has done multiple training sessions and solar cooker distribution to women in surrounding villages.

These cookers are produced locally, using local materials. Communities are empowered with the knowledge and ownership of the making and maintenance of solar cookers. Local production strengthens the local economy and is more environmentally friendly than transporting large amounts of product over large distances. This project incorporates complementary technologies, including retained heat baskets (insulated baskets to keep food hot) and Water Pasteurisation Indicators (WAPIs) that indicate when water has reached pasteurisation temperature and is safe to drink.

Ms. Gabone uses the Solar Cooking Adoption and Impact Survey, designed by SCI, to track fuel use and savings. In ten months with solar cooking, 30 women reduced their total fuel usage by 1,955 bundles of wood (24 per cent savings), 566 kg of charcoal (28 per cent savings), 486 litres of kerosene (25 per cent savings), and 694 bags of crop waste (19 per cent savings). The total savings were 5.5 million Tanzanian Shillings (US$ 2,438), or 25 per cent of their fuel costs. The rate of smoke-related health problems, for themselves and their families, dropped from 77 per cent to 33 per cent with solar cooking.



SCI supports capacity development for partners such as Ms. Gabone to share information, develop best practices, and strengthen and scale the activities of the whole solar cooking sector. SCI does this in many ways (in person and digitally) including events, webinars, conference calls, email and print publications. For example, SCI connected Ms. Gabone to a solar cooking partner in Uganda, who has a financially sustainable and scalable solar cooking business. SCI also hosted a webinar on successful solar cooking businesses in Africa, connected partners with business mentorship and funding opportunities, and included solar cooking entrepreneurship as a regular session topic at events. This empowers Ms. Gabone and other solar cooking partners with knowledge, opportunities, resources, and connections to scale their activities to help meet the demand of 3 billion people cooking over open fires who could benefit from solar cooking.

Another region of significant progress and collaboration is Nepal. SCI established a Solar Cooker Performance Evaluation Process (PEP) testing centre there, as well as setting up strong, effective partnerships with local organizations that exemplify best practices in natural disaster preparedness. The opportunity for solar cooking in Nepal is significant, since 80 per cent of the people use firewood and farm residue for cooking fuel.

Solar cookers in Nepal can be tested using the PEP, which was developed to help individuals, communities, and governments chose the best solar cooker for their needs. It measures the standardized cooking power (in Watts) of various solar cookers according to ISO/TC 285 standards being developed for clean cookstoves and clean cooking solutions. SCI's global PEP testing centres empower communities with income and knowledge, and standardize comparison for solar cooker manufacturers on all continents.

In addition to the PEP, SCI shares a variety of resources to empower partners and government representatives, and to further solar cooking. For instance, there is an online database with 1,700 web pages of information on solar cooking. It includes best practice guides on training and project design, a by-country directory of partners and solar cooking history, and up-to-date news and events.

SCI also partners with local Nepalese organizations, who embody best practices for solar thermal cooking technology implementation. Nepalese partners have been leading solar cooking workshops for local groups, such as students, women-headed households, people with disabilities, and the elderly. When communities know about a solution such as solar cooking, and have access to it and training before a disaster strikes, it increases their chances of being able to effectively utilize it during and after a disaster or crisis. SCI's local Nepalese partners exemplified this best practice before the 7.8 magnitude earthquake in Nepal in 2015.

One woman from Machhegaon, Kathmandu Valley, Nepal (pictured opposite) is one of many who has benefited from solar cooking. As part of the 57 per cent of the population in Nepal that lives on less than the equivalent of US$ 2 per day, she earns approximately US$ 100 each month to support her family. Her biggest expenses are cooking fuel (US$ 30 per month) and rice (US$ 30 per month). This widow and provider for a family of five started solar cooking in February 2014. With the solar cooker, she cuts her monthly fuel costs in half, saving US$ 15 per month which she can use to buy more food for her family. She was already confidently using this solar cooker technology to safely cook and pasteurize water before the earthquake struck, and was therefore prepared for managing in the aftermath. Solar cooking is also an effective solution for her and her family to deal with the wood, liquefied petroleum gas, and kerosene fuel shortages that are the result of political tensions and border trade restrictions. Solar thermal cooking is the ultimate fuel independence.

Institutional-scale solar cooking, together with numerous examples of solar cooker innovations, exist in India. For example, the sixth SCI World Conference 2017 was held at the Muni Seva Ashram, where solar concentrators are used to prepare food for thousands of people per day. Solar cooking is a well-suited solution for India because of its large and growing population; air pollution is considered hazardous in some regions; and many people live in rural areas.

To facilitate the sharing of best practices and the scaling up of solar cooking, SCI engages a team of global advisors who provide information and regional expertise. Global Advisor, Dr. Janak Palta McGilligan has spent decades educating

Image: Charley Cross

Solar Cookers International's Global Advisor, Dr. Janak Palta McGilligan and Executive Director, Julie Greene in India

Image: Julie Greene

Nepalese woman using solar energy for cooking

rural Indian women about the benefits of solar cooking and empowering them with the ability to solar cook. Local experts, especially women, are crucial in spreading this technology, because they speak the same language, cook the same foods, understand the culture and available resources, and lead by example.

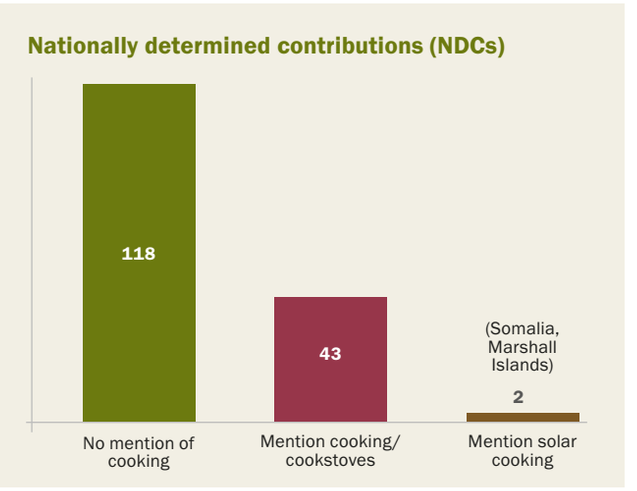
Connecting government leaders with local experts and global advisors, SCI made sure that Dr. McGilligan's voice was heard around the world by bringing her to the United Nations High Level Political Forum (HLPF) in New York. There she could advocate solar cooking to government leaders and offer a solution to a real world challenge.

Government leaders also learned about the many benefits of solar cooking from SCI at the United Nations Climate Change Conference in Bonn, Germany in 2017. Government leaders, such as those from South Africa, Papua New Guinea, and Nigeria, examined SCI's global data on solar cooking, and how their countries would be able to implement the technology.

Solar cooking is an effective mitigation and adaptation solution for countries and communities to address climate change. Of the 165 Nationally Determined Contributions, or plans on how countries will reduce climate change, 45 of them mention cooking or cookstoves. Somalia and the Marshall Islands specifically mention solar cooking as a solution in their plans. More government leaders can include solar cooking in their national programmes, policies, plans, and budgets to address climate change and land degradation.

Solar cooking is a powerful solution that government leaders and communities can implement to prevent land degradation. In addition to strongly addressing United Nations Sustainable Development Goal (SDG) 15.3: Land Degradation Neutrality, solar cooking addresses all 17 SDGs.

India, Nepal, and Tanzania are just a few examples of how SCI works with local experts to grow this solution through sector capacity building, advocacy, and research. Solar cooking is increasing in over 130 counties, becoming more widely recognized as a viable solution to the challenges during this critical time for the environment and world population.



Countries' plans to address climate change (NDCs) and the opportunity for impact of solar cooking. Of 163 NDCs submitted, 43 mention cooking or cookstoves. 2 additional NDCs have specifically included solar cooking as a sustainable approach

Sustainable management of white bamboo — helping the giant panda to return to nature

Liu Yong, Giant Panda Rewilding Training Centre at the Huaying Mountain of Guang'an; Wang Shan, Guang-An City Forestry Bureau; Huang Yongqiang and Li Yingping, Sichuan Forestry S&T Extension Station; Zhang Kebin, Beijing Forestry University, and Central Project Management Office of PRC-GEF Partnership on Land Degradation in Dryland Ecosystems, Beijing; Song Zengming, Central Project Management Office of PRC-GEF Partnership on Land Degradation in Dryland Ecosystems, Beijing; Liu Shirong PhD, Corresponding Author, and Technical Director, Central Project Management Office of PRC-GEF Partnership on Land Degradation in Dryland Ecosystems, Beijing

The Giant Panda Rewilding Training Centre is located in a state-owned farm in the Tianchi Forest, Sichuan province, where forest resources are plentiful and the forest coverage rate reaches 98 per cent. The area's karst topography is typically home to natural bamboo that grows in 10,000 ha of the forest area, including Huaying Mountain. There is a wide range of vegetation types with a mixture of broad-leaved evergreen and deciduous trees, bamboo, and bush land. The bamboo and broad-leaved forests together account for most of the area's vegetation coverage.

The forest plays an important role in maintaining the ecological security of the central part of Huaying Mountain, supporting the forest farmers, their living and production cycles. The forest also creates a sustainable setting for the Giant Panda Rewilding Training Centre, which was established in 2014, with two giant pandas brought there in the same year.

Image: PRC-GEF

The collected bamboo culm for sale

However, the problem with natural white bamboo (*Phyllostachys bissetii*) is that it declines within 7–8 years, with some plants prone to wither and die. To ensure its sustainable use as well as guarantee a stable diet for the giant panda, the Centre carries out its White Bamboo Tending and High-yield Technology Demonstration Project, with the support of the PRC–GEF Partnership on Land Degradation in Dryland Ecosystems.

Through improving the profile of bamboo, adjusting forest density and composition, and providing technical training, the project raises the bamboo yield per unit in degraded land, strengthens the ecological function of the bamboo forest, and influences other karst areas of Huaying Mountain in developing the bamboo industry. The project supplies sufficient, quality food for the giant panda, while extending the panda's living space, facilitating its rewilding process, and contributing to the area's biodiversity.

Sustainable land management techniques for bamboo

Human intervention both prevents natural bamboo forests from degrading and promotes the sustainable management of degraded land. The primary techniques are:

Cleaning — cutting and spreading the weeds and bushes in a bamboo forest allows them to decompose for use as fertilizer. The practice can improve the yield of newly-grown bamboo as well as eliminating the habitats of pests, reducing disease within the forest. The technique is adopted after the shoots break through the soil or after they grow into forest. The strategy is to keep the thick, newly-grown, sparsely-grown, and well-grown shoots, as well as those growing at field edges; and to cut the slim, old, densely-grown, badly-grown shoots as well as those growing in field centres. The stumps are cut to no more than 5–10 cm above the soil, and the culm is carried outside the forest for possible use there. The bamboo branches are cut into small sections, laid on the land and trodden down.

Soil covering — the ground is covered yearly with a further layer of soil to improve growth and raise the bamboo yield.

Image: PRC-GEF

Giant pandas at the Giant Panda Rewilding Training Centre

This technique is practiced in winter while there is available labour. Gentle slopes of less than 20 deg. are selected and covered with soil to a depth of 3cm, preferably using soil from bogs and ditches. The soil covering expedites the decomposition of the bamboo leaves and weeds and improves the fertility of the forest land.

Fertilizing — white bamboo grows quickly and extracts nutrients from the soil. Large amounts of nutrients are therefore lost when leaves and branches are carried out of the forest. It takes a long time for the stumps to decompose, rendering those nutrients unavailable most of the time. Fertilizing enriches the soil with nutrients, ensuring a smooth energy cycle within the forest. Organic fertilizer and manure are mainly used, with 7,500 kg of organic fertilizer per ha applied at a depth of 5–10 cm and covered immediately with soil.

Density adjustment — this technique is practiced along with cleaning, and is carried out according to the regulated technical procedures of density comparison testing. To find the appropriate density for shoots and bamboo harvesting, various types of site are selected, with average bamboo growing densities of 2 bamboo/m^2, 4 bamboo/m^2 and 6 bamboo/m^2. A total of 15 plot sites are set, each 26 m long, 26 m wide and covering an area of 1 mu (1/15 ha), with each plot site identified with pegs and markers. Observations are made every five days from April to June, and the data collected and recorded according to accumulation, number and age of plants, diameter at breast height, and other factors of the sites after the shoots break through the soil and before the branches and leaves begin to spread out. The density can be readjusted by collecting shoots scientifically.

Fresh white bamboo shoots can be gathered and sold in 10–30 kg bundles, which not only raises a farmer's income but also achieves the sustainable management of the forest.

Achievements

The project has improved the composition and pattern of the forest and optimized the bamboo growth environment — all helpful to the giant pandas' return to nature. The project has also increased the forest's soil and water conservation capacity, preventing land degradation and achieving sustainable land management.

The forest farmers' income has been raised by over US$ 29,000, the rate of growth of bamboo shoots has increased by 20 per cent, the plant rate by 10 per cent, and the average growth rate per plant has increased by over 10 per cent. The project has also improved fresh shoot yield by 2,150 kg, and

culm by 21,500 kg, rendering a total value of US$ 6,250 at the price of US$ 1.5/kg for fresh shoots and US$ 0.15/kg for culms.

The project has created more than 30 jobs for local forest farmers. Three terms of training on high yield white bamboo were carried out, with over 500 farmer trainees participating, among whom 20 have become technical experts. Empowered with bamboo management skills and witnessing the high yield of the demonstration site, it is expected that more farmers will be willing to participate in the bamboo industry.

Image: PRC–GEF

Natural bamboo forest surrounding the Giant Panda Rewilding Training Centre, before intervention

The project provides abundant white bamboo for the giant panda, and promotes the reorganization of the species in Huaying. Protecting the pandas benefits plants and other animals in the same areas, safeguarding biodiversity. As a result, the project generates multiple benefits for GEF focal areas. The project has also explored an operating model for developing forest industry and promoting rural rejuvenation, and has established an integrated model for developing mountains, rivers, forests, land and lakes.

Conclusion

The project operating under the PRC–GEF Partnership on Land Degradation in Dryland Ecosystems has improved the ecological function of the white bamboo forest, driven the development of the bamboo industry in the karst areas of Huaying Mountain, enriched the diet of the giant panda with high quality bamboo, extended its living space and helped rewilding, as well as protecting biodiversity.

Image: PRC–GEF

After treatment of the natural bamboo forest

Restoring and expanding green cover under bamboo for biodiversity conservation and a sustainable resource base in Indian mountain villages

Pankaj Tewari and Pratap Dhaila, Central Himalayan Environment Association (CHEA), Uttarakhand, India

Bamboo has been used for centuries by communities across India to solve their needs for housing, food, and culture in general. Commonly mistaken as a type of wood, bamboo is a grass, with features that make it tremendously beneficial for use as a contemporary engineering material. Bamboo also provides considerable environmental and ecological benefits in its contribution to regional biodiversity, soil stabilization and erosion prevention on hill slopes and land margins. Over 1,200 different species grow worldwide, with approximately 18 million ha of bamboo distributed across world forest ecosystems in Asia, Africa, and America[1].

There are more than 450 villages in Uttarakhand state, India, home to the majority of India's ringal[2] and bamboo artisans.[3] Bamboo and ringal craftsmanship has been the traditional occupation of this socially and economically marginalized group. With agriculture supplemented by animal husbandry as the primary source of livelihood in the Uttarakhand hills, the socially vulnerable members of society have invariably been those with little or no landholdings. It was therefore decided that 29 villages in the area, known over generations for their bamboo-based handicrafts, should benefit from a project run by the Central Himalayan Environment Association (CHEA), to support the villages' livelihoods.

Image: CHEA

Water conservation through natural methods

Forest restoration is an ongoing process of revitalizing ecological functionality and enhancing human well-being in degraded places. More than simply planting trees, restoration enables societies to meet their present and future needs, offering multiple benefits and various land uses over time.

The purpose of the project was therefore to create a model for bamboo plantation in hilly areas, ensuring an increase in green cover on degraded land and scaling up bamboo handicrafts by providing a resource base for enhancing the income of a marginalized community. Thus, the interventions focused around creating a biomass pool of bamboo and developing skills for diversifying the products.

As the planting of bamboo was known to have been unpopular due to myths and superstitions associated with it, a participatory approach was required to bolster restoration activities through developing model villages and uplifting the status of the artisans. The strategy therefore required the communities' direct involvement, with a good representation from among the youth.

