RURAL 21
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Healthy soil

Healthy people

Healthy planet

FOOD SECURITY
Why yield isn't the whole picture

THE LAND-SEA INTERFACE
Associated mangrove aquaculture for sustainability

LIVESTOCK
Strengthening the role of women in vaccine delivery services

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Dear Reader,

We cannot live without healthy soil and land. It is on these resources that we produce most of our food and build our homes. We need them to provide clean water and precious plant nutrients, to conserve biological diversity and to cope with climate change. And they form the basis for the livelihoods of millions of people. But despite such known facts, these valuable resources are in a dire state. A third of all soils world-wide are already degraded, and each year, further huge expanses of fertile land go lost.

Alarming statistics were also announced at the 15th Conference of the Parties (COP 15) of the United Nations Convention to Combat Desertification (UNCCD) in Abidjan/Côte d'Ivoire in May. Sticking to business as usual would result in an area the size of South America showing progressive land degradation by 2050, and more than three-quarters of the world's population could be affected by drought. The current drought in the Horn of Africa – the fourth in succession, with millions of people on the brink of starvation – gives an inkling of this. Of course, droughts have always been a part of nature and the human experience. But never before have frequency and duration been so marked. And since land degradation, desertification and drought are inextricably linked, the international community emphasised its commitment to restore one billion hectares of degraded land by 2030 at the COP 15.

We know that the only way to achieve this goal is with a paradigm shift – away from a resource-intensive mode of production and towards a resource-friendly mode considering the planetary boundaries while placing our global agricultural and food systems on sustainable foundations. One example of this is regenerative agriculture, which comprises a wide range of site-specific nature-positive practices – on the premise of the "Law of return", i.e. of also giving substances we take from nature back to it.

In order to upscale these practices globally, in addition to corresponding technical know-how, farmers must have a holistic understanding of the soil ecosystem. But above all, shifting practices to sustainable land and soil management has to become an attractive option for them – regardless of whether they are growing half a hectare of maize in Western Kenya or 80,000 hectares of soy in Brazil's State of Mato Grosso. Here, financial incentives are needed, both from the public and the private sector. And then there is the importance of the political will to really spread soil preservation and restoration world-wide while, in the spirit of the Sustainable Development Goals, leaving no-one behind. Our authors and interview partners share examples of global and national initiatives and policies addressing this topic with you.

We hope that this issue of Rural 21 is going to inspire you to not only theoretically approach the valuable resource of soil. For as World Food Prize Laureate Rattan Lal recently said: "Everyone should know what healthy soil looks, feels and smells like." On this note, we wish you a multisensory reading experience.

Patricia Summa Silvia Richter

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RETURNING LAND TO NATURE

Land misuse and soil mismanagement have resulted in large expanses of our soil being degraded. Our author describes how the global agricultural and food systems can be made more environmentally friendly, and the role which regenerative agriculture can play in this context.

By Rattan Lal

Photos: Jörg Böthling (top), UNCCD (bottom)
Composition: Andrea Trapani

One third of all soils of the world are degraded. Given its drastic effects on water, energy and biogeochemical cycles, anthropogenic soil degradation must be recognised in the planetary boundaries framework proposed by Rockström and colleagues in 2009. Aggravation of soil degradation may weaken critical ecosystem services and even create disservices. It is also important to understand that the severe and global problem of soil degradation is driven by land misuse and soil mismanagement. The prevalence and perpetuation of conventional agricultural practices accelerate degradation processes such as depletion of soil organic carbon (SOC), decline of soil structure, acceleration of soil erosion, increase in risks of salinisation, and decline in activity and diversity of soil biota (see also article on pages 10–12). Such a downward spiral must be stopped and reversed through innovation in agricultural practices, so that agriculture is a solution rather than a major problem of environmental degradation.