The project's holistic approach resulted in creating a wider understanding among the artisans as well as developing champions to promote the bamboo-based activities. The project focused on sustainability, both in terms of resource availability and creating items as per market demand. Now, various market driven products are created using less raw

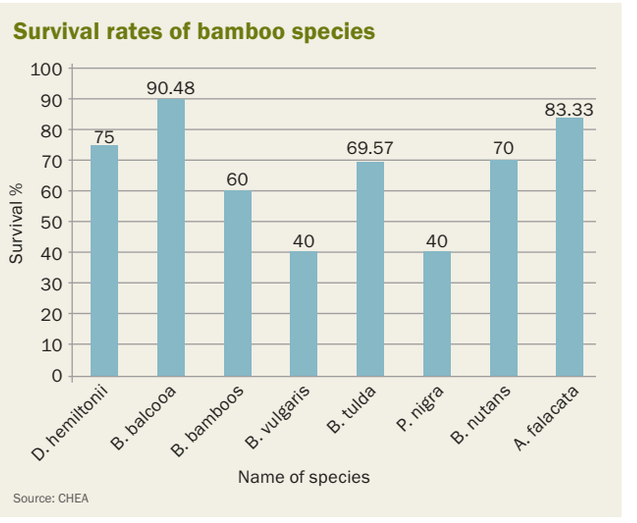


Image: CHEA

Preparation for planting in the community forest lands (*Van Panchayats*)

material and time, thus increasing the net benefit, and reducing pressure on natural resources due to expanding the area of bamboo plantations.

Artisans' groups were formed as Self Help Groups (SHGs) and Joint Liability Groups (JLGs) and linked to banks. Funds were released directly to the SHGs' and JLGs' bank accounts which were jointly operated.

To ensure ownership as well as the maximum survival of the plantations, the groups were combined into a single platform as a village level institution. In all, 27 women's SHGs and 29 artisans' JLGs, together representing 551 households, were formed to facilitate a community-wide understanding of the project and to add financial strength by linking with various development programmes and microfinance institutions and banks.

The main aim was to promote bamboo plantation in rural areas in order to reduce pressure on the natural resource base through the easy availability of the new raw material. Various bamboo and ringal species were selected following consultation with visiting scientists, and planted in the community forest lands (*Van Panchayats*) and at household level. Approximately 48 ha of land was brought under bamboo plantation, with 81,465 plants (27,660 household; 53,805 community forest) of seven bamboo species: *Dendrocalamus strictus*, *Dendrocalamus asper*, *Bambusa balcooa*, *Dendrocalamus hemiltonii*, *Bambusa nutans*, *Bambusa vulgaris*, *Phyllostachyus nigra* and *Arundineria falcata* (ringal).

Planting on private land was carried out mainly along the field bunds, or on barren land around the houses. The soil work and pit digging was completed well in advance, before the onset of monsoon. The activity was supplemented by water conservation interventions for moisture retention and to reduce the runoff of soil and water during heavy rains. Contour trenches were created in the project areas, facilitating groundwater recharge through infiltration of surface runoff into the soil. Several contour trenches and micro-reservoirs have been created to further improve results and to encourage the revival of perennial streams as well as to create springs along the way. This *Chal-Khal* barrage[4] method was developed for conserving rainwater for use in summer, retaining moisture and reviving several plant species that are either planted or grow naturally in the area. In the hilly areas the main source of water is from natural features such as springs, streams and wells.

The idea of creating micro reservoirs has been introduced to the *Van Panchayats* as part of the project. In all 14,700 contour

trenches and 3,080 micro reservoirs have been created in various areas, along with provision for their maintenance. Trained professionals within CHEA have supported the appropriate layout and selection of sites.

Outcome of the interventions

The continuous and encouraging efforts of participation, involving the stakeholders and communities through regular workshops, resulted in the development of a human resource for sustaining the programme. The traditional artisans have developed their skills and capacities through participation in training on plantation and management techniques of various bamboo species and the establishment of nurseries.

Outcome on land restoration, and soil and water conservation

The plantation of bamboo species has resulted in creating a pool of resources for the future including the restoration of degraded soil and land. The activity has also reduced rainwater and soil runoff, thus inducing natural growth. The bamboo species have also been planted around the trenches and reservoirs to keep the soil there intact.

Outcome on livelihood initiatives

Artisans are now regularly trained and are able to create diverse decorative products along with traditional utility items, and are attempting to impress the markets in a cooperative manner. The more progressive artisans are also encouraging others to persevere with the handiwork as the lengthy processes of learning and making should be coordinated to match market demand. Approximately 900 diverse products have so far been created due to a decrease in the need for raw material and the time required in crafting with improved equipment. The total income from the range of bamboo and ringal articles made over three years and sold in various markets and through participation in different fairs was approximately US$ 50,000.

Outcomes to the changes in raw material extraction

Previously, the bamboo was found in the forests but with few plants grown on private land. Artisans therefore had to travel long distances to collect the raw material, which was both time consuming and more expensive. The planting of bamboo in the *Van Panchayats* enabled the establishment of

Image: CHEA

Training given for crafting the bamboo

Image: CHEA

Village meeting for ownership development

Image: CHEA

Bamboo nursery under a poly house

Image: CHEA

Well established dwarf bamboo

Image: CHEA

Artisan busy with bamboo product development

private lands and nurseries. Now, the pool of raw material is easily available and the harvesting more convenient for the artisans.

Outcome on gender and social equality

Women's empowerment was successfully achieved through the project by involving women in the SHGs and JLGs. With regular monthly meetings, SHGs deposit money on a monthly basis and create possibilities for better linkages with banks and financial institutions. The project has also motivated the weaker people within the community to continue bamboo craft within the context of modern tastes.

Recommendations for the future

Preliminary findings have been encouraging — the project's activities have facilitated sustainable development by positively addressing environmental, social, and financial needs. There must now be sustained focus on the involvement of women in the programme along with the development of the skills of artisans and youths for backward and forward linkages.

Skills development training needs to be organized on a regular basis to ensure sustainability and self reliance. Networking should be encouraged with institutes, agencies and universities to add value to the bamboo products and for the development of new products. The information and assistance necessary for marketing the products developed by the artisans should also be provided.

The availability of raw material should be improved by the cultivation of suitable bamboo species in consultation with experts in the *Van Panchayats* and private areas, and there is also need to provide artisans with the means for sustainable extraction as well as the transportation of raw materials. Convergence with other development agencies as well as the publicizing of the programme at state level must be explored for the benefit of the artisan community. Also, a pool of bamboo stock should be created to aid environmental restoration.

Ringal and bamboo plantations should be incorporated in the micro plans of the *Van Panchayats*. For the harvesting in the future, rules need to be drafted carefully so that conflicts can be resolved quickly and equality can be achieved in resource utilization.

Overall it is recommended that a biomass pool of bamboo should be increased to reduce the pressure on the natural bamboo resource base through plantation and sustainable extraction by ensuring participation of the community. Also, the creation of diverse artefacts appropriate to the markets, to optimize net income, has to create a balanced relationship between natural resources and livelihood.

Restoring the most ecologically valuable forest ecosystems in the world

Natasha Ferrari, Communications Officer, Global Restoration Initiative, World Resources Institute (WRI)

The Tambopata National Reserve in the Madre de Dios region of Peru is located between the fringes of the Amazon rainforest and the city of Puerto Maldonado. The land here had become degraded through both illegal mining and the single crop plantations of papaya that provided the community with much needed income but stripped the soil of nutrients. This type of practice led to deforestation as farmers moved on in search of new plots of nutrient-rich land, often forested. These scenarios are rapidly changing due to a groundbreaking project to transform agriculture in the southeastern region of Peru run by local, non-governmental organization AIDER and supported by impact investor and leading global natural capital fund manager, Althelia funds, part of Mirova, an affiliate of Natixis Investment Managers.

Image: Tambopata National Reserve

Papaya trees have been left standing in order to provide shade for the cacao crop, as part of the agroforestry programme for the Tambopata National Reserve buffer zone, Peru

AIDER is a technical partner of Initiative 20x20, a country-led effort to bring 20 million ha of land in Latin America and the Caribbean into restoration by 2020. So far, 17 countries and three regional programmes have committed to begin restoration of more than 50 million ha for the initiative, with the support of over 40 technical organizations and institutions. The partnership, with an acting secretariat within the World Resources Institute (WRI), combines expertise, intent and capital in the region to transform the dynamics of land degradation and advance restoration. An earmarked US$ 2.5 billion of private investment has been pledged by 20 financiers and impact investors, and restoration and conservation projects covering 10 million ha of land are already underway.

The initiative, launched formally at COP 20 in Lima, supports the Bonn Challenge, a global commitment to bring 150 million ha of the world's deforested and degraded land into restoration by 2020, as well as the New York Declaration on Forests that seeks to restore 350 million ha by 2030.

Intact rainforests are thought to absorb more carbon from the atmosphere than other types of tree cover or forest. It has therefore been an imperative, over decades, for AIDER's dedicated specialists to help conserve the Amazon, carrying out biological monitoring and protection of the rainforest reserves, and preserving the trees vital to carbon absorption and climate change mitigation. To date, AIDER has facilitated the restoration of 8,682 ha, protected 638,520 ha of sustainable forest, and conserved 498,040 ha.

The Tambopata National Reserve is an internationally recognized biodiversity hotspot in the Peruvian Amazon. Here, the lush tropical rainforests provide habitat for an enormous variety of rare and endangered wildlife. The organization's first REDD+ project in 2009 involved 10 types of forest in the national rainforest and its neighbouring buffer zone. REDD+ projects provide AIDER with the ability to support conservation efforts through selling carbon credits.

The buffer zone sits just north of the Tambopata National Reserve where AIDER is working with the local community and farmers to restore land and incorporate sustainable agricultural practices. Here, papaya plantations are gradually being replaced with mixed agroforestry systems that benefit both people and the environment. The farmers are enthusiastic drivers of this project, a fact critical to its success. The types of tree used in the design of the agroforestry systems bring value to the farmers, increasing incentives to replace crops such as coca and papaya which had led to land degradation, with the

result that the farmers are now able to not only diversify their income, but also remain on the same plot of land.

It takes approximately 32 years to transform degraded land into dense forest, so dedication and understanding are key. In 2014, AIDER supported the establishment of the Cooperativa de Servicios Multiples Tambopata Candamo (COOPASER), then a cooperative of 21 farmers. This has since grown to 350, a remarkable success story. Part of the success is due to careful and intentional design. Agroforestry systems do not typically offer a quick return on investment, and the seasons are important considerations regarding harvests and income. So, a typical agroforestry system in this region is constructed to include a shadow component, for example banana or papaya; a main crop such as cacao; a recovery crop such as guava; and quick- and slow-growing timber species — together incorporating short and long-term income cycles for the farmer. Growing a mix of trees and shrubs in this way mimics the behaviour of a forest, and helps the soil retain nutrients and water, protecting the land and increasing carbon absorption. Indeed, restoration and conservation could deliver 60 per cent of emissions reductions needed by 2050 in Latin America and the Caribbean.

AIDER works with farmers to develop individual business plans. For every 40 ha of land, including 20 ha of primary forest and 20 ha of crops, farmers must manage a minimum of 3 ha using these types of sustainable practices. Mr. Pedro Villa is one of the farmers in the cooperative, with land on the outskirts of the rainforest. Many years ago, his land was home to virgin forest, but this was cleared to make way for a papaya farm with intensive use of chemicals. This has now changed.

The newly restored land has all of the appearances of forest but is, instead, a cleverly laid out agroforestry system. Mr. Villa's main income is cacao, of which he grows four varieties. Two types of soil help the cacao to establish and it takes six months for the fruit to emerge from each flower. Papaya is still present on the farm, but is now in service as a shade tree, sheltering the cacao that grows underneath. Boliana also grows here, a quick-growing timber species that matures ready for harvesting and selling within five years.

Mr. Villa arrived in the area in 1975 as a cattle rancher, motivated by incentives from the government at the time that led to widespread deforestation as farmers cleared forest for pasture land. Now, he says: "I am bringing back forest to my farm." As he restores the pasture land, trees are returning to what is now a diversified farm where fruits and cacao are grown, and cattle and pigs raised. In 2017, he processed 3 tons of cacao, the raw ingredient of chocolate, and now he feels comfortable in processing 20 tons, a mark of huge success, this time of benefit to the environment.

At the processing facility, wet cacao arrives from Puerto Maldonado and is dried. The farmers' cooperative collectively partners with a fermentation and drying facility, responsible for post-harvest production, and this is where Mr. Villa takes his harvest. The cacao beans are collected from each farm, then classified, weighed and left to ferment. Fermentation can take up to a week, after which the beans are laid out to

Image: Tambopata National Reserve

Mr. Villa's productive agroforestry farm, with papaya as the shadow component, two types of cacao, guava and timber species, Tambopata National Reserve buffer zone, Peru

Image: Tambopata National Reserve

Mr. Cirilo Sanchez showing a cacao crop, Tambopata National Reserve buffer zone, Peru

dry under direct sunlight. After 20 days, the beans are ready for classification based on quality and type. They are selected for flavour and aromatics, relying on specialized staff for testing, and are then roasted, ground and refined for chocolate. In 2018, the facility received certification, with the result that the farmers can now earn an extra US$ 300 per ton. The facility is hoping to add an organic stamp to this certification which will add a further US$ 200 per ton.

Not far away, Mr Cirilo Sanchez, president of the COOPASER cooperative, is practicing agroforestry of a slightly different kind. Although he also grows cacao, he cultivates tropical flowers to sell to lodges in the rainforest. These lodges rely on the flowers' colour to decorate the accommodation in service of the increasingly popular ecotourism industry. He grows 15 varieties of flower, all native to the Amazon. In sympathy with the biodiversity of the nearby rainforest, he is now seeing wild trees populate his land. He also grows maize, cacao and bananas, as well as keeping cattle. Also helping to bring life back to the land is Mr. Sanchez's use of makuna, an extremely invasive legume which he uses in the first stage of restoration to help fix nitrogen in soil previously depleted of nutrients. This prepares the soil for planting and is then cleared to make way for trees and crops.

To date, AIDER has restored and conserved 1,300 ha of forest within the Tambopata National Reserve buffer zone project. The role played by the organization, however, is not without risk. Illegal mining is rife, commanding huge swathes of land and destroying valuable virgin and secondary rainforest, and bringing in a steady stream of illicit money. The lives of those leading restoration and conservation efforts, such as AIDER, are often threatened, but their passion for change does not falter.

Althelia funds, a financial partner of Initiative 20x20, funds AIDER's important work. This US$ 12 million investment programme is creating an economic buffer zone around a 570,000 ha forest (an area of approximately the size of Los Angeles). By helping local farmers with the transition to sustainable cocoa production, degraded land is being restored and deforestation pressures relieved. This creates a barrier to protect the rainforest and provides people with a forest-friendly and sustainable livelihood, with income generated through the sale of both carbon credits and cocoa.

The Althelia funds organization manages investments that deliver financial returns fully aligned with the conservation of nature and sustainable social development. They leverage expertise and capital to define pathways for innovative solutions to the climate and environmental challenges currently facing society. Althelia funds has invested in Ecosphere+, a leading company that is building a market for the environmental assets yielded by the fund, such as carbon credits, as well as for sustainably produced agricultural products such as deforestation-free cocoa. Ecosphere+'s customers, a variety of companies ranging from large corporations to small and medium-sized enterprises, use a price on carbon and the purchase of carbon credits to finance forest protection projects, including the work of AIDER, which allows them to align their actions with global climate and development goals.

Image: Tambopata National Reserve

Tree canopy layers surrounding the Tambopata river, Tambopata National Reserve, Amazon rainforest, Peru

Christian del Valle, founder and managing partner of Althelia funds, says: "Althelia funds is deploying capital in support of a portfolio of projects in the region to improve agricultural practices, restore degraded lands, and reduce pressure on natural ecosystems, with concrete results in emissions reductions, zero-net deforestation commodities, biodiversity, and livelihoods."

AIDER receives carbon income from conserving virgin and secondary rainforest and managing the risk of buffer zone projects by engaging the local community in sustainable agriculture including agroforestry, instead of reforesting the area and fencing it off. The region has become an attractive opportunity for investors due to the lower risk of its carbon credits. Local people have incentives to restore and conserve land because of the benefit to their livelihoods, presenting a lower risk for the carbon credits economy of increasing tree and shrub cover to reduce emissions. In short, money raised from the carbon credits of forest conservation is funding the farmers' crops and agroforestry.

In recent years, more than 40 per cent (650 million ha) of forests in Latin America and the Caribbean have been completely deforested or degraded. These areas contain some of the most ecologically valuable forest ecosystems in the world, but recently 20 per cent of forest lands (nearly 350 million ha) have been completely deforested and a further 20 per cent (300 million ha) badly degraded. The drivers of this change include large- and small-scale agriculture, infrastructure projects, and mining. As a result, the bulk of the emissions in the Latin America region are generated not from energy but from land use, land use change, and forestry. Of the 4.7 GT emitted by Latin American and Caribbean countries in 2010, approximately 67 per cent was from land use and loss of forests.

Initiative 20x20 supports reforestation (natural and assisted) and the conservation of forests, as well as avoided deforestation, as elements of an integral restoration process. Cognizant of the various degrees of land degradation in the region, the initiative also supports efforts to recover land functionality — soil conservation and recovery; carbon storage; water retention and stable hydrologies; biodiversity conservation and recovery — through agroforestry, silvopasture, and other sustainable land use schemes.

The initiative inspires national commitments to restoration by engaging in a robust dialogue with ministers of agriculture and environment in the region, as well as making an economic case by assessing the societal benefits from restoration and avoided deforestation and establishing a financial mechanism that allows private sector impact investors to fund restoration projects. A WRI report in late 2016, The Economic Case for Landscape Restoration in Latin America, found that restoring 20 million ha of degraded lands in Latin America and the Caribbean by adding trees and improving farming practices would yield US$ 23 billion in net benefits over 50 years, a value equivalent to approximately 10 per cent of annual food exports from the region. That is an average of US$ 1,140 per ha.

Towards land degradation control in China

Wang Lili, National Bureau to Combat Desertification, National Forestry and Grassland Administration, China; Ding Rong, Forestry Department of Inner Mongolia Autonomous Region, China; Zhang Xiangmei, Forestry Bureau of Qianxinan Bouyei and Miao Autonomous prefecture of Guizhou province, China

As one of the largest developing countries in the world, China is facing the threat of severe desertification and land degradation. Since the signing of the United Nations Convention to Combat Desertification (UNCCD) agreement in 1994, the Chinese government has implemented various strategies for land degradation control, successfully managing a reversal in the desertification of land under its remit, and achieving land degradation neutrality under the terms agreed by the UNCCD. In recent years, the country's forest areas have been increasing and grassland vegetation has been restored, with the result that China's overall ecological status has been greatly improved.

Sand control

One of the objectives, between 2010 and 2020[1], has been to control sandification of 20 million ha of land, decreasing the affected area year by year and improving the ecological status and living standards in those areas. It is predicted that, by 2020, more than half of China's desertified land will be managed and, by 2050, desertification will have been successfully managed over the entire country.

Soil and water conservation

By 2020[2] an integrated soil and water conservation and control system will be established to meet China's economic and social development objectives. The prevention and control of soil erosion in key areas will be effectively managed, with an increase in the soil conservation area reaching 320,000 km^2, including 290,000 km^2 of water erosion control. Soil erosion due to wind will also be gradually reduced, and soil erosion caused by human intervention will be effectively controlled. Forest vegetation will also be protected and restored, with an annual reduction of 800 million tons in soil loss, and the volume of sediment reaching rivers and lakes reduced proportionally.

By 2030, the country's soil and water conservation area will reach 940,000 km^2, of which a new soil erosion treatment area will cover 860,000 km^2. Here, moderate to severe erosion will be significantly reduced, with the wind erosion area effectively managed and man-made soil erosion fully controlled. Forest vegetation will also be fully protected and restored. The annual reduction of soil loss is estimated to be 1.5 billion tons by 2030.

Image: Forestry Department of Inner Mongolia Autonomous Region

Contrast in the growth of vegetation inside and outside an aerial seeding area near Alxa League, Inner Mongolia Autonomous Region

Objectives of Land Degradation Control in China

Indicator	2020	2030
Cultivated land areas (100 million mu*)	18.65	18.25
Forest coverage (%)	>23	>24
Integrated vegetation coverage of grassland (%)	56	60
Newly controlled sandification land (10,000 ha)	1,000	
Newly treated soil erosion area (10,000 km^2)	32	94
Safe use of polluted arable land (%)	90	95
Natural wetland protection rate (%)	>50%	>90%

*Mu is a Chinese unit of land measurement equivalent to 1/15 ha or 0.06665 ha

Grassland protection

By 2020[3], the total output of fresh grass from natural grassland in China will reach 1.05 billion tons, with 56 per cent of vegetation coverage, and an overgrazing rate of no more than 10 per cent. The trend of grassland overgrazing and degradation will be curbed, the grassland ecosystem will be improved, and the self-restoration capacity of the grassland ecosystem will be strengthened. Grassland subsidies, reward policies and compensation systems will be established to include grassland protection; contract management; both banned and fenced grazing; rotational grazing; and monitoring and evaluation,

By 2030, the integrated coverage rate of grassland vegetation will reach 60 per cent, and the average livestock overgrazing rate on natural grassland will be no more than 8 per cent. The ecological function of grassland will be enhanced and productivity will be steadily improved, with a grassland self-restoration system and protection systems formed.

Sustainable forest management

By 2020[4], forest management will have made significant progress, with forest management theory, technologies, policy and sustainable management systems established and promoted. The national forest coverage rate will reach over 23.04 per cent, and the forest accumulation volume will be more than 16.5 billion m^3. The arbor forest volume per ha will be more than 95 m^3; and the mean annual growth of arboreal forest per ha will reach 4.8 m^3. Forest quality in key areas will reach the world's average level over the same period.

By 2030, the rate of national forest coverage will top 24 per cent, forest volume will increase by 4.5 billion m^3 compared to 2005. In 2050, the national forest coverage rate will be greater than 26 per cent, and forest accumulation will be more than 23 billion m^3. Arboreal forest volume per ha will be more than 121 m^3; average annual growth of arboreal forest per hectare will be 5.2 m^3 or more. The national forest quality will exceed the world average over the same period.

Arable land protection and conservation

By 2020, 124 million ha (1.865 billion mu)[5] of arable land in China will be strictly protected; soil environment safety for arable land will be guaranteed; the quality of arable land will be improved by a grade of 0.5; and there will be zero growth in the use of fertilizer and pesticide.

By 2030, the national average arable land quality will be improved by 1.0 grade (level) compared to that of 2015. Land unsuitable for farming will be converted to forest. A rotation and fallow system will be established along with an overall pattern of efficient use of the arable land, ensuring a stability of quality and environmental safety.

Soil pollution control

According to the action plan of soil pollution prevention and control[6], by 2020 the trend of increase in soil pollution will be restrained, soil quality will be stabilized, and the soil security of agricultural and construction land will be guaranteed. The safe utilization rate of polluted arable land will be approximately 90 per cent, and the safe utilization rate of other polluted land will be above 90 per cent.

By 2030, national soil quality will be stable, soil security for agricultural and construction land will be effectively protected, and the environmental risk of soil pollution will have been overcome, with a safe utilization rate of polluted arable and other land of over 95 per cent.

Wetland protection and utilization

By 2030[7], the number of national wetland protection areas in China will increase to 713, and the number of internationally important wetlands will increase to 80, such that more than 90 per cent of natural wetlands will be effectively protected.

Saving wetlands in Inner Mongolia

The Juyan Lake Wetland is located at the lower reaches of Black River, the second largest inland river in China. The area was listed in a directory of key wetlands under protection of the state in 1994, as well as in the directory of important wetlands in China under the China Action Plan for Wetland Protection in 2000. According to data from the second survey on wetland resources conducted in 2010, the total area of Juyan Lake Wetland was 5,881.87 ha. Since 2002, through unified management and an optimal allocation of water resources, the Black River has undergone trans-province and trans-regional diversion engineering with the result that the average water area of Juyan Lake has now reached 42 km^2. Although the water area is being restored constantly, the wetland is still changing dynamically due to the turbulence of headwaters and the fragility of the desert grassland ecosystem.

In 2004, under the instruction of the state council, the restoration and construction of Juyan Lake Wetland was listed in the National Wetland Protection Plan (2002–2030). The project began in 2008, and was officially launched in 2009, with the approved investment of US$ 3.3 million. The chief concerns of the project were wetland conservation and restoration; scientific research; and monitoring and support for the engineering and construction work. In later stages, two sets of video surveillance systems were installed through a wetland subsidy programme, enabling the automatic monitoring of birds in some of the areas. Meanwhile, a batch of advanced testing devices has been purchased, allowing for more convenient and accurate monitoring of birds with greater clarity of information.

The area of aquatic vegetation such as reeds is continuously growing in the wetland, rising from under 1,000 mu at the start of the project to 30,000 mu in 2018. The degraded area of vegetation has been gradually restored with the implementation of measures such as irrigation and close monitoring, with the restored area of forests and grass reaching approximately 100,000 mu. The number of bird populations is also constantly growing, with 84 species monitored so far, including four species under first-grade state protection, 12 species under second-grade state protection and 68 species under

Image: Forestry Department of Inner Mongolia Autonomous Region

Aquatic plants at Juyan Lake

Image: Forestry Department of Inner Mongolia Autonomous Region

The biodiversity of Juyan Lake in the arid area

provincial protection. The research clearly shows important economic and scientific benefits of the project.

The periods between late March and early May and between mid September and late October each year are the peaks for bird migration, with the number of birds passing the Juyan Lake Wetland reaching over 40,000 in every migration season. Today, the Juyan Lake Wetland has become a welcoming haven for many migrant birds, as well as a place for bird watching, and recreation in general for people in the nearby city of Ejina.

Stony desertification control in Guizhou Province

Zhenfeng County is located in the south west of Guizhou Province and the east of Southwest Guizhou Autonomous Prefecture. It covers a national territorial area of 1,511.9 km^2, of which the stony desertification area is as high as 597.48 km^2 or 39.52 per cent of the total. Shuangru (double breasts) Mountain is the most characteristic landform of the area's karst topography.

During a time when economic and social development had slowed and farmers struggled to avoid poverty, the area's natural resources were exploited limitlessly, deteriorating the eco-environment and making development more difficult. However, it was decided that, by 2020, the area should have built a moderately prosperous society in parallel with the entire country.

Therefore, in 2008, integrated efforts to control and prevent stony desertification began, with eco-environmental restoration and poverty relief formally implemented in the area. Through detailed planning and a focus on the key points for recovery, the county set up systems for the restoration of the stony desertification areas, with sensitivity to local topography and conditions. Forest coverage was improved by returning grain plots to forestry, closing hillsides to facilitate afforestation, growing economically viable fruit forests, and conducting conservation tillage.

To prevent and control stony desertification in general, reservoirs were impounded and a great number of check dams, debris dams, sand basins, feed pipes, irrigation and drainage canals and ditches and were constructed. A comprehensive programme was carried out for the management of mountains, water, forests, farmlands, roads and wetlands. To meet targets for ecological, industry-based poverty relief in the stony desertification areas, various methods were explored and popularized including the Dingtan mode of pepper planting, Pingshang mode of honeysuckle planting, and the Baiceng mode of plum planting.

Through an integrated string of measures taken over a decade, Zhenfeng County has treated 371.47 km^2 of karst areas and 143.47 km^2 of stony desertification areas, in addition to completing a variety of ecological projects covering 430,900 mu.

A total of US$ 23.3 million has been spent implementing a series of Grain for Green projects covering 135,000 mu and including: the consolidation of 44,200 mu of Grain for Green achievements; carrying out the Pearl River shelter forest project that covers 12,000 mu; recovering 62,500 mu of forest vegetation; conducting 130,000 mu of integrated stony desertification management and ecological construction projects; 45,000 mu of afforestation subsidy pilot projects; and 2,200 mu of overall agricultural development.

Through implementing ecological rehabilitation projects, Zhenfeng County has secured favourable ecological benefits. Its forest coverage rate increased from 22.85 per cent in 2007 to 45.8 per cent in 2017, and its soil erosion volume reduced by 284,000 tons each year. Through controlling stony desertification, the county has created a poverty alleviation path with both economic and ecological benefits. It has also built a group of ecological poverty relief industries — 130,000 mu of plum gardens, more than 80,000 mu of walnut orchards, 50,000 mu of pepper fields, 30,000 mu of honeysuckle, 30,000 mu of chestnut orchards, and 30,000 mu of soapberry. In 2018, the county's output of crispy plums and April plums alone reached 100,000 tons, with a value of US$ 87 million, giving a credible push to poverty alleviation in the area.

The success in controlling stony desertification in Zhenfeng County is attributable to local and national government as well as to the hard work of local people. The initiative has unified the ecological, social and economic benefits of the project, and promoted the mutual benefits of ecologically sensitive development and construction.

Image: Forestry Bureau of Qianxinan Bouyei and Miao Autonomous prefecture of Guizhou province, China

Villagers of Beipanjiang Town manage the pepper fields

Image: Forestry Bureau of Qianxinan Bouyei and Miao Autonomous prefecture of Guizhou province, China

Tour of the plum orchard at Balceng Town

Gully erosion control promotes sustainable management in degraded land

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Loess hill is a significant geomorphic landform on the Loess plateau of China. The area is named for its most distinctive feature, the highly friable loess soil. But, due to severe damage of the surface vegetation, in the rainy season of July and August, water running over the surface erodes the porous loess to create gullies, worsening the degradation of the area's ecosystem.

Horinger county in the Inner Mongolia Autonomous Region is located to the north of Loess Plateau at the transitional zone between the Inner Mongolia Plateau and the Loess Hills in Northwest Shanxi province. The region has a variety of geomorphic landforms referred to as "50 per cent hills, 30 per cent mountains, 20 per cent gully". In the north of the region, gullies cut across the loess-covered hilly area, breaking it into fragments, with the result that the area faces serious soil and water loss, low soil fertility, severe land degradation, and reduced biodiversity.

Grassland in the arid, hilly area is the main vegetation type but the coverage rate is low. Long-term overgrazing and inappropriate reclamation and farming have damaged the land resource and deteriorated the production environment for agriculture and livestock-raising. Worsened by climate change and confronted with the threat of more aridity, the area became a typical example of the serious land degradation that has occurred over the last 50 years along the

Image: PRC-GEF

Topography of the project area

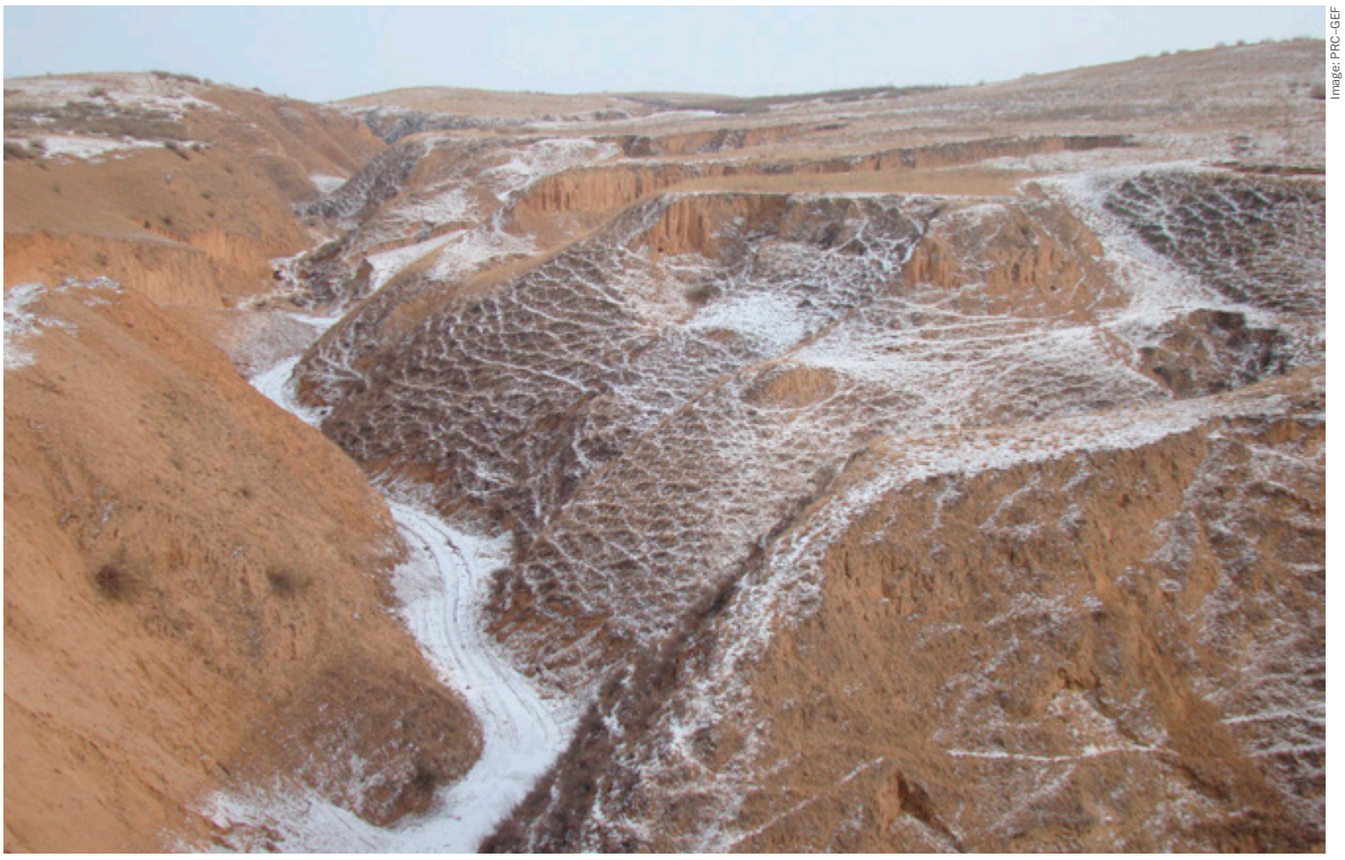

Image: PRC–GEF

Gully No. 8 in 2013, showing the extent of soil erosion

central reach of the Yellow River and Northern China where agriculture and husbandry have traditionally combined. The county's soil erosion area is approximately 105,333 ha, occupying 30.7 per cent of the total land area and with an erosion module of 5,000–10,000 t/km^2.