Why we need a paradigm shift

Conversion of natural to agroecosystems has been a major source of increase in atmospheric concentration of carbon dioxide (CO_2) ever since the dawn of settled agriculture. In all, land use, land use change and agriculture may have emitted a total of 555 gigatonnes (Gt) of carbon into the atmosphere since the beginning of agriculture about ten millennia ago (see Table on page 6). Agroecosystems may have lost as much as 133 Gt of soil organic carbon, with adverse impacts on soil health and functionality and aggravation of the anthropogenic global warming. As Yang and Tan stated in 2021, global consumption of agricultural and forestry commodities, excluding wood fuel, resulted in the loss of 15.6 Gt of land C annually, of which 29 per cent and 25 per cent were attributed to beef and wood consumption, respectively.

Although it is obvious that present food systems have failed to end hunger and malnutrition and haven't provided nutritious/ healthy and safe food – the latter being a prerequisite for reaching the UN's Sustainable Development Goal (SDG) 2 – the prevalence of hunger and hidden hunger is still being used as an excuse for deforestation and conversion of natural to agroecosystems, drastic soil disturbance and excessive ploughing, indiscriminate use of agro-chemicals and expansion of flood-based irrigation in conjunction with monoculture systems. Such systems are degrading soil health, diminishing biodiversity, declining agronomic productivity, reducing use efficiency of inputs and increasing rural poverty. Thus, there is a need for a paradigm shift towards sustainable agricultural systems which restore rather than degrade soil health, mitigate and adapt to rather than aggravate climate change, promote negative emission farming rather than being a source of greenhouse gases (GHGs), make land a major sink rather than a source of atmospheric C stock, and return some land to nature rather than expand land area under agroecosystems. Therefore, innovative agroecosystems are needed which can lead to re-carbonisation of the terrestrial biosphere (soil and vegetation) as the bedrock of sustainable development. Simply put, agriculture must restore degraded soils and improve the environment while

> The health of soil, plants, animals, people, ecosystems and planetary processes is one and indivisible

Strategies of transforming the global food systems

Conventional agriculture (5 Ds)		Regenerative agriculture (5 Rs)	
1. Deplete	Take land and other resources from nature	1. Reduce	Spare land and other resources from nature
2. Degrade		3. Reuse	
3. Destroy		3. Recycle	
4. Discard		4. Restore	
5. Dominate		5. Regenerate	

Transformational change

strengthening the ecosystem services essential for human wellbeing and nature conservancy. Such is the premise of so-called regenerative agriculture, which may be a clarion call and a solution towards achieving sustainable food systems.

Producing more from less with regenerative agriculture

Regenerative agriculture (RA) is an integration of two contrasting approaches – agroecology and sustainable intensification – under the same banner. In other words, it is a biometric technology, based on the concept of producing more from less. It is not to be confused with no-input agriculture. In fact, the concept is based on the Law of Return which states that "substances we take from nature must be returned to the same place from which they were taken". The strategy is to create a positive soil/ ecosystem carbon budget so that the terrestrial C stock (soil and vegetation) is restored and is always on an increasing trend. Because of the coupled cycling of C with other elements (nitrogen, phosphorus, sulphur), the overall soil fertility must be restored through inputs (recycling) of biomass-C along with strengthening of biological nitrogen fixation.

At the core of RA are the goals to restore soil organic matter (SOM) content, enhance new soil formation and set in motion the nature-positive trend, including adaptation to and mitigation of climate change and alleviation of the recurrent drought-flood syndrome. By re-carbonisation of soils via photosynthesis, and by practices which take cues from nature and biology, RA can sequester atmospheric C and thus is an effective climate responsible option.

Six aspects of promoting regenerative agriculture

Adoption of RA practices may be promoted through

1. conducting life cycle analysis and costing,
2. calculating full cost to society of all inputs such as pesticides,
3. labelling of food products with the C or environmental footprint,
4. incentivising farmers through payments for ecosystems services,
5. prioritising research on RA,
6. promoting urban agriculture.