The gullies, which are severely eroded with little vegetation coverage, have been formed mainly by water and gravity erosion, with the gully-head cutting downwards, leaving a steep slope at the top. The floods, formed by summer rainstorms, destroy roads and farmlands, severely damaging production and the living conditions of the local communities, and dumping a large amount of sediment into rivers. Significantly, the area becomes the cause of silting in the middle reach of the Yellow River.

To improve the regional eco-environment, combat land degradation and reduce the hazards of soil erosion, the Forestry Department of the Inner Mongolia Autonomous Region, the Forestry Bureau of Horinger and The Nature Conservancy (TNC) jointly established a Gully Control Demonstration project in the Loess hilly area. The initiative was devised in the Horinger town of Shengle, with the support of the project of Climate Resilient Sustainable Land Management in Western PRC under the PRC–GEF Partnership on Land Degradation. The project aims to explore an integrated management model to address the degraded land of the hill and gullies. The project combines biological and engineering measures to restore vegetation and ecological services, thus achieving sustainable land management and improving the lives of farmers and herdsmen.

Project area survey

In the project area of Shengle town, the gully density is 4.07 km/km^2 and the erosion module is 7,000 t/km^2 (severe). A total of 14 gullies required treatment within a 6.63 km^2 catchment area. Gully No. 8 was chosen as the pilot site, with a channel length of 1,550 m and a catchment area of 0.54 km^2. Here, *Caragana microphyla* and *Pinus sylvestrsi var. mongolica* were planted, which grew well on the slopes of both sides, yielding high vegetation coverage and effecting soil and water conservation, thus stabilizing the gully channel. The 22 unstabilized sub-gullies have a total length of 2,140 m.

The total project area is approximately 23.31 ha with 5.23 ha of arbor and bush forest. The area with slopes of less than 15 deg. cover 8.62 ha; slopes of between 15 and 35 deg. cover 5.08 ha; and areas with other slope gradients cover 4.38 ha. The project treats a total of 16.36 ha of land area

Key techniques

The slope and the gully were treated simultaneously and comprehensively, with a graded protection system applied using the land degradation control methods of the neighbouring area.

Ecological measures: for slopes of less than 15 deg. and soil depths of greater than 30 cm, a belt of contour planting took place using a mixture of arbor and bush forest with *Pinus tabulaeformis* and *Caragana microphyla*. For slopes of between 15 and 35 deg., apricots were established together with *Caragana microphyla*. A willow shelter belt was planted at the bottom of the gully along with dense *Caragana*

microphyla within 5 m of the gully bank edge. *Robinia pseudoacacia L.* and willow were planted around the muddy field at the mouth of the gully to avoid slope erosion.

Engineering measures: conservation was the project's top priority, at the same time as integrating measures of prevention, hysteresis and discharging. A contour ditch was established in areas of slope of less than 15 deg. from the gully head downwards. Fish-scale pits were adopted in areas of broken surface on slopes of between 15 and 35 deg., and a check dam was built at the bottom of the gullies. Slopes were cut and contour-planted with *Pinus sylvestrsi var. Mongolica*. Some steep slopes were covered with a biological blanket to avoid gravity erosion.

Achievements

Ecological benefits: the integrated method of gully management and regional vegetation restoration has raised the vegetation coverage by over 30 per cent, effectively controlling soil and water loss, and yielding significant soil and water conservation effects, thus improving land productivity.

Social benefits: the project has provided a viable case study for gully control in other areas with similar conditions. It has promoted technical intervention in the county, restored 500 ha of degraded land, and improved the environment for the community's farmers and herdsmen. Sustainable agriculture practices have been simultaneously carried out on the recovered land by introducing advanced planting techniques, applying rational formula fertilizing, and guiding farmers to developing rain-fed farming.

Conclusion

The project has explored gully control measures, integrated with vegetation restoration, on degraded land in the hilly, loess soil areas of Horinger. It has significantly increased forest and grass vegetation coverage, improved the regional ecological environment, explored environmentally-friendly sustainable management practices on degraded land such as under-forest farming, grassland grazing and dryland farming, and transformed traditional land management ideas and methods on the farms. The project has helped the area to realize green production in agriculture and livestock-raising, and sets the model for increasing farmers' income. It has made great strides in the sustainable management of degraded land.

Image: PRC-GEF

Slopes cut into the gully before being contour-planted

Image: PRC-GEF

Gully No. 8 in 2018, demonstrating the project's success

Sustainable land and ecosystem management approaches and technologies — India's scenario

Takpa Jigmet, IFS, Joint Secretary, Ministry of Environment, Forest and Climate Change (MOEFCC), Government of India; Kohli Priyanka, PhD, Consultant Coordinator, Desertification Cell, MOEFCC, Government of India

India covers 2.5 per cent of the world's land area while supporting 18 per cent of its population and approximately 20 per cent of its livestock. Over 400 million of India's people live in drylands, but the total area of the country under land degradation is 96.4 million ha, and under desertification is 82.64 million ha. Approximately 1.87 million ha has been lost to degradation over a decade[1]. There are 12 million ha of degraded land in forested areas and 29 million ha of degraded croplands[2]. The various causes of decline are vegetal degradation, water erosion, wind erosion, waterlogging, salinity and alkalinity, frost heaving, frost shattering, mass movement and other anthropogenic origins[1]. However, sustainability initiatives are being implemented throughout the country to enable adaptation and mitigation, building both resilience and successful ecosystem management.

Land shaping for climate change adaptation and sustainable livelihoods in Sundarbans

Sundarbans is a Complex Diverse Risk (CDR) prone agro-ecosystem situated just east of Kolkata. Agriculture is the mainstay occupation for the majority of people, with approximately 68 per cent of total cultivable land low-lying and mono-cropped. The crop yield in the area is usually very poor due to soil, water and climatic constraints such as salinity build up, lack of irrigation during dry months (rabi season), deep waterlogging, and drainage congestion. When the heavy rains arrive — 1,700–1,800 mm per year during monsoon season — most of the water goes direct to the sea as runoff. There is also a dry period of six months, resulting in a crippling scarcity of sweet water. In low-lying land where water stagnation is relatively high — 2 to 3 ft during rainy season — only a traditional variety of paddy is grown. A second crop is not possible in the rabi season due to the late release of land as well as the scarcity of irrigation water. Attempts have been made to alleviate the problems of salinity and waterlogging in this region, under one of the objectives of the National Agricultural Innovation Project (NAIP)

Paddy-cum-fish cultivation in Dhamkol Village

In previous years, through farming 0.2 ha of land, Nimai Halder and his family were earning US$ 31 per annum. This low income compelled Mr. Halder to migrate to Kolkata in search of a job during the non-farm activity period, post-monsoon, eventually pulling a rickshaw in Kolkata. But now, as a beneficiary of the Sustainable Rural Livelihood Security initiative, and with the use of land shaping technology on the farm pond, the family has a net income of US$ 425 per annum.

The project enabled a portion of low lying area to be raised, using excavated soil, for growing vegetables all year round. This raised land is now free from waterlogging during monsoon and there is less soil salinity due to the reduced effect of brackish groundwater at a shallow depth. Now, along with the female members of the family, Mr. Halder is able to practice integrated farming with his paddy-cum-fish-cum-vegetable cultivation, earning almost daily by selling vegetables in the local market. He is also able to spend on other activities such as education for the children, and health and nutrition for the family.

Image: MOEFCC

A paddy-cum-fish-cum-vegetable cultivation made possible by creating embankments for the growing of vegetables all year round

Image: MOEFCC

The raised land is free from waterlogging during monsoon and there is less soil salinity due to the reduced effect of brackish groundwater

Image: MOEFCC

Planning session with nomads

initiative. The Sustainable Rural Livelihood Security through Innovation in Land and Ecosystem Management initiative is being implemented in Sundarbans as well as Andaman and Nicobar islands with the objective to sustainably manage degraded land and water resources for enhancing the livelihood security of farming communities.

Land shaping is an effective agro-technology that helps to harvest rainwater for the cultivation of vegetable crops after the kharif paddy period. The method is multifaceted by which a high yielding paddy variety replaces low yielding, traditional deep water varieties in the kharif season and helps the growth of high value vegetable crops during the winter season. It is also possible to facilitate pisciculture and duck rearing in the same paddy field and to grow fruit and vegetables alongside it.

The typical principles of land shaping for the Sundarbans farmers are:

- Excavation of 1/5th of the area of low land down to a depth of 8–9 ft
- Adjoining low land raised by up to 1.5 ft
- Pond embankment constructed at 5 ft wide by 4 ft high
- Land embankment around the area constructed at 3 ft wide by 3 ft high
- With the above arrangement, 6–9 acres per inch of rain water can be harvested and stored in the pond.

Sustainable land and ecosystem management initiatives in the Ladakh region

Ladakh is home to a unique assemblage of biodiversity, adapted to exploit the harsh conditions of the Trans-Himalayan region. The region's ecology has faced the added stress of anthropogenic impact, characterized by material poverty and a lack of sustainable alternative livelihoods for local villagers. In the past, local communities in this resource-scarce region were largely dependent on resource extraction to supplement their agro-pastoral practices. This included the hunting of ungulates for consumption, but there was also competition between livestock and wild herbivores over access to pastures, and depredation of livestock by large carnivores, especially snow leopards. This form of direct conflict between human communities and wildlife was detrimental to biodiversity conservation and imposed a significant constraint on developmental activities. As a result of this and the challenging terrain of the landscape, biodiversity in Ladakh remained fragmented under the various climatic, ecological and anthropogenic pressures. Also, the landscape and patterns of the human settlement in Ladakh — centred predominantly on access to water and agro-pastoral resources and tempered by risks posed by geological flood channels — made it impractical to implement the protected area framework as mandated by conservation laws.

Image: Jigmet Takpa

Village resource mapping and planning exercise, Pangong Lake, Ladakh

Intervention and Impact

In 1996, Mr Jigmet Takpa took charge as regional wildlife warden for the Ladakh region. He inherited a fragmented and degraded biodiversity characterised by human-wildlife conflicts and retaliatory killings. People were still hunting wildlife for consumption and extracting resources, even as their developmental aspirations were being articulated more clearly.[3]

The region had witnessed rapid change since the mid-1970s, leading to a shift from a traditional land-based economy centred on agriculture and livestock rearing to a monetary economy based on mass tourism. This shift has, however, added to the anthropogenic pressure on the region such as land use change, unsustainable use of water resources and a greater demand for livestock products such as pashm (a fine, soft wool from the underfur of local goats and sheep). This has been detrimental to biodiversity conservation and to livelihoods.

In 2001, in an effort to understand the challenges for biodiversity conservation and developmental aspirations in the region, Mr Takpa decided to expand the scope of his mandate as manager. He initiated a collaboration between Ladakh Autonomous Hill Development Council, Leh District, which oversaw the activities of the Department of Wildlife Protection in the area, and Tata Institute of Social Sciences, Mumbai to conduct a micro-level planning exercise across the district. This was an important participative exercise in order to understand the local dynamics in terms of resource use, aspirations and challenges for biodiversity conservation. The exercise provided a strong foundation for a number of interventions and policy instruments, which were developed to address the twin challenges of biodiversity conservation, especially of the top predator, the snow leopard, and sustainable forms of development.

The results of the micro-level planning exercise transformed the role of the Department of Wildlife Protection from one of policing people to one of enabling communities to benefit from the conservation of their biodiversity. Mr Takpa transformed his role from a manager to adopting a multi-pronged approach that included manager, policy-maker, scientist and community leader, enabling synergy between various interest groups.

Biodiversity conservation and rural livelihood improvement

The Biodiversity Conservation and Rural Livelihood Improvement Initiative was launched to conserve biodiversity by making communities self-reliant and ensuring sustainability of development. This flagship programme provided the framework for several target-oriented sub-projects — co-management of biodiversity conservation, the Ladakh Ecotourism Project, and the Seabuckthorn plantation — that were implemented under the Project Snow Leopard banner (see below).[4]

Co-management of natural resources

The pluralistic approach to managing natural resources is based on the participation of various partners to ensure environmental conservation as well as sustainable use of — and equitable access to — resources. Approximately 70 per cent of Leh district is managed as a biodiversity conservation protected area that includes a national park and two wildlife sanctuaries. Hemis High Altitude National Park is spread over 3,500 km^2, while Changthang Cold Desert Sanctuary covers 22,000 km^2 and Karakoram Wildlife Sanctuary covers 5,000 km^2.

In the past, Ladakhi society was based on a relatively closed-knit social system under which natural resources were managed, and these institutional systems were embedded in local cultural beliefs. The monetisation of the local economy and changes in the value of various knowledge systems weakened these institutions of management, resulting in the disempowerment of local communities. The initiative for co-management of resources, however, is based on reviving traditional systems in the context of modern development and shared responsibilities, for which the department has provided support to improve livestock corrals and guarding mechanisms to reduce material loss to snow leopards and other predators.[5]

Project Snow Leopard

The snow leopard is found in varying numbers across the region's various land use matrices. Local communities and wildlife have shared this landscape for several millennia, accommodating each other's presence, but current changes and anthropogenic impacts on various ecosystems have changed this relationship. Project Snow Leopard was established since there were no dedicated programmes for biodiversity conservation in the Himalayas. Using the template of India's flagship conservation programmes such as Project Tiger and Project Elephant, the Snow Leopard project provides a structured and institutional network between government agencies and civil society across five Himalayan states in India where the snow leopard is present.[6]

Landscape-level conservation management

The dominant conservation practice across the world, India included, is based on the assumption that humans and wildlife cannot coexist. This has led to the island model of conservation, whereby rich spots of biodiversity are declared as protected areas, and become wildlife habitat islands surrounded by a sea of non-habitat. In protected areas, the rights of communities are curtailed, with the communities relocated outside the area. However, this has provided mixed results, including alienation and misery for the marginalised peoples.

Based on these challenges and inputs from a micro-level planning exercise, the management regime was shifted to a landscape-level model in which a mosaic of various resource regimes is co-managed together with the local communities.

Ladakh ecotourism project

Ecotourism models aim to minimize the negative effects of conventional tourism on the environment and to enhance the cultural integrity of local communities. Such models also integrate and promote recycling, renewable energy, energy efficiency, water conservation, and the creation of economic opportunities for local communities. Ladakh was opened to tourism in 1974 with 500 visitors, but the number exceeded 230,000 in 2016. However, the benefits of tourism are felt by the town of Leh in terms of infrastructure and monetary gains. Also, this model of tourism depends on the use of ponies, porters, cooks and helpers from outside of the region. These practices have intensified anthropogenic pressures, especially pollution, on various ecosystems and have depleted already scarce resources. The main challenge for conservation was to offset the negative impacts of conventional tourism, while maximising tourism's benefits for local communities.

The Ladakh Ecotourism Project was initiated to extend the participation model and strengthen linkages between conservation and the livelihood security of local communities. The project focused on strengthening institutional frameworks and on improving the capacity of protected area managers, local communities and other stakeholders. It initiated training schemes for youths to manage tourism sustainably and

Image: MOEFCC

Water heating system installed in an area now recognised for its vast renewable energy resources. The use of these technologies ensures sustainability while reducing the long-term impact of developmental activities on the environment

serve as eco-guides. In the last decade, the project supported the establishment of more than 1,100 home-stays, as well as eco-cafes and women's self help groups.

Mr Takpa has personally encouraged youth from biodiversity-rich areas to form their own association. For instance, the Youth Association for Conservation and Development of Hemis National Park has been formed as a registered organisation and now oversees ecotourism activities in the national park. The allocation of home-stay, naturalist guides and the management of activities is now handled through this association. Resources have been invested in developing an office in Leh market to provide a platform for eco-development committees to publicise their services and facilities to tourists and travel agents. As a result, the practices of livelihood improvement for biodiversity conservation have now become institutionalised and managed under the aegis of the Ladakh Snow Leopard Foundation of the Ladakh Autonomous Hill Development Council, Leh.

Image: MOEFCC

Treking, introduced as part of the Ladakh Ecotourism Project, implemented under the Project Snow Leopard banner

Image: MOEFCC

Digging an irrigation channel

Image: MOEFCC

Community involvement in a campaign protesting against pollution

Image: Jigmet Takpa

The greenhouse enables the growing of vegetables throughout the season, even in the peak of winter

Renewable energy

The introduction of renewable energy technology in Ladakh has been spearheaded by the Ladakh Renewable Energy Development Agency, providing the basis for a key strategy to reduce anthropogenic pressure on natural resources in the area, which is now recognised for its vast renewable energy resources. The use of these technologies also ensures sustainability while reducing the long-term impact of developmental activities on the environment, with direct benefits to biodiversity and the reduction of human-wildlife conflicts.

Greenhouse installations

As a cold desert, there is only one growing season in Ladakh and that is during the peak summer season. Even in summer, it is not possible to produce large crops of the vegetables grown on the plain, which are costly. However, new technology has been deployed for vegetable production in the area. The main problems are the short growing period, long winter season, low humidity, poor irrigation, infertile and unproductive desert soil, and a high diurnal fluctuation of temperature. The greenhouse was found to be the best solution to overcome these problems, providing many advantages such as sprouting taking place 10–15 days earlier than otherwise. Also, less water is required for irrigation as water vapour is recycled inside the greenhouse. Now, vegetables can be grown throughout the season, even in the peak of winter when the outside temperature is below -25° C.

Land use scenarios for assessing sustainable ecosystem services — a study for an energy-self-sufficient ecovillage in Japan

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The town of Yoichi is located approximately 20 km west of Otaru city, the main port on the island of Hokkaido, in the lower reaches of the Yoichi River basin. Yoichi and the neighbouring town of Niki have similar climatic and topographical conditions and are well known for their orchards including apples, pears, peaches and cherries. The area is also home to several wineries that use locally produced grapes and there are also whisky distilleries.

The two towns have a combined population of around 23,000. The area is mountainous, and primary industries, such as agriculture and fishing, are the main economic activities. The area is relatively accessible from Hokkaido's capital city, Sapporo, and many farmers open their orchards to tourists from the city during harvesting times. The wineries also conduct tastings, attracting customers from as far away as Tokyo.

Hokkaido Ecovillage Promotion Project

The Hokkaido Ecovillage Promotion Project (HEPP) was created as a site for learning and practical engagement in the creation of a sustainable region. It is also a not-for-profit organization that offers hands-on experience of self sufficiency to members, students and the general public. Activities at the Yoichi Ecovillage are aimed at exploring environmentally-friendly lifestyles and forms of farming, while simultaneously developing a transitional movement that seeks to gradually transform the entire region via beneficial relationships between various local actors.

Within the Yoichi Ecovillage, facilities have been created to promote learning about and experiencing an environmentally harmonious lifestyle. With the help of participating engineers and builders, locally produced and recycled timber has been used alongside passive design principles to make the most of natural light and air flows, ensuring high levels of thermal insulation and air tightness during the coldest times of the year, when temperatures can fall to -10°C. The village also uses stoves that burn locally-sourced wood, and composting toilets that process human waste onsite. Both construction and installation of these facilities have been made possible by the participation of local residents and visitors to the Ecovillage, including cooperating farmers and, as such, has been a successful exercise in community-driven building, as construction staff and visitors now live together in a communal shared house.

Survey of the potential for self-supplied energy in the area

A study is now underway on the potential for renewable energy use within the region, based on the Ecovillage model. The study focuses on:

- Quantities of exploitable energy resources
- Energy demand
- Renewable energy scenarios.

The ultimate aim of these efforts is the demonstration of sustainable energy, using scenarios involving the participation of both the Ecovillage and the local community.

Available energy resources

The most available renewable energy resources in the area include pruned branches from local orchards, and wood produced through forest management activities. The quantities of branches and the seasons in which they are pruned differ according to the type of tree and pruning methods used. Empirical studies have been carried out to ascertain the potential quantities, the amount of labour required for branch collection and the possibility of utilizing this resource as a source of energy.

These studies have shown that cherry trees will produce approximately 2.0–2.3 t/ha of pruned branches from living trees. While the branches are pruned each spring, the grape vines are pruned in autumn. Also, new trees are planted over a 10–20-year cycle, at the end of which large amounts of waste wood are produced. Pruned branches are rarely utilized by local farmers, with most of these materials often burned in the fields as waste. Some of them are turned into mulch and returned to the orchards and some are treated as industrial waste.

The area also contains many mountain forests. These include forests planted for timber that are no longer properly managed, as well as secondary forests created by naturally occurring hardwoods growing in areas after timber has been

Image: CGER

Yoichi Ecovillage built as part of the Hokkaido Ecovillage Promotion Project

removed. The Ecovillage also encompasses around 1.14 ha of forest which, although currently not adequately managed, may provide a viable energy source with the implementation of appropriate management.

A survey of local forest resources has identified around 250 m^3 of above-ground biomass, the equivalent of some 140 t of wood fuel. If this wood were collected in a sustainable manner over a 30-year cycle, 4.7 t of wood fuel would become available for use each year.

Energy demand

A study of current energy demands was conducted. The shared house is usually occupied by two or three people, but as much as ten during busy periods. Heat is produced by burning kerosene which is used to heat water for bathing, cooking and cleaning, and for heating the house. Electricity is used to power a kitchen oven, refrigerator, office appliances, boiler and lighting.

Meeting these energy demands with local sources requires a detailed demand analysis and the drafting of an energy plan based on the findings. In the winter of 2017, devices were installed to monitor the consumption of electricity and heat, and the size of the necessary renewable energy equipment has been analyzed. The largest consumption of electricity in a single day was found to be 12 kWh, while the largest consumption of heat energy was 102 kWh. During winter, over 90 per cent of heat energy was used for heating the rooms.

Scenario analysis

Considering available energy resources and energy demand, in what ways should these energy resources be used? Is it possible to balance supply and demand, supplying only the amount of energy required? Would such a scenario be sustainable?

In order to answer those questions, the Yoichi Ecovillage was used as a model to estimate the amounts of energy both required and available over a one-year period, based on the findings of resource and energy demand surveys. Two scenarios for the use of locally-sourced energy were considered:

- Scenario A: Energy supplied to the shared house only
- Scenario B: Energy supplied to all Ecovillage facilities.

Scenario A is simple. The annual amount of energy required by the shared house is estimated at 3,200 kWh of electricity and 16,000 kWh of heat energy. In this scenario, electricity would be supplied by photovoltaic solar panels, while heat would be provided by woody biomass in firewood boilers, boiler stoves and rocket stoves. The wood would be supplied by the pruning of orchard trees. To generate the required amount of electricity would need 4 kW solar panels, covering an area of 24 m^2. The necessary heat energy could be supplied by 5.5 t of fuel wood obtained from 1.4 ha of forest, provided that the forest management practices were carried out, or 9.6 t of pruned branches from 4.6 ha of orchards.

This scenario envisions supplying energy to each residence separately and is the most individually distributed system.

Image: CGER

The shared house used as the base for the assessments

Image: CGER

Pruned branches collected from the orchards for fuel

Image: CGER

Sample plot survey used in the sustainability analysis

Image: CGER

Study meeting within the shared house

Scenario B widens the scope of energy supply to include surrounding facilities and residences such as a café and cottages, and envisions energy supplied by a small, district-level heating system. Unlike Scenario A, this would involve supplying energy to multiple buildings simultaneously, requiring larger equipment but also achieving higher energy efficiency and improving maintainability. While installing energy delivery equipment would require additional costs, it would be possible to limit costs per unit of energy from boilers owing to the benefits of scale. Chip boilers have the additional benefit of automatic operation.

Efforts are underway to consider these scenarios jointly with stakeholders and to identify potential methods of obtaining energy resources and introducing efficient system operations.

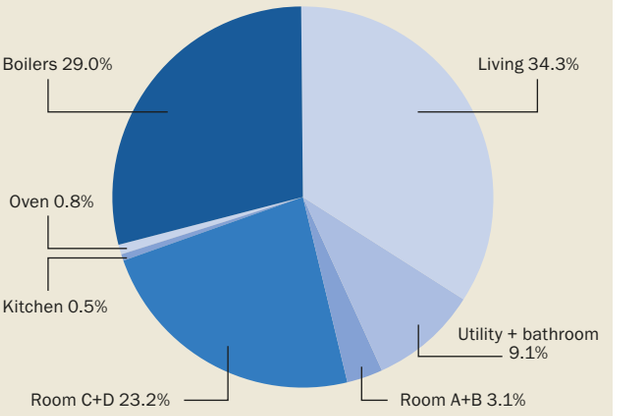
Training programme of sustainable regional development

Training programmes, conducted mainly for national and local governmental officers in charge of natural resource management from developing countries, were held at the HEPP from 2015 to 2017, organized by Rakuno Gakuen University, Japan, and the Japan International Corporation Agency (JICA).

The programmes focused on the methodology used to analyze ecosystem services using geographic information systems, remote sensing, and the InVEST (integrated valuation of ecosystem services and tradeoffs) model, developed by Natural Capital Project. After that, the participants visited HEPP and its surroundings for a closer understanding of the area. With this first-hand experience, participants attended a workshop to discuss a future vision for the region's sustainability, with scenarios proposed throughout the workshop.

It was found that technical training was not always necessary. Therefore, in order to focus on the future visions and scenarios, integration systems and datasets are being developed to evaluate and compare several ecosystem services.

Electricity demand in winter



Source: CGER

Combatting desertification through participatory natural resource management

Arjuna Srinidhi, Marcella D'Souza, Watershed Organisation Trust (WOTR)

Approximately 1.2 billion people are at risk from desertification as deserts expand and degraded drylands cover close to one-third of the world's land surface area, according to estimates by the United Nations.

While Africa is the worst affected continent, India too has about 32 per cent of its land affected by land degradation. New areas in the northern state of Jammu and Kashmir, and eastern Indian states like Orissa and Jharkhand are turning arid, with nine states together accounting for nearly 24 per cent of desertification. In states like Jharkhand, Rajasthan, Delhi, Gujarat and Goa, more than 50 per cent of land is under desertification

Desertification is mainly a problem of sustainable development. Its causes include over-cropping, overgrazing, improper irrigation practices, and deforestation. Poor land management practices such as these often stem from the socio-economic conditions in which the farmers live, and can be prevented.

Watershed development to combat desertification

Agriculture in India is predominantly rainfed (68 per cent) and farmers depend on livestock in addition to arable farming as an alternative source of income. According to the Food and Agriculture Organisation, nearly two-thirds of India's cattle subsist in rain-fed regions. Intensive cultivation in marginal areas, together with unbridled grazing, has led to a decline of common property resources.

Compounding issues of a poor resource base is the uncertainty in climatic conditions. Rainfall is becoming erratic. Droughts occur once in 3 to 5 years, either due to a deficit in seasonal rainfall during the main cropping season or from inadequate soil moisture availability during prolonged dry spells between successive rainfall events.

This necessitates development measures targeted at enhancing the capacity of rural habitat to utilize existing resources optimally and to ensure their sustenance through regeneration. Herein lies WOTR's approach of participatory watershed development to deal with the issue of land degradation.

Wasundhara — the participatory approach

Watershed development projects are designed to harmonize the use of water, soil, forest and pasture resources in a way that conserves them while raising agricultural productivity, both through in-situ moisture conservation and increased irrigation through tank and aquifer-based water harvesting. Watershed projects have become widespread in rain-fed areas in recent years. Hence, the watershed development interventions focus on improving agricultural productivity by initiating various soil, water and biomass conservation measures, thereby reversing a vicious cycle of resource degradation and underdevelopment.

While the interventions include operations like forestry, fodder, soil and water conservation, agriculture, drinking water supply and livelihoods, the Watershed Organisation Trust (WOTR) strongly believes that, unless the entire community commits to participate in the process, it will not impact strongly on the area nor can it become sustainable.

Wasundhara means "caring earth," and for WOTR it also means WOTR Attentive to Social Unity for Nature, Development and Humanity in Rural Areas. Wasundhara represents a paradigm shift, placing the responsibility for development in the hands of not only NGOs and agencies but of the villagers themselves. Only in this way can the projects sustain themselves organically over time.

The Wasundhara strategy has four main components for leading villagers in creating economic prosperity and a greater sense of dignity for themselves.

- Each group and hamlet designs their development plan starting from what they agree to be their most pressing needs

Image: WOTR

Watershed development treatments begin to stem land degradation and improve soil and moisture conservation

Image: WOTR

Degraded lands in semi-arid regions of Maharashtra, India

- Village leadership represents all classes and both genders proportionately, and decisions are made with social equity in mind. Likewise, there must be a transparent and socially just system of monetary contributions in which those with higher income pay more to the general fund than those with less
- Micro-loans are provided to village women and their self-help groups so they can lend money to jumpstart economies and livelihoods
- The Village Development Committee is linked to the Gram Panchayat (village council) and is encouraged to work with the government on development projects.

Impacts of the Wasundhara approach

The WOTR has played an important role in developing techno-participatory approaches to watershed development that have proven to significantly conserve soil and water and improve land productivity. Importantly, WOTR has always focused on developing scalable and replicable interventions and has directly and indirectly implemented and supported watershed development works across 9,250 km^2 in 1,552 villages in seven states of India, benefiting over 1.43 million people.

The impacts of WOTR's watershed development on land, measured through vegetation cover changes and the assessment of soil samples, show a significant improvement in combatting desertification.

Land use and land cover changes

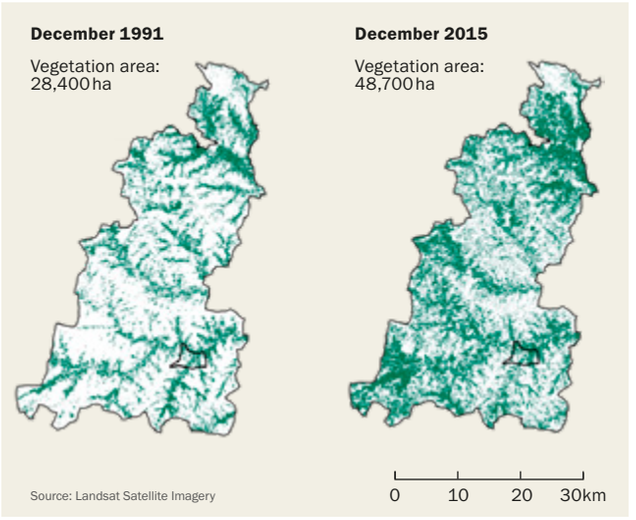
In the Bhokardan block, Jalna district, Maharashtra state, WOTR has been actively implementing watershed activities for some 25 years and, in the process, has covered almost 90 per cent of the villages in the block.

The impact of the watershed activities on the drylands of Bhokardan can been seen for the fact that the vegetation cover has changed from approximately 28,400 ha to 48,700 ha; an increase of 71.5 per cent.

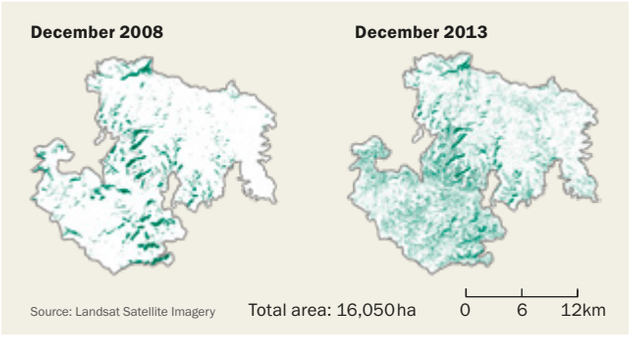
In the Sangamner block of the Ahmednagar district, Maharashtra, a total of 4,180 ha was treated, covering 17 villages. Besides this, in the previous decade, 4,506 ha in six villages had watershed development works implemented with WOTR support.

Satellite image analysis shows that the area under vegetation cover in project villages increased by more than 500 ha, or almost 30 per cent, between 2009 and 2013. This can be attributed to plantation and grazing regulation and monitoring activities done under watershed development projects by WOTR and other government project implementing agencies.