Source: Pearson, 2007

Anthropogenic effects on the global carbon cycle

	Era	Carbon emissions (Gt)	Source
I	**Land use conversion**		
	8000 BC to 1750	320	Ruddiman (2003)
	1750 to 2020	235	Friedlingstein et al. (2022)
	Total	*555*	
II	**Emissions from soil**	133	Lal (2018)
III	**Fossil fuel combustion**		
	1750 to 2020	460	Friedlingstein et al. (2022)
IV	**Total anthropogenic emissions**		
	1750 to 2020	695	
	Uptake by the atmosphere	290	
	Uptake by ocean	180	
	Uptake by land	215	

Of the total anthropogenic emissions since 1750 (695 Gt), 41.7 per cent (290 Gt) were absorbed by the atmosphere, 25.9 per cent (180 Gt) by the ocean, and 31.1 per cent (215 Gt) by the land. Thus, natural sinks absorbed about 57 per cent of the anthropogenic emissions.

Regenerative agriculture comprises site-specific nature-positive agricultural practices which restore functions of degraded/ depleted soils and improve environment quality. It is specifically designed to harness the power of the food-energy-water-soil (FEWS) nexus. According to Rhodes (2017), the specific goal of adopting RA is to improve soil health, and through it, enhance the quality of water, air, biodiversity and productivity of agroecosystems. The overall strategy is to replace the current "take, make, dispose waste creation" model by a "reduce, reuse, recycle, regenerate" approach (see Figure on page 5). Being a "one size fits none" approach, a wide range of practices (e.g. cover cropping, agroecology) and outcomes (e.g. improvement of soil health, C sequestration, increase in biodiversity, or combination of both) can be grouped under RA. System-based conservation agriculture (CA) – practised globally on roughly 200 million hectares (M ha) – and integration of crops with trees and livestock are among RA practices. Permaculture, circular economy, sustainable livestock rearing and urban agriculture are also integral to RA.

Scientific evidence for benefits of regenerative agriculture

Soil quality indicators under regenerative agriculture have been developed to assess impacts on ecosystem services in general. However, specific effects of RA on soil organic matter content and soil organic carbon stocks need to be quantified in relation to climate action. Jordon and colleagues (2022), for example, used the Rothamsted Carbon (Roth C) Model to assess the impacts of three RA practices on SOC stocks: cover cropping, reduced tillage and grass-based ley rotations. They found that cover cropping increased SOC stock at the rate of 10 tons of carbon/hectare (t C/ha) within 30 years of adoption across Great Britain. SOC stocks were increased by 3 to 16 t C/ha for ley-arable systems depending on the length of the ley-phase, but little change in SOC stocks was observed under reduced tillage systems.

De Otalora and colleagues (2021) observed that regenerative rotational grazing of dairy sheep achieved 30 per cent higher topsoil C storage and soil ecosystem services than conventional grazing. Kleppel (2020) assessed the importance of herbivore-carnivore interactions in relation to grassland ecosystem functionality and human nutrition and observed that regenerative-multi-paddock (RM) management may reduce blue water withdrawals and greenhouse gas (GHG) emissions by 75 per cent relative to industrial conventional management. Kleppel also observed that a significant amount of anthropogenic CO_2eq emissions can be removed from the atmosphere and sequestered in soil by RM management services. Horton and colleagues (2021) reported that RA practices used in conjunction with silicate amendment of soils to sequester atmospheric CO_2 increased SOC stocks and yield and improved C storage. These practices include less intensive RA, afforestation, bioenergy crops, etc.

Humans cultivate about 150 of an estimated 30,000 edible plant species globally, and most

diets comprise only 30 plant species in all. Therefore, commercial uses of new crops and wild plants of local origin can help diversify local food systems, and improve adaptation to diverse environments humans live in. It is argued that conventional agricultural practices are stripping essential nutrients from food and polluting it with chemicals and increasing risks of modern diseases. Several studies have documented improvements in the nutritional profile of crops and livestock raised with RA to address human health challenges. Montgomery and colleagues (2022), for example, reported that wheat crops in northern Oregon had a higher density of mineral micronutrients in the crops grown by RA practices than that in conventionally grown crops. They also found higher levels of omega-3 fats and a more health-beneficial ratio of omega-6 to omega-3 fats in beef and pork raised under RA. These beneficial impacts on micronutrient and phytochemical concentrations under RA could help in chronic disease prevention.

Returning resources to nature

Giving some land back to nature is an important criterion of regenerative agriculture. For the five billion (B) hectares of land under agriculture (1.5 B ha under cropland and 3.73 B ha under grazing/ rangeland), there must be a well thought of agenda to return some land to nature (see Table above). The overall goal is to renaturalise 0.75 B ha of cropland and 2 B ha of grazing land by 2100. However, other resources also ought to be given back to nature or at least saved on. Improving fertiliser and irrigation water use efficiency would lead to a drastic reduction in the consumption of both while increasing the global average cereal yield. To achieve the goal of improving the use efficiency of fertiliser, emphasis must be on carbon, nitrogen, phosphorous and potassium (CPNK), rather than just NPK, so that an increase in soil C stock can reduce over time the use of chemical fertilisers.

A proposed timetable for humanity to return land and other resources to nature

Resource use	Units	2020	2030	2050	2100
Fertiliser	M t	200	150	100	50
Irrigated area	M ha	350	400	600	750
Cropland area	M ha	1,500	1,400	1,000	750
Conservation agriculture	M ha	200	250	500	750
Grazing/ rangeland	M ha	3,700	3,500	2,500	1,500
Water use for agriculture	km^3	3,150	3,000	2,000	1,000
Global cereal yield	t/ ha	4.00	4.50	6.00	8.00

Furthermore, improvement in soil health would create disease-suppressive soils and reduce the need for pesticide use. Integration of crops with trees (and livestock) would increase the forest cover on agroecosystems and enhance the terrestrial C stock. Change of flood-based or sprinkler system of irrigation to drip sub-fertigation may increase the land area equipped for irrigation and yet decrease the total water use for agriculture.

Drivers of change for translating science into action

Global upscaling of RA practices requires an understanding of what motivates land managers to adopt them. Based on a study in New South Wales, Australia, Gosnell (2022) concluded that, along with positive experiences with the microbiome, negative experiences with agrochemicals in combination with increasing costs and declining results were important motivations to bring about the desired transformation towards upscaling of RA practices. Policy interventions for incentivising farmers through payments for ecosystem services is another option. The technical potential of organic carbon sequestration in soils across the world is put at about 2.5 Gt C per year or 25 per cent of the C emissions from fossil fuel combustion. The cumulative potential of C sequestration in soil and vegetation between 2020 and 2100 is estimated at 333 Gt C or drawdown of atmospheric CO_2 by roughly 157 ppm. However, to exploit it, payments must be provided at a societal value of C estimated at about 120–125 US dollars per t C to promote C-farming. In this context, the role of the private sector in translating science into action cannot be over-emphasised. Education about healthy diets and the use of plant-based protein may be a further important strategy to reduce land area under grazing as well as enteric emission of methane (also see Box). Reducing food waste, by improving the shelf life and storage facilities, is among important strategies to sparing land for nature. Promoting soil-less culture in conjunction with urban farming and home gardening is a pertinent option to promote RA and spare land. There is no shortage of food or capacity to produce enough food to adequately feed the current and foreseeable population globally.

Reducing livestock is key

It is widely believed that global average crop yields could be more than doubled through the adoption of proven agricultural practices. This strategy would allow the reduction of cropland area by nearly 50 per cent of its current extent. Reportedly, 25 per cent of the global land surface is used as grazing land for raising livestock. Livestock grazing removes a large quantity of C from global rangeland. Globally, 35 per cent of all primary crop harvests and 24 per cent of all crop residues are consumed by livestock. In addition to these fodder sources, global livestock currently grazes on roughly 25 per cent of all ice-free land area, compared to only two per cent before the onset of industrial revolution.

Presently, global biomass of mammalian livestock is 67 per cent greater than that of humans, 1,329 per cent larger than of all wild mammals, and 318 per cent larger than total mammalian biomass that was supported by the Earth 100,000 years ago. Therefore, an objective evaluation of grazing land and sparing some of it for nature by reducing the livestock population (through changes in human diet) is critical for humans to live in harmony with nature.