Besides the impact on land restoration and arresting degradation, the interventions under the project have had tangible impacts on the livelihoods and well-being of local communities. While the pre-project intervention was characterized by widespread reliance on daily wages, the end-line assessment of the project found that the average number of days where



Vegetation cover change in Bhokardan, Maharashtra, India, 1991–2015



Vegetation cover change in Sangamner, Maharashtra, India, 2009–2013

people are engaged in primary occupation (agriculture) has increased by 16.8 per cent (from 184 days to 215 days) post-project implementation. Further, due to poor land conditions within the village, in the pre-project period 22.7 per cent of the individuals reported temporarily migrating in search of labour. Post-project data indicates a 29 per cent reduction in the number of individuals reporting temporary migration.

Concerning the aggregate benefits of watershed interventions, the World Resources Institute calculates that the net present value of a project implemented by WOTR in Kumbharwadi village in Sangamner ranged from US$ 5,573 to US$ 8,172 per ha treated, or US$ 29,650 to US$ 43,479 per household, with a benefit-cost ratio that ranged from 2.28 to 3.76.

Digital soil mapping

To study the effects of watershed development on the quality of soil and changes in characteristics indicating stemming of desertification, WOTR conducted assessments on the soils of villages in and around the Sangamner cluster.

Two adjacent micro-watersheds (A and B) were considered for the study in order to ensure minimal variation among the ecological and climate parameters. One of the selected micro-watersheds (B) was earmarked for controlled assessment with no interventions, while in micro-watershed (A) all of the techniques and interventions of integrated watershed management were implemented.

Samples of soil were collected and assessed to measure the effect of these interventions. Some 180 samples from each watershed were taken at two depths and analyzed for their physio-chemical parameters. Preliminarily results of the study showed that the treated watershed had approximately 19 per cent higher organic carbon than the controlled, untreated watershed.

The area treatments implemented during the watershed development allow runoff water to infiltrate the soil and retard soil erosion. Soil erosion washes out the fertile topsoil (especially silt and clay particles) leaving behind sand and gravels. It has been observed that the treated watershed has 5 per cent less sand particles than the controlled watershed. Moreover, the bulk density of the treated watershed is also lesser by 5 per cent, which shows that the soils in the treated watershed are well-structured, having good aeration capacity. Such well-structured, aerated soils facilitate better crop growth and higher production.

Wasundhara in the future — the water stewardship programme

Inclusive development and a strong sense of ownership of the projects are core values of the Wasundhara approach. WOTR has been applying these values over the years to deepen its engagement in rural areas as well as across other activities. One such ongoing initiative is the promotion of water stewardship. This initiative involves:

- A village water management committee or a team of water stewards, who promote and ensure effective management of local water sources
- Jal Sevaks – local youth, trained as para-technologists for water management. They motivate the water stewards as well as farmers and help prepare and implement water management plans at village and farm level
- Water management plans prepared by undertaking water budgeting exercises. A customized water budgeting tool enables villagers to estimate water availability and plan cropping patterns and water uses accordingly
- Villagers monitor daily rainfall through rain gauges and use the data to better manage their crops and estimate the next cropping season's water availability
- Several automatic weather stations have been installed in some of the villages to provide weather-based crop-specific advisories to farmers to reduce crop losses and improve productivity
- Multistakeholder engagements involving villagers, service and technology providers, local and state level government officials and researchers are regularly organized to promote cross-learning, increased access to technology and resources, a shared understanding of problems and a consensus on solution pathways
- Preparation of projects that improve water use, for instance, micro-irrigation and other plans, and submitting them to the district authorities.

The inclusivity in the development activities can be seen across a diverse array of WOTR projects. Entering its 25th year, WOTR would like these values to be its guiding light. Together with the information and knowledge that is

provided to the villagers, the protagonists of the development activities — the village communities — are encouraged to keep sustainability in mind and work towards the creation of wholeness in their lives.

Climate change considerations

It has been observed that, unless climate change adaptation is factored into project design, weather variations will continue to obstruct progress and development. Land degradation is a major contributor to climate change, and climate change is foreseen as a leading driver of biodiversity loss, along with crop agriculture and infrastructure development, up until 2050. The contribution of land degradation to climate change includes the release of carbon sequestered in soil. Between 2000 and 2009, land degradation was responsible for annual global emissions of 3.6–4.4 billion tonnes of CO_2.

With this in mind, WOTR is introducing new elements such as agro-meteorology for tracking weather patterns at village level, leading to the generation of advisories to farmers on what steps to take in emergency conditions. This is also linked to water budgeting, crop planning, adaptive and sustainable agronomic practices and irrigation management. Added to this, WOTR integrates biodiversity concerns in all of its activities and encourages alternate energy to meet some of the rural energy requirements. Overlaying these initiatives is a focus on securing sustainable livelihood opportunities together with market linkages for people in these areas. Advanced project management and geographic information systems are also being deployed so as to track progress, capture results and identify impacts.

Image: WOTR

Image: WOTR

Villagers discussing community projects Darewadi, Maharashtra, India, 2009

Image: WOTR

Image: WOTR

Image: WOTR

Darewadi, Maharashtra, India, in 1996 (top), 1999 (centre), 2009 (above)

Given the complexity of the challenge presented by land degradation and climate change, it is apparent that any effort to respond to these problems would require collaboration among various stakeholders, both state and non-state. WOTR's work demonstrates that with appropriate support, communities are able to combat land degradation, co-create a sustainable natural resource base, and leverage the possibilities presented by innovations in information technology to develop inclusive governance of shared resources and increased access to benefits for all.

Notes and References

Page 2: Life on Land — An introduction to Goal 15

1 See: https://unstats.un.org/sdgs/indicators/Global%20Indicator%20Framework%20after%20refinement_Eng.pdf.
2 2005. World Resources Institute. *Millennium Ecosystem Assessment, 2005. Ecosystems and Human Well-being: Desertification Synthesis*.
3 2017 UNCCD, *The Global Land Outlook*.
4 2018. *IPBES. Summary for policymakers of the thematic assessment of land degradation and restoration of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services* https://www.ipbes.net/system/tdf/downloads/ipbes-6-15-add-5_spm_ldr_advance.pdf?file=1&type=node&id=23015, accessed 26 June 2018.
5 2011, Edward B. Barbier and Jacob P. Hochard, 2014. "Land Degradation, Less Favored Lands and the Rural Poor: A Spatial and Economic Analysis." A Report for the Economics of Land Degradation Initiative. Department of Economics and Finance, University of Wyoming. *An ELD Assessment: Land degradation, Less favored lands and The rural poor – a spatial and economic analysis*. www.eld-initiative.org accessed 27 June 2018.
6 2018. *IPBES. Summary for policymakers of the thematic assessment of land degradation and restoration of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services* https://www.ipbes.net/system/tdf/downloads/ipbes-6-15-add-5_spm_ldr_advance.pdf?file=1&type=node&id=23015, accessed 26 June 2018.
7 2013, ELD Initiative. *The rewards of investing in sustainable land management*. Interim Report for the Economics of Land Degradation Initiative: A global strategy for sustainable land management.
8 2018. EU/JRC. *World Atlas on Desertification*, press release dated http://europa.eu/rapid/press-release_IP-18-4202_en.htm, dated 21 June 2018, accessed, 26 June 2019.
9 2018, General Assembly. Resolution A/RES/72/220: Implementation of the United Nations Convention to Combat Desertification in Those Countries Experiencing Serious Drought and/or Desertification, Particularly in Africa.
10 2012, International Labor Organization. *Working towards sustainable development. Opportunities for decent work and social inclusion in a green economy*, cited in "A Natural Fix: A joined-up approach to delivering the global goals for sustainable development, undated.
11 See the UNFCCC synopsis series of slow onset events: https://unfccc.int/files/adaptation/application/pdf/soe_synopsis.pdf.
12 2018. IPBES. *Summary for policymakers of the thematic assessment report on land degradation and restoration of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services*. R. Scholes, L. Montanarella, A. Brainich, N. Barger, B. ten Brink, M. Cantele, B. Erasmus, J. Fisher, T. Gardner, T. G. Holland, F. Kohler, J. S. Kotiaho, G. Von Maltitz, G. Nangendo, R. Pandit, J. Parrotta, M. D. Potts, S. Prince, M. Sankaran and L. Willemen (eds.). IPBES secretariat, Bonn, Germany. p5.
13 A World of Opportunity for Forest and Landscape Restoration. Global Partnership on Forests and Land Restoration. Undated.

Page 4: Where do we stand on achieving Land Degradation Neutrality?

1 2011, UNDP and UNCCD. *The Forgotten Billion: MDG Achievement in the Drylands*.
2 2017, UNCCD. *The Global Land Outlook*, first edition, Bonn, Germany (www.unccd.int/glo).
3 Op.cit. *The Global Land Outlook*.
4 The United Nations Conference on Sustainable Development – or Rio+20 – took place in Rio de Janeiro, Brazil on 20–22 June 2012. It resulted in a focused political outcome document which contains clear and practical measures for implementing sustainable development. This included a commitment to a land degradation neutral world.
5 2017, Orr, B.J., A.L. Cowie, V.M. Castillo Sanchez, P. Chasek, N.D. Crossman, A. Erlewein, G. Louwagie, M. Maron, G.I. Metternicht, S. Minelli, A.E. Tengberg, S. Walter, and S. Welton. *Scientific Conceptual Framework for Land Degradation Neutrality*. A Report of the Science-Policy Interface. http://www2.unccd.int/publications/scientific-conceptual-framework-land-degradation-neutrality accessed, 26 June 2018.

Page 10: Land degradation neutrality and tenure security — the SDGs' prospects

1 VGGT–FAO 2012.
2 Steve J., Harold L. and Antonio R., paper presented at the World Bank Land and Poverty Conference 2017, featuring the outcomes of the International Fund for Agricultural Development (IFAD)-supported projects.
3 Roth and McCarthy 2014.
4 FAO, 2014, Steve Lawry et.al. 2014.
5 Information on the Continuum of Land Rights available from: https://gltn.net/home/access-to-land-and-tenure-security/.
6 Information on the New Urban Agenda available from: http://nua.unhabitat.org/.

Page 14: Land and quality education — building the capacities of the change agents of the future

1 United Nations Convention to Combat Desertification. 2017. *The Global Land Outlook*, first edition. Bonn, Germany.
WWF. 2016. *Living Planet Report 2016. Risk and resilience in a new era*. WWF International, Gland, Switzerland.
2 UN General Assembly, Transforming our world: the 2030 Agenda for Sustainable Development, 21 October 2015, A/RES/70/1, available at: http://www.refworld.org/docid/57b6e3e44.html [accessed 1 July 2018].
3 Orr, B.J., A.L. Cowie, V.M. Castillo Sanchez, P. Chasek, N.D. Crossman, A. Erlewein, G. Louwagie, M. Maron, G.I. Metternicht, S. Minelli, A.E. Tengberg, S. Walter, and S. Welton. 2017. "Scientific Conceptual Framework for Land Degradation Neutrality." A Report of the Science-Policy Interface. United Nations Convention to Combat Desertification (UNCCD), Bonn, Germany.
4 Whisenant, S.G. 1999. *Repairing Damaged Wildlands: A Process-Oriented, Land-Scale Approach*. Cambridge University Press, Cambridge, UK.
5 http://www.unulrt.is; http://www.facebook.com/unulrt; twitter: @UNULRT.
6 Crofts, R. 2011. "Healing the Land: the story of land reclamation and soil conservation in Iceland." Soil Conservation of Iceland, Gunnarsholt, Iceland.
7 Ljungman, C.M., Carneiro, G., Engstrand, K. Juliet, N. 2017. "Evaluation of the UNU Programmes in Iceland." NIRAS indevelop.
8 ibid.
9 WWF. 2016. Living Planet Report 2016. "Risk and resilience in a new era." WWF International, Gland, Switzerland.
10 UNDP. 2016. Human Development Report 2016. New York, USA.
11 Moussa, B., Nkonya, E., Meyer, S., Kato, E., Johnson, T., Hawkins, J. 2016. Economics of land degradation and improvement in Niger. In *Economics of land degradation and improvement – A global assessment for sustainable development*, ed. Nkonya, E., Mirzabaev, A., von Braun, J. Chapter 17, pp. 499–539.
12 Webpage of CAMP Alatoo: http://en.camp.kg/.
13 Isakov, A., Thorsson, J. 2015. "Assessment of the land condition in the Kyrgyz Republic with respect to grazing and a possible development of a quoting system on the local governmental level." Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH, Bishkek, Kyrgyzstan.
14 Webpage of Camp tabiat: http://camptabiat.org/en/.

Page 24: Development of intensive watershed management models for areas prone to soil erosion in Sub-Saharan Africa

1 UNEP 1997: "World Atlas of Desertification" 2nd Edition, eds. N. Middleton and D. Thomas, pp. 30–31, Arnold, London, UK.
2 FAO 2016, "Conservation Agriculture". Available from http://www.fao.org/3/a-i6169e.pdf.
3 Giller KE, Witter E, Corbeels M, Tittonell P, "Conservation agriculture and smallholder farming in Africa: the heretics' view". Field Crops Res. 114, 23–34. DOI: 10.1016/j.fcr.2009.06.017, 2009.
4 Ikazaki K, Nagumo F, Simporé S, Barro A, "Are all three components of conservation agriculture necessary for soil conservation in the Sudan Savanna?" Soil Sci Plant Nutr. 64, 230–237. DOI: 10.1080/00380768.2017.1422393, 2018.
5 World Future Council, "Future Policy Award crowns the World's Best Land Restoration Policies". (WFC) 2017. Available from https://www.zu.de/forschung-themen/forschungszentren/ecs/assets/pdf/Press-Release-Future-Policy-Award-crowns-the-World-s-Best-Land-Restoration-Policies.pdf (accessed 2018-05-11).

Page 28: Securing soils through people-centric watershed management for sustainable agricultural development

1 UNDP. Sustainable development goals. 2018 [cited 2018; Available from: http://www.undp.org/content/undp/en/home/sustainable-development-goals.html.
2 Mueller, N.D., et al., Closing yield gaps through nutrient and water management. Nature, 2012. 490: p. 254.
3 Foley, J.A., et al., Solutions for a cultivated planet. Nature, 2011. 478: p. 337.

4 Wani, S., J. Rockstrom, and B. Venkateswarlu, New Paradigm to Unlock the Potential of Rainfed Agriculture in the Semiarid Tropics, in World Soil Resources and Food Security. Advances in Soil Science, R. Lal and B.A. Stewart, Editors. 2011, CRC Press: Boca Raton, Florida. p. 170–207.
5 FAO. Global Soil Partnership. 2016 [cited 2018; Available from: http://www.fao.org/global-soil-partnership/resources/highlights/detail/en/c/416516.
6 Borrelli, P., et al., An assessment of the global impact of 21st century land use change on soil erosion. Nature Communications, 2017. 8(1): p. 2013.
7 Yang, D., et al., Global potential soil erosion with reference to land use and climate changes. Hydrological Processes, 2003. 17(14): p. 2913–2928.
8 Walling, D. Global change and the sediment loads of the world's river. in 10th International Symposium on River Sedimentation,. 2007. Moscow, Russia.
9 Pathak, P., et al., Hydrological behavior of Alfisols and Vertisols in the semi-arid zone: Implications for soil and water management. Agricultural water management, 2013. 118: p. 12–21.
10. Garg, K.K., et al., Assessing impacts of agricultural water interventions in the Kothapally watershed, Southern India. Hydrological Processes, 2012. 26(3): p. 387–404.
11. Sahrawat, K., et al., Soil Nutrient Mapping for On-farm Fertility Management. Harnessing Dividends from Drylands: Innovative Scaling up with Soil Nutrients, 2016: p. 59.
12. Araya, T., et al., Effects of conservation agriculture on runoff, soil loss and crop yield under rainfed conditions in Tigray, Northern Ethiopia. Soil Use and Management, 2011. 27(3): p. 404–414.
13. Potter, K.N., H.A. Torbert, and J.E. Morrison Jr, Tillage and residue effects on infiltration and sediment losses on vertisols. Transactions of the ASAE, 1995. 38(5): p. 1413–1419.
14 Patil, M.D., S.P. Wani, and K.K. Garg, Conservation agriculture for improving water productivity in Vertisols of semi-arid tropics. Current Science, 2016. 110(09): p. 1730–1739.
15 Sahrawat, K.L., et al., Stretching soil sampling to watershed: evaluation of soil test parameters in a semi-arid tropical watershed. . Commun. Soil Sci. Plant Anal., 2008. 39: p. 2950–2960.
16 Wani, S., et al., Soil fertility atlas for Karnataka, India. 2011: International Crops Research Institute for the Semi-Arid Tropics.
17 Anantha, K., et al., Social and Economic Benefits. Harnessing Dividends from Drylands: Innovative Scaling up with Soil Nutrients, 2016: p. 259.
18 Garg Kaushal, K., et al., Jatropha production on wastelands in India: opportunities and trade-offs for soil and water management at the watershed scale. Biofuels, Bioproducts and Biorefining, 2011. 5(4): p. 410–430.
19 Wani. S.P. and Raju. K.V. Corporate Social Responsibility: Win-win Propositions for Communities, Corporates and Agriculture. CAB International, UK. October 2018.