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References: **www.rural21.com**

Facts and figures on land and soil

Definitions

Land degradation: The persistent or long-term loss of land-based natural capital. Land degradation affects all types of land, from cities and rangelands to farmland and wilderness. While often quite evident on the surface, it is the hidden and insidious deterioration in the physical, chemical, and biological properties of soil, water and biodiversity that is undermining human health and economic prosperity. Land becomes degraded in many ways. Some are natural or indirect, but most result from direct human activities. For example:

- people cut down forests for timber and fuelwood or to grow crops and graze livestock;
- grasslands or drained wetlands are converted to cultivate food or expand urban areas;
- mining and infrastructure contribute to land degradation in both urban and rural areas;
- in the drylands, the over-exploitation of soil, water and vegetation results in desertification.

Land degradation neutrality: 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. Land degradation neutrality aims to balance anticipated losses in land-based natural capital and associated ecosystem functions and services with measures that produce alternative gains through approaches such as land restoration and sustainable land management. The goal is maintaining or enhancing the land resource base – in other words, the stocks of natural capital associated with land resources and the ecosystem services that flow from them.

Land restoration: A continuum of sustainable land and water management practices that can be applied to conserve or "re-wild" natural areas, "up-scale" nature-positive food production in rural landscapes and "green" urban areas, infrastructure and supply chains. It can be active (such as planting grasses, shrubs, and trees or managing soils and wildlife), or passive (such as allowing land to recover by itself after disturbance).

Regenerative agriculture: The use of techniques that restore soil health and protect water and biodiversity by controlling soil erosion, reducing tillage and the use of agrochemicals, and adopting integrated systems of crops, trees and livestock, in addition to a wide array of other farm restoration measures.

Sustainable land management: The use of land resources, including soils, water, animals and plants, for the production of goods to meet changing human needs, while simultaneously ensuring the long-term productive potential of these resources and the maintenance of their environmental functions.

The gender aspect of land use and land degradation

In many countries, women have unequal and limited opportunities to access or own land in their name. According to data from the 2019 OECD Social Institutions and Gender Index,

- even in countries where women have the same legal rights as men to own and access land – as is the case in Costa Rica – only 15.6 per cent of farm ownership is in the hands of women;
- in Central Asia and the Caucasus, despite legal gender equality under law, women own on average only 23 per cent of land;
- in the Middle East and North Africa, only 4 per cent of women hold land titles;
- disinheritance of the surviving spouse still occurs in 96 countries;
- women's rights to inherit their husbands' property are denied in 102 countries under customary, religious or traditional laws and practices; 103 countries do not criminalise property dispossession or grabbing of inheritance;
- not having land titles that can be used as collateral or the lack of secure tenure hinder women's access to loans and credit, and also limit their access to extension services and training.

Women tend to adopt sustainable land management technologies at a rate that is typically lower and slower than that of men – for various reasons: gender norms and roles, education, literacy, insufficient land tenure security, a lack of access to information, agricultural inputs, extension services and financing.

A recent UNCCD study shows how differently land degradation and desertification impact on women and men:

- Drought and land degradation tend to increase the burden of unpaid care and domestic work shouldered by women and girls, such as standing in line and waiting for water, walking long distances or protecting the sick from unsafe water.
- Drought- and land degradation related food scarcity affects intra-household food distribution; women tend to eat smaller portions or skip meals. Food scarcity is also linked to the higher incidence of miscarriages as well as maternal and child death.
- Carrying water has negative effects on the health of women of all ages; physical loads can cause musculo-skeletal disorders. According to the United Nations Children's Fund (Unicef), globally, women spend a collective 200 million hours every day collecting water.
- Drought-related migration increases women's workload when they are left to manage their households. They may lack power to make timely farming decisions or respond to effects of drought, land degradation and desertification.
- When droughts become disasters, technology is critical to manage the risks. But early warnings do not reach women in many cases. Women have less access than men to climate forecasts (owing to language barriers, inability to read written documents, workshops that take place outside the community, inconvenient timing of the meetings) and therefore have more difficulty preparing for droughts.
- Men are consulted more often than women by humanitarian organisations; in a study by Care in Afghanistan from 2021, 70 per cent of men reported being consulted about their needs, whereas nearly 70 per cent of women had not been consulted.
- Out of the 30 country land degradation neutrality profiles listed on the UNCCD website, only two (6.66 %) include references to women.

International agreements

Rio Conventions: At the Earth Summit 1992 in Rio de Janeiro, Brazil, three global agreements were adopted: the Convention on Biological Diversity (CBD), the United Nations Convention to Combat Desertification (UNCCD) and the United Nations Framework Convention on Climate Change (UNFCCC). The Conventions work together to ensure that land, climate and biodiversity benefit from a joint approach to restore our balance with nature. In 2001, the secretariats of the Rio Conventions established a Joint Liason Group to collect and share information on work programmes and operations of each convention.

UN Decade on Ecosystem Restoration: Preventing, halting and reversing the degradation of ecosystems world-wide is the focus of the UN Decade on Ecosystem Restoration (2021–2030). It calls for a broad and balanced response, addressing all ecosystems and their connectivity to re-establish a healthy landscape mosaic. These efforts are closely aligned with Sustainable Development Goal (SDG) target 15.3, which calls on countries to strive for land degradation neutrality by 2030.

Global land-use class change 2000–2019 (in million hectares)

Land-use class	2000	2019	Change
Land under permanent meadows and pastures	3,387	3,196	-191
Cropland (arable land and permanent crops) - Arable land (land under temporary crops) - Land under permanent crops	1,493 1,359 134	1,556 1,383 170	+63 +24 +36
Agricultural land (total of cropland, permanent meadows and pasture)	4,880	4,752	–128
Land area equipped for irrigation	289	342	+53
Forest land (land area > 0.5 ha with trees > 5 m + 10 % canopy cover)	4,158	4,064	-94
Other land	3,968	4,188	+220

Source: FAO STAT

Global Land Outlook 2: what the future could look like

The Global Land Outlook 2 projects the planetary consequences of three scenarios up to 2050: business as usual, restoration of 50 million square kilometres of land and restoration measures augmented by the conservation of natural areas important for specific ecosystem functions. The results in brief:

1) Baseline
Business as usual, continuing current trends in land and natural resource degradation, while demands for food, feed, fibre and bioenergy continue to rise. Land management practices and climate change continue to cause widespread soil erosion, declining fertility and growth in yields, and the further loss of natural areas due to expanding agriculture.

By 2050:
- 16 million square kilometres show continued land degradation (an area the size of South America).
- A persistent, long-term decline in vegetative productivity is observed for 12-14 per cent of agricultural, pasture and grazing land, and natural areas – with sub-Saharan Africa worst affected.
- An additional 69 gigatonnes (Gt) of carbon is emitted from 2015 to 2050 because of land use change and soil degradation. This represents 17 per cent of current annual greenhouse gas emissions: soil organic carbon (32 Gt), vegetation (27 Gt), peatland degradation/ conversion (10 Gt).

2) Restoration
Assumes the restoration of around 5 billion hectares (50 million square kilometres [km^2], or 35 % of the global land area) using measures such as agroforestry, grazing management, and assisted natural regeneration (current international pledges: 10 million km^2).

By 2050:
- Crop yields increase by 5-10 per cent in most developing countries compared to the baseline. Improved soil health leads to higher crop yields, with the largest gains in the Middle East and North Africa, Latin America and sub-Saharan Africa, limiting food price increases.
- Soil water holding capacity increases by 4 per cent in rainfed croplands.
- Carbon stocks rise by a net 17 Gt between 2015 and 2050 owing to gains in soil carbon and reduced emission.
- Biodiversity continues to decline, but not as quickly, with 11 per cent of biodiversity loss averted.