Page 33: Towards managing Africa's twin challenges — mitigating land degradation and meeting food security

1 Islamic Development Bank Group (2018). *Change for Impact: Transforming agriculture and rural development in IsDB member countries*. Jeddah, Kingdom of Saudi Arabia.
2 Africa Soil Information Service (AfSIS): http://africasoils.net/about/
3 Parboiling definition (according to Wikipedia): Parboiled rice (also called converted rice) is rice that has been partially boiled in the husk. The three basic steps of parboiling are soaking, steaming and drying. These steps also make rice easier to process by hand, boost its nutritional profile and change its texture. Approximately 50 per cent of the world's paddy production is parboiled.
4 http://www.babbangona.com/.
5 The MDG Centre for West and Central Africa: http://unsdsn.org/where-we-work/members/mdg-center-west-and-central-africa/.

Page 36: The Great Green Wall Initiative — building resilient communities in Africa's drylands

1 First Global Land Degradation Neutrality Forum, 4–5 July 2018, Koreana Hotel, Seoul, Korea.
2 Harmonized Regional Strategy for the Implementation of the Great Green Wall Initiative.
3 Data from the project Officer of Action Against Desertification, a programme implemented by FAO as part of the Great Green Wall Initiative.
4 Amadou Ndiaye, Practices of the Great Green Wall Project in the Ferlo (Senegal): Effects on Pastoral Resilience and Development, World Journal of Social Science, URL: http://dx.doi.org/10.5430/wjss.v3n2p1.

Page 44: Agricultural innovation platform as a framework for sustainable land utilization

1 Gibbs H.K. and J.M. Salmon (2015). Mapping the world's degraded lands Applied Geography, Vol 57: 12–21.
2 FAO (2004). The ethics of sustainable agricultural intensification. FAO ethics series 3. Food and Agriculture Organization of the United Nations.

Page 47: Protection, restoration and the sustainable use of landscapes — a remedy to land degradation, and solutions to achieve the SDGs

1 IPBES, 2018.
2 ELD Initiative, 2015.
3 ibid., 2013.
4 Nkonya, 2016.
5 IUCN, 2015.
6 De Groot et al., 2013.

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REFERENCES
— ELD Initiative (2013). The rewards of investing in sustainable land management. Interim Report for the Economics of Land Degradation Initiative: A global strategy for sustainable land management. Available from: www.eld-initiative.org/.
— ELD Initiative (2015). The value of land: prosperous lands and positive rewards through sustainable land management. The Economics of Land Degradation, Bonn, Germany.
— IBPE (2018). Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) Media Release: https://goo.gl/ERXLNr.
— International Union for the Conservation of Nature (B). 2015. Bonn Challenge: What Are the Benefits of Restoration? Available at: http://www.bonnchallenge.org/content/restoration-benefits.
— Nkonya, E.; Anderson, W.; Kato, E.; Koo, J.; Mirzabaev, A.; von Braun, J.; Meyer, S. 2016. Global cost of land degradation. In: E. Nkonya, A. Mirzabaev; J. von Braun, eds. Economics of Land Degradation and Improvement – A Global Assessment for Sustainable Development, Springer International Publishing AG Switzerland. https://www.springer.com/us/book/9783319191676.

Page 55: The African Forest Landscape Restoration Initiative

BIBLIOGRAPHY
— Cervigni R and Morris M. 2016. *Confronting Drought in Africa's Drylands: Opportunities for Enhancing Resilience*. Washington, DC: World Bank; and Agence Française de Développement. https://openknowledge.worldbank.org/handle/10986/23576.
— Danano Dale D. 2010. *Sustainable Land Management Technologies and Approaches in Ethiopia*. Addis Ababa, Ethiopia: Sustainable Land management Project, Natural Resources Management Sector, Ministry of Agriculture and Rural Development of the Federal Democratic Republic of Ethiopia. https://www.wocat.net/library/media/94/.
— FAO. 2015. "Global Guidelines for the restoration of degraded forests and landscapes in drylands: building resilience and benefitting livelihoods". FAO Forestry Paper 175. http://www.fao.org/3/a-i5036e.pdf .
— GPFLR [Global Partnership on Forest Landscape Restoration]. 2014. "Atlas of Forest Landscape Restoration Opportunities". http://www.wri.org/applications/maps/flr-atlas/#.
— Hanson C, Buckingham K, DeWitt S and Laestadius L. 2015. *The Restoration Diagnostic: A Method for Developing Forest Landscape Restoration Strategies by Rapidly Assessing the Status of Key Success Factors*. Washington, DC: World Resources Institute. http://www.wri.org/publication/restoration-diagnostic.
— IUCN. 2017. Gender-responsive restoration guidelines: *A closer look at gender in the Restoration Opportunities Assessment Methodology*. Gland, Switzerland: IUCN. https://portals.iucn.org/library/node/46693.
— Kumar C, Begeladze S, Calmon M and Saint-Laurent C. (eds.) 2015. *Enhancing food security through forest landscape restoration: Lessons from Burkina Faso, Brazil, Guatemala, Viet Nam, Ghana, Ethiopia and Philippines*. Gland, Switzerland: IUCN. https://portals.iucn.org/library/node/45774.

— Leakey RRB. 2013. "Addressing the causes of land degradation, food and nutritional insecurity and poverty: A new approach to agricultural intensification in the tropics and subtropics." In: Hoffman, U (ed.) "Wake Up Before It Is Too Late: Make Agriculture Truly Sustainable Now for Food Security in a Changing Climate". UNCTAD Trade and Environment Review. Geneva, Switzerland: UN Publications. pp. 192–198. http://unctad.org/en/PublicationsLibrary/ditcted2012d3_en.pdf.
— Leakey RRB. 2017. *Multifunctional Agriculture: Achieving Sustainable Development in Africa*. Cambridge, MA: Academic Press. https://www.elsevier.com/books/multifunctional-agriculture/leakey/978-0-12-805356-0.
— Reij C and Winterbottom R. 2015. "Scaling up Regreening: Six Steps to Success. A Practical Approach to Forest and Landscape Restoration". Washington, DC: World Resources Institute. http://www.wri.org/publication/scaling-regreening-six-steps-success.

For more information, please contact the NEPAD Agency/AFR100 Secretariat: http://afr100.org/content/contact.

Page 62: A stepping stone towards sustainable financing in Africa through the experience of Groupe Crédit Agricole du Maroc

1 Land and environmental degradation and desertification in Africa, FAO

Page 65: Are the outcomes that are vital for the survival of mankind achievable in an era of global warming?

1 Chris Arsenault, "Only 60 Years of Farming Left If Soil Degradation Continues". Available from https://www.scientificamerican.com/article/only-60-years-of-farming-left-if-soil-degradation-continues/.
2 United Nations Department of Economic and Social Affairs, "World population projected to reach 9.7 billion by 2050", 29 July 2015. Available from http://www.un.org/en/development/desa/news/population/2015-report.html.
3 United Nations Decade for Deserts and the Fight against Desertification: http://www.un.org/en/events/desertification_decade/.
4 Colin Bettles, "Australian on farm ecological work 'largely invisible' to public", 1 April 2018. Available from http://www.farmonline.com.au/story/5316091/australian-on-farm-ecological-work-largely-invisible-to-public/?cs=5375.
5 Robin Batterham (https://en.wikipedia.org/wiki/Robin_Batterham), personal communication.
Robin Batterham, "Two Focusing Questions that Suggest our Soils Deserve More Attention" and "Climate Change – Nature's Solution – Photosynthesis." Working papers available on request from info@greeningthedesert.com.
6 UN Food and Agriculture Organization Report 2014.
7 United Nations, Department of Economic and Social Affairs, Population Division, "World Urbanization Prospects: The 2014 Revision, Highlights", 2014 (ST/ESA/SER.A/352).
8 UN Food and Agriculture Organization Report 2014.
See also Financial Review, "Can this planet feed 10 billion people?", 9 March 2018. Available from http://www.afr.com/business/agriculture/can-this-planet-feed-10-billion-people-20180219-h0waof.
9 Mahesh K. Guar and Victor Squires, eds., *Climate Variability Impacts of Land Use and livelihoods in Dry lands* (Springer, 2018).
10 M. Qadir and others, "Economics of salt-induced land degradation and restoration", *Natural Resources Forum*, 38:282-295. doi: http://dx.doi.org/10.1111/1477-8947.12054.
11 Michael D. Young and Christine Esau, eds., *Transformational Change in Environmental and Natural Resource Management. Guidelines for Policy Excellence*, Earthscan from Routledge, 2017.
12 Wikipedia, "Regenerative agriculture". Available from https://en.wikipedia.org/wiki/Regenerative_agriculture.
13 Andrea Thompson, "What is a Carbon Sink?", 21 December 2012. Available from https://www.livescience.com/32354-what-is-a-carbon-sink.html.
14 Bjorn Berg and Ryszard Laskowski, *Litter Decomposition: A guide to carbon and nutrient turnover* (Elsevier, 2006).
15 Hassan M. El Shaer and Victor Squires, eds., *Halophytic and salt tolerant feedstuffs; Impacts on Nutrition, Physiology and Reproduction of Livestock* (CRC Press, Taylor & Francis, 2016).
16 Paul Fraser of the Commonwealth Scientific and Industrial Research Organization.
17 Editorial comment on proposals for Biosequestration of Carbon, Climatic Change DOI 10.1007/s10584-007-9385-6 (Springer Stanford University, 2008) Leake J.E.
18 Australian Government Clean Energy Regulator, "Millions of tonnes of carbon emissions to be stored in carbon", 26 November 2016. Available from http://www.cleanenergyregulator.gov.au/Infohub/Media-Centre/Pages/Resources/ERF%20media%20resources/Millions-of-tonnes-of-carbon-emissions-to-be-stored-in-carbon.aspx.
19 Wikipedia, "C4 carbon fixation". Available from https://en.wikipedia.org/wiki/C4_carbon_fixation.
20 M. Sargent, "The ability of Distichlis spicata to grow sustainably within a saline discharge zone while improving the soil chemical and physical properties", *Aust. Journal of Soil Research* 2008, 46, 37–44.
21 Drawdown, Frequently asked questions. Available from http://www.drawdown.org/frequently-asked-questions.
22 Papers referred to in PundaZoie's research:
– Victorian Case Study Analysis Saline Pasture Economic Assessment SGSL Report – Bairnsdale; Jonathan Tucker Farm Business Analyst (DPI Ballarat-Victoria) -3/11/2006.
– M A Chadwick, P E Vencoe, I H Williams and S K Revell, "Programming sheep production on saltbush; adaptations of offspring from ewes that consumed high amounts of salt during pregnancy and early lactation".
– "Saltbush hedgerows – trading low productivity for high protection", *Animal Production Science*, 2009, 49, 311-17; CSIRO Publishing 2009.
– EverGraze Case Study Bangworden, East Gippsland, Victoria 2008–2009.
– Saltbush for saline land; Note Number AG 1294; September 2007 (updated June 2009); Agricultural Ecosystems & Environment; Elsevier 164; (2013) 80–99.
– MA Khan, M Ozturk, B Gul, MZ Ahmed, eds., *Halophytes for Food Security in Dry Lands* (United States of America, Academic Press, 2015) pp. 317–329.
– Ecosystem and Environment. Food and Agriculture Organization of the United Nations, *Carbon Sequestration in Dryland Soils*; World Soil Resources Report 102. (Rome, United Nations, 2000).
– Glenn, E.P., Pitelka, L.F., Olsen, M.W., "The Use of Halophytes to Sequester Carbon", *Water, air and soil pollution*, vol. 64, pp. 251, 1992, doi: 10.1007/ BF00477105.
– Wisniewski, J., Dixon, R.K., Kinsman, J.D., Sampson, R.N., Lugo, A.E., 1993. "Carbon Dioxide Sequestration in Terrestrial Ecosystems", *Climate Research*, vol. 3, 1993, pp. 1–5.
– L.L. Walden and others, "Mitigation of carbon using Atriplex nummularia revegetation", 2017. Available from https://www.sciencedirect.com/science/article/pii/S0925857417302896.
– Government of South Australia Department of Water, Land and Biodiversity Conservation, *Carbon Sequestration from Revegetation: Southern Murray-Darling Basin Region*, DWLBC Technical Report, 2010. Available from https://data.environment.sa.gov.au/Content/Publications/dwlbc_carbon_from_reveg_2010.pdf.
– Judith D. Schwartz, "Soil as Carbon Storehouse: New Weapon in Climate Fight?", 4 March 2014. Available from https://e360.yale.edu/features/soil_as_carbon_storehouse_new_weapon_in_climate_fight.
23 John E Leake and Julian Morison, "Land Repair Fund: a model for exploiting the nexus between land repair, improved production and profit", *Australian Agribusiness Review* – Vol.16 – 2008 Paper 3 ISSN 1442-6951.
24 Food and Agriculture Organization of the United Nations and Earthscan, "Chapter 4: Technical options for sustainable land and water management" in *The state of the world's land and water resources for food and agriculture* (Rome, FAO and London, Earthscan, 2011). Available from http://www.fao.org/docrep/017/i1688e/i1688e06.pdf P. 144.
25 Terra Genesis International, *Regenerative Agriculture: A Definition*. Available from http://www.terra-genesis.com/wp-content/uploads/2017/03/Regenerative-Agriculture-Definition.pdf.
26 Drawdown, Food: Regenerative agriculture. Available from http://www.drawdown.org/solutions/food/regenerative-agriculture.
27 Gabriel Haros, *Cooling the planet to feed the world*, video, 11 Oct 2016. Available from https://www.youtube.com/watch?v=WdzU4O1iw5c.
28 Wikipedia, "List of the largest stations in Australia". Available from https://en.wikipedia.org/wiki/List_of_the_largest_stations_in_Australia.
29 "Land owned by Aboriginal Groups". Available from http://www.gwb.com.au/onenation/truth/land.html.
30 Walter Jehne, Healthy Soils Australia, *Regenerate Earth – The practical drawdown of 20 billion tonnes of carbon back into soils annually, to rehydrate biosystems and safely cool climates*. Available from http://www.globalcoolingearth.org/regenerate-earth/.

Papers published by UTAs, PundaZoie personnel, and collaborators in the development of its technology:

— Panta, S., Flowers, T., Lane, P., Doyle, R., Haros, G., Shabala, S., "Halophyte agriculture: Success Stories", *Environmental and Experimental Botany*, 107, 71–83, 2014.

— Panta, S., Lane, P., Doyle, R., Hardie, M., Haros, G., Shabala, S., *Halophytes as a Possible Alternative to Desalination Plants: Prospects of Recycling Saline Wastewater During Coal Seam Gas Operations*, 2015.
— Panta, S., Flowers, T., Doyle, R., Lane, P., Haros, G., Shabala, S., "Growth responses of Atriplex lentiformis and Medicago arborea in three soil types treated with saline water irrigation", *Environmental and Experimental Botany*, 2016.
— Squires, V.R., Glenn, E.P., Long, R., "Rangelands as a Sink for Carbon" in V.R. Squires, eds., *Range and Animal Science and Resources Management*, vol. 1. (EOLSS Publishers Co. Ltd., 2010) pp. 193–216.
— Panta S, Doyle R, Hardie M, Lane P, Flowers T, Haros G., Shabala S., "Can highly saline irrigation water improve sodicity and alkalinity in sodic clayey subsoils?", *Journal of Soils and Sediments*, 2018.

Page 69: The potential of agroforestry to enhance Land Degradation Neutrality

1 Intergovernmental Working Group 2015, Orr et al 2017.
2 Hillbrand et al 2017.
3 Bai et al 2008; Øystese et al 2015, Hillbrand et al 2017.
4 Hillbrand et al 2017; Zomer et al 2016; Duguma et al 2017.
5 Hillbrand et al 2017, Orr et al 2017.
6 Kamwenda 2002, Duguma et al 2015.
7 Duguma et al 2015; Duguma & Minang 2015.
8 Duguma et al 2015.
9 Duguma et al. 2014.
10 Kaale et al 2002, Duguma et al 2015.
11 Kaale 2002.
12 Kamwenda 2002.
13 Kaale et al 2002, Kamwenda 2002.
14 Kamwenda 2002; Maro 1995.