3) Restoration and protection
This scenario includes the restoration measures, augmented with protection measures of areas important for biodiversity, water regulation, conservation of soil and carbon stocks, and provision of critical ecosystem functions.

By 2050:
- An additional 4 million km^2 of natural areas (the size of India and Pakistan together); largest gains expected in South and Southeast Asia and Latin America. Protection measures prevent land degradation by logging, burning, draining or conversion.
- About a third of the biodiversity loss projected in the baseline is prevented.
- An additional 83 Gt of carbon is stored compared to the baseline. Avoided emission and increased carbon storage are equivalent to more than seven years of total current global emissions.

Recent publications

Study on the differentiated impacts of desertification, land degradation and drought on women and men. *UNCCD, 2022.*
Global Land Outlook. Second Edition. *UNCCD, 2022.*
Drought in numbers. *UNCCD, 2022.*
The state of the world's land and water resources for food and agriculture. *FAO, 2021.*
Restoring life to the land. The role of sustainable land management in ecosystem restoration. *UNCCD & WOCAT, 2021.*
The information above has been taken from these publications.

Soil organisms for healthy soil and sustainable agriculture

Soils form a thin layer on the Earth's surface and host an immense biological diversity, most of which is invisible. Yet the organisms living in soil provide crucial ecosystem services that human societies depend on. While intensive agricultural management often poses a threat for soil communities, managed properly, they could strongly and sustainably support yields.

By Franz Bender and Marcel van der Heijden

Soils form the basis of human existence and are an integral component for the functioning of our planet Earth. Although people know that there are organisms, such as earthworms, insects, bacteria, protists or fungi, living in soil, they are mostly hidden and the fact that soils are hotspots of biological activity is easily overlooked. It has been estimated that at least one quarter of global biodiversity is found in soils, ranking them among the most important habitats for living organisms. Soil organisms not only live in soil, they are an integral component of the formation and functioning of healthy soils. Without their living components, soils as we know them would not exist; neither would plants be able to grow without the activity of billions of organisms in soil breaking down organic matter, recycling nutrients, improving soil structure or controlling pathogen spread, among other things.

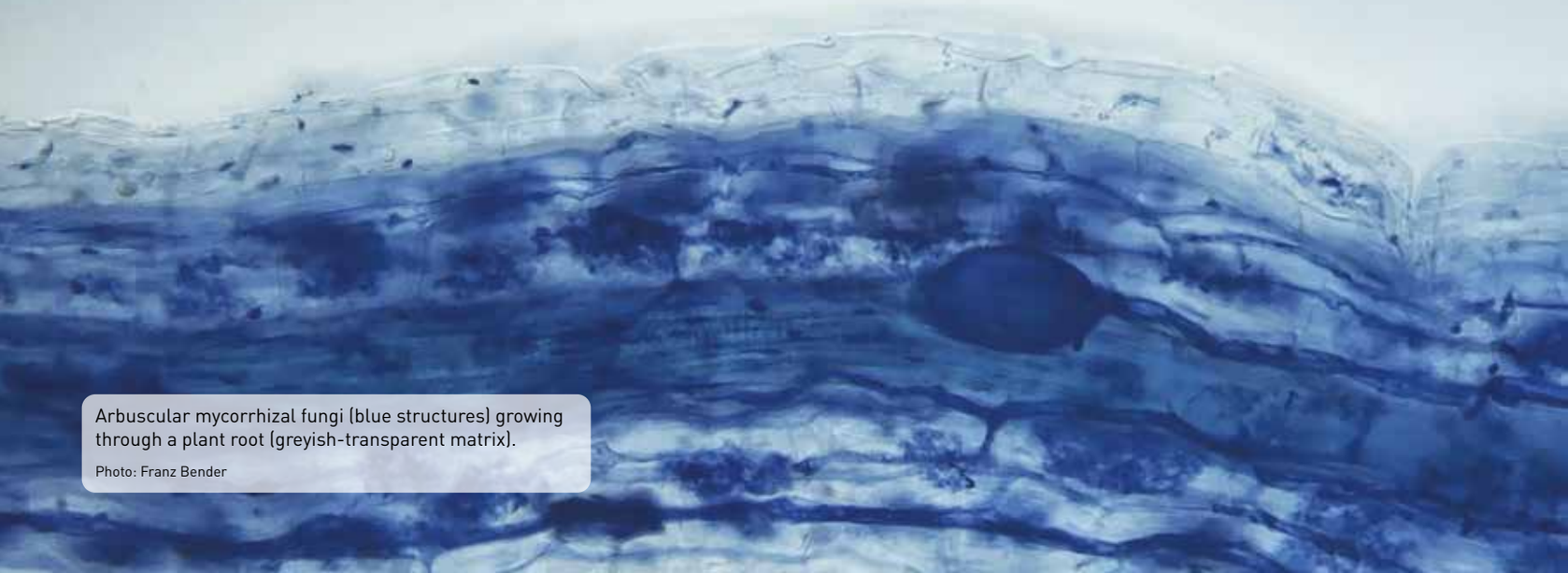
How natural soil ecosystems work

Natural soil ecosystems are almost exclusively maintained by internal resource recycling processes in which soil organisms play a major role. Nutrients contained in plant litter need to be converted into plant-available forms before plants can access them. An underground collaboration between soil animals and the soil microbiome (the entity of microorganisms such as fungi, bacteria and archaea living in a soil) chew up and digest the organic material and release plant available nutrients. Other organisms, like the symbiotic mycorrhizal fungi, can help plants to access and take up these nutrients. Plants can acquire up to 90 per cent of phosphorus and nitrogen from soil microbes. Soil organisms also feed on each other, leading to a constant uptake, transformation and release of nutrients. The soil microbiome emits all kinds of substances and enzymes that can help to improve soil structure, control pathogens and support plants in boosting their own immune systems. They degrade chemical compounds, thereby filtering water and preparing our drinking water. On top of that, soils form the biggest carbon storage on Earth, and soil organisms hold the key to this immense stock. Their activities can lead to C storage through the formation of humus but can also lead to the release of CO2 into the atmosphere when organic matter is decomposed. So soil biological activity can be considered a major determinant of soil C sequestration and the mitigation or aggravation of climate change.

The flipside of intensive agriculture

Soil organisms are controlled by complex ecological networks and shaped by climatic, soil chemical and other environmental conditions. In agriculture, soils are managed to be able to produce high amounts of produce or fibre. Such management operations can also affect soil organisms. Soil tillage can harm larger soil organisms and disrupt fungal hyphae spreading through soil. High nutrient inputs through fertilisers and the use of agrochemicals, such as pesticides, affect soil biological communities and functioning. Crop breeding efforts during the last century focused in huge parts on maximising yields, ignoring belowground processes or the ability of crops to associate with beneficial microbes. Often, monocultures are grown, and, compared to a natural ecosystem, this reduction in plant diversity, together with the addition of agrochemicals, has trickle-down effects on soil biodiversity, which is commonly lower in such systems.

Although the achievements of the Green Revolution have enabled massive increases in food and fibre production and helped to support a strongly increasing human population over the last century, it has become clear that these practices have also promoted the deterioration of soils and their biological resources. Soils are lost at alarming rates through erosion. In addition, external inputs and management processes negatively affected soil biological communities, depriving soils of their inherent potential to sustain plant growth and ecosystem functioning. In industrialised agricultural systems,



Arbuscular mycorrhizal fungi (blue structures) growing through a plant root (greyish-transparent matrix).

Photo: Franz Bender

internal, soil biology-driven ecosystem processes have been systematically replaced by external resource inputs.

Before the Green Revolution, agriculture was much more reliant on soil microbiome processes than industrialised agricultural systems of today. The symbiosis between nitrogen-fixing bacteria and roots of certain plants (Legumes or Fabaceae) or the mycorrhizal symbiosis between beneficial soil fungi and roots of most plant species provided much-needed nutrients for crop production in natural ways. Such plant-soil interactions supported crop production from the beginnings of arable farming and are still part of many traditional and sustainable farming systems of today. As