REFERENCES

— Duguma, L. A., Minang, P. A., Mpanda, M., Kimaro, A., & Alemagi, D. 2015. Landscape restoration from a social-ecological system perspective? In Minang et al (Eds.). Climate-Smart Landscapes: Multifunctionality in Practice, pp 63–73. Nairobi, Kenya: World Agroforestry Centre (ICRAF).
— Hillbrand, A., Borelli, S., Conigliaro, M. & Olivier, A. 2017. Agroforestry for landscape restoration: Exploring the potential of agroforestry to enhance the sustainability and resilience of degraded landscapes. Food and Agriculture Organization of the United Nations Rome.
— Kamwenda, G.J., 2002. Ngitili agrosilvipastoral systems in the United Republic of Tanzania. In: A. Perlis (ed.). An international journal of forestry and forest industries. Vol. 53 2002/4 FAO. Food and Agriculture Organization of the United Nations.
— Øystese, S., Berger, V., Jungermann, U. and Somogyi, D. 2015. Land Degradation Neutrality: A business perspective. World Business Council for Sustainable Development (WBCSD) ISBN 978-2-940521-34-0.
— Zomer, R. J. et al. 2016. Global Tree Cover and Biomass Carbon on Agricultural Land: The contribution of agroforestry to global and national carbon budgets. Sci. Rep. 6, 29987; doi: 10.1038/srep29987 (2016).
— Bai, Z.G., Dent, D.L., Olsson, L. and Schaepman, M.E., 2008. Proxy global assessment of land degradation. Soil use and management, 24(3), pp. 223–234.
— Duguma, L. A., and Minang, P. A., 2015. Leveraging landscapes: A systems approach to drivers of change. In Minang et al (Eds.). Climate-Smart Landscapes: Multifunctionality in Practice. World Agroforestry Centre (ICRAF). Nairobi, Kenya. pp.135-149. DOI: 10.13140/2.1.1880.2242.
— Duguma, L. A., Minang P. A., & van Noorwidjk, M. 2014. Climate Change Mitigation and Adaptation in the Land Use Sector: From Complementarity to Synergy. Environmental Management, 54(3), pp 420–432.
— Duguma, L.A., Nzyoka, J., Minang PA, Bernard F. 2017. How Agroforestry Propels Achievement of Nationally Determined Contributions. ICRAF Policy Brief no. 34. World Agroforestry Centre, Nairobi, Kenya.
— HASHI. 2001. The Shinyanga Natural Resource Management Strategy, Devolution Equation for Action 2001–2002. Ministry of Natural Resources, Forestry and Beekeeping Davison, Tanzania, Dar-es-Salaam.
— Intergovernmental Working Group (2015). Report of the Intergovernmental Working Group on the follow-up to the outcomes of the United Nations Conference on Sustainable Development (Rio+20). Advance Draft 1 June 2015.
— Kaale, B., Mlenge, W. & Barrow, E. 2002. The potential of Ngitili for forest landscape restoration in Shinyanga Region – a Tanzania case study. Paper for the International Expert Meeting on ForestLandscape Restoration, San José, Costa Rica, 27–28 February 2002.
— Maro, R.S. 1995. In situ conservation of natural vegetation for sustainable production in agropastoral system. A case study of Shinyanga, Tanzania. M.Sc. thesis, Agricultural University of Norway, Ås, Norway.
— Orr, B.J., A.L. Cowie, V.M. Castillo Sanchez, P. Chasek, N.D. Crossman, A. Erlewein, G. Louwagie, M. Maron, G.I. Metternicht, S. Minelli, A.E. Tengberg, S. Walter, and S. Welton. 2017. Scientific Conceptual Framework for Land Degradation Neutrality. A Report of the Science-Policy Interface. United Nations Convention to Combat Desertification (UNCCD), Bonn, Germany.

Page 73: Productive forests — an untapped and underused resource for addressing some of humanity's biggest challenges

— Garcia Murales, J.S. 2015. Guatemala's timber traceability system. Tropical Forest Update, 24(1): 14–16.
— Chai, P.P.K., ed. 2017. Pulong Tau Buffer Zone: ecosystem, biodiversity and people. ITTO, Yokohama, Japan, and Forest Department of Sarawak, Kuching, Sarawak.

Page 77: Land degradation and forest restoration in the Pacific islands

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Page 85: Rejuvenating soil health through organic farming

1 DOA,Malaysia 2015.
2 Shamsuddin et al, 2011.
3 Elisa et al, 2014.
4 Theeba et al 2015.
5 Zahari et al., 1984.
6 David et al, 1996.
7 DOA, Malaysia 2015.
8 Niggli et. al., 2016.
9 de Ponti et al., 2012.
10 Kamman et.al. 2017.
11 Scow et al., 1994.
12 Linderman, 1988; Werner, 1997.
13 Schisler & Linderman, 1989.
14 Elmholt & Kjoller, 1987.
15 Bachinger, 1995; Mader et al, 1995.
16 Higa & Wididana, 1991; Higa, 1994.
17 Cook & Baker, 1983.
18 Theeba et al, 2015.
19 Theeba et al, 2016.

REFERENCES

— Bachinger, J. (1995). Effects of organic and mineral fertiliser on chemical and microbial parameters of C and N-dynamics and root parameters. *Proc. Second Meeting in Oberwil (Switzerland): Effect of low and high external input agriculture on soil microbial activities in view sustainable agriculture*. 15–16 Sept 1995, pp 52–8. Darmstadt: Institute of Organic Agriculture and Institute for Biodynamic Research.
— Cook, R.J. & Baker, K.F. (1983). The Nature and Practice of Biological Control of Plant Pathogens. The American Phytopathological Society. St. Paul, Minnesota, US.
— DOA, Malaysia, (2015), Asian Soil Partnership Consultation Workshop on Sustainable Management and Protection of Soil Resources 12–14 May 2015; Bangkok, Thailand.
— David J. Midmore, Hans G. p, jansen Robert g. Dumsday 1996, Soil Erosion and environmental impact of vegetable production in Cameron Highlands, Malaysia, Agriculture, Ecosystem and environment, Vol 60, Issue 1, pp 29–46.

— de Ponti T, Rijk B, van Ittersum M.K. (2012) The crop yield gap between organic and conventional agriculture. Agric Syst 108: pp 1–9.
— Elmholt, S. & Kjøller, A. (1987). Measurement of the length of fungal hypae by the membrane filter technique as a method of comparing fungal occurrence in cultivated field soils. *Soil Biology & Biochemistry*, 19: pp 679–682.
— Higa, T. (1994). Effective Microorganisms: A new dimension for nature farming. In: Proceedings of the Second International Conference of Kyusei Nature Farming. J.F. Parr, S.B.
— Higa, T. and Wididana, G.N. (1991). The concept and theories of effective microorganisms. In:Proceedings of the First International Conference of Kyusei Nature Farming. J.F. Parr, S.B. Hornick, and C.E. Whitman (eds) US Department of Agriculture, Washington, D.C., US, pp 118–124.
— Kammann C, Ippolito JA, Hagemann N, Borchard N, Cayuela ML, Estavillo JM, Fuertes-Mendizabal T, Jeffery S, Kern J, Novak J, Rasse D, Saarnio S, Schmidt HP, Spokas K, Wrage-Mönnig N (2017) Biochar as a tool to reduce the agricultural greenhouse-gas burden – knowns, unknowns and future research needs. J Environ Eng Landsc Manag 25(2): pp 114–139.
— Linderman, R.G. 1988. VA (vesicular-arbuscular) mycorrhizal symbiosis. ISI Atlas Anim. Plant Sci., 1(2): pp 183–188.
— Mader, P., Fliessbach, A., Wiemhen, A. and Niggli, U. (1995). Assessment of soil microbial status under long-term low input (biological) and high input (conventional) agriculture.In *Effect of low and high external input agriculture on soil microbial activities in view sustainable agriculture*. (Mader, P. and Raupp, J., ed.) pp 24–28.
— Niggli U, Schmidt J, Watson C et al (2016) Organic knowledge network arable. State-of-the-art research results and best practices. Report D.3.1.
— Scow, K.M., O. Somasco, H. Ferris, N. Gunapala, S. Lau, R. Venette, R. Miller, C. Shennan. 1994. Transition from conventional to low-input agriculture changes soil fertility and biology. California Agriculture 48(5): pp 20–26.
— Shamshuddin j, Fauziah C.I. M, anda m, Kapok, J and Shazana M.A.R.S (2011) Using ground basalt and/or organic fertilizer to enhance productivity of acid soils in Malaysia for crop production. *Malaysian Journal of Soil Science*, vol. 15: pp 127–146.
— Ramli, B. & Robert, W. (2003). Organic farming in Malaysia.Seminar on Sustainable farming — ensuring food safety and environmental quality. Kuala Lumpur. Malaysia. 1–8 Jun 2003.
— Eswaran, H.; R. Lal; P.F. Reich (2001). "Land degradation: an overview". Responses to Land Degradation. Proc. 2nd. International Conference on Land Degradation and Desertification. New Delhi, India: Oxford Press.
— Tantemsapya, N. (1995) Sustainable Agriculture in Thailand. *Thai Environment Institute Quarterly Environment Journal* 3, 2, pp 55–64.
— Theeba ; Illani Zuraihah, I ;Nor Ziana Z,Z; Mohd Zain, M; Mat Ti, O and Hamidah H, Kajian Keberkesanan Baja Bio Organik untuk tanaman padi di tanah berasid (Kg Golok). In proceeding of Persidangan Padi Kebangsaan 2017, Subang Jaya, Malaysia. pp 232–245.
— Theeba Manickam , Gerard Cornelissen, Robert T. Bachmann , Illani Z. Ibrahim , Jan Mulder and Sarah E. Hale. 2015. Biochar Application in Malaysian Sandy and Acid Sulfate Soils: Soil Amelioration Effects and Improved Crop Production over Two Cropping Seasons. *Journal of sustainability* ISSN 2071–1050 www.mdpi.com/journal/sustainability.
— Werner, M.R. 1997. Soil quality characteristics during conversion to organic orchard management. Applied Soil Ecology 5: pp 151–167.
— Zahari, A.B., Ghulam, M.H., Tay, T.H. and Joy, S. 1984. Management of Problem Soils in Malaysia. In Proceeding of Conference Asean Agriculture in the 2000, UPM Serdang, Malaysia.
— Zulkefli, M (2004). Empirical monitoring on natural farming system on soil properties, insect diversity, disease and harvest quality. Report on Natural Farming Project (MARDI/DOA/NPC) 2004.
— Zulkefli, M., Aini, Z., Norziana, Z.Z. and Illani, Z.I (2011). Trend and changes on soil fertility of selected organic farms of varying ages of development in Malaysia Proceedings of the Third Scientific Conference of ISOFAR-Organic Is Life-Knowledge For Tomorrow. 28 Sept–1 Oct 2011, Namyangju, Republic of Korea. pp 165–169.

Page 90: The power of collective action among water vulnerable communities in rural India

1 Ground Water Assessment Report, 2015. Central Water Commission, Ministry of Water Resources, Government of India.

Page 97: Caribbean Small Island Developing States — a response to sustainable land management

1 McConaughy 1970.

Page 101: Ecological restoration of forest ecosystems through the Chilean National Strategy on Climate Change and Vegetation Resources

1 CONAF. 2016(a). Estrategia Nacional sobre Cambio Climático y Recursos Vegetacionales. https://www.enccrv-chile.cl/index.php/descargas/documentos-2017/90-documento-de-la-estrategia/file.
2 CONAF. 2016(b). Programa de Acción Nacional contra la Desertificación, la Degradación de las Tierras y la Sequía. PANCD-Chile 2016–2030. https://www.enccrv-chile.cl/descargas/publicaciones/86-pancd-2016-2030/file.
3 CONAF. 2018. Desarrollo de un modelo de inversión socio-ambiental para restauración de tierras semiáridas en Chile. Final Report. Forest Ecosystem Restoration Initiative (FERI). 86 pp.
4 Castro, M. and Bahamondez, M. 1986. Surgimiento y transformación del Sistema comunitario: las comunidades agrícolas, IV Región, Chile. Programa el Hombre y la Biósfera. UNESCO-MAB3. Revista Ambiente y Desarrollo. Volumen II, N°1 [111–126].
5 CONAF. 2017. Gira de Campo. Proyectos de Restauración en la Región de Coquimbo con Cooperantes Internacionales y Servicios Públicos vinculados a la Estrategia Nacional de Cambio Climático y Recursos Vegetacionales (ENCCRV) https://www.enccrv-chile.cl/index.php/giras/item/453-gira-decampo-coquimbo-octubre-2017.
6 CONAF. 2015 (a). Resultados del Taller Participativo Región de Coquimbo. Salvaguardas Ambientales y Sociales. http://www.conaf.cl/wp-content/files_mf/1450106623Informecoquimbo.pdf.
7 CONAF. 2015 (b). Taller en Coquimbo de Salvaguardas Sociales y Ambientales. Video. https://www.enccrv-chile.cl/index.php/videos-talleres/item/308-talleren-coquimbo-de-evaluacion-social-y-ambiental-enccrv.

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Page 107: A transformative project to combat land degradation through the sustainable production of cocoa in the post conflict context of Colombia

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Page 111: Allowing Nature to Recover without Human Interventions

1 Caribbean Conservation Association, 1991; Government of Grenada, 1988.

REFERENCES
— IWCAM St. Johns Watershed Project Report, 2011.
— Grenada Water sector Report, 2007.
— LBS Grenada study 2009.

Page 121: Restoring and expanding green cover under bamboo for biodiversity conservation and a sustainable resource base in Indian mountain villages

1 Ram et al., 2010; Hogarth and Belcher, 2013.
2 Any of various Himalayan bamboos of the genus Yushania, having long flexible stems used to make baskets, matting, etc.
3 Uttarakhand Bamboo and Fiber Development Board, 2004.
4 The Chal-Khal system comprises natural earthen ponds and percolation pits created on slopes, from which water infiltrates the soil, recharging the groundwater and, ultimately the springs.

REFERENCES
— Anonymous. 2005a. Annual Report 2004–2005. Uttaranchal Bamboo and Fiber Development Board. Government of Uttarakhand, Dehradun.
— Anonymous. 2005b. National Mission on Bamboo Technology and Trade Development (NMBTTD). Department of Agriculture and Cooperation, Ministry of Agriculture, Government of India, New Delhi, India.
— Annual Reports of Central Himalayan Environment Association. http://www.cheaindia.org/about.php.

— Biswas, S. 2004. Bamboo diversity and conservation in India. www.ipgri.cgiar.org/publications/HTMLPublications/572/ch25.htm (5/12/2008).
— Rai, S.N. and K.V.S. Chauhan. 1998. Distribution and growing stock of bamboo in India. Indian Forester 124: 89–98.
— Ram, N., Singh, L., and Kumar, P. 2010. Bamboo plantation diversity and its economic role in North Bihar, India. Nature and Science. 8(11): 111–115.
— Sundriyal, M. and R.C. Sundriyal. 2009. Vanishing Trade of Bamboo: A Case study of Traditional Artisans of Uttarakhand. Published in VII WBC Congress (Sept 15–18 Sept, 09) proceedings 7: 29–36.

Page 125: Restoring the most ecologically valuable forest ecosystems in the world

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— https://ecosphere.plus/.
— http://ca.aider.com.pe.
— https://althelia.com/investment/supporting-sustainable-production-coffee-cocoa-peruvian-amazon/.
— http://www.wri.org/publication/economic-case-for-restoration-20x20.
— https://ecosphere.plus/blog/quantifying-the-impacts-of-the-tambopata-bahuaja-project/.
— https://ecosphere.plus/tambopata/.
— http://www.tambopata-bahuaja.info/.

Page 129: Towards land degradation control in China

1 State Forestry Administration, National Sand Control Plan (2011–2020), NBCD [2013] No. 76.
2 National Development and Reform Commission, Ministry of Water Resources, National Soil and Water Conservation Plan (2015–2030), December 2015.
3 Ministry of Agriculture: the national grassland protection, construction and utilization in the "13th FYP" plan, Dept. of agro-animal husbandry [2016] 16, Dec. 30, 2016.
4 SFA, "National Forest Management Plan (2016–2050)", Dept. of planning, [2016] No. 88.
5 Mu is a Chinese unit of land measurement equivalent to 1/15 ha, or 0.06665 ha
6 The State Council, the Soil Pollution Prevention and Control Action Plan), State Council [2016] No. 31.
7 State Council Office "Wetland Protection and Restoration System", Nov. 30, 2016.

Page 136: Sustainable land and ecosystem management approaches and technologies — India's scenario

1 Space Applications Centre Atlas 2016.
2 A study by Le et al. (2014).
3 Bedi and Bedi 1984; Fox et al 1991; Fox et al 1994.
4 Satterfield (2009) and Goeury (2010)
5 Ladakh Autonomous Hill Development Council, Leh (2005).
6 Ministry of Environment and Forest, India (2008).

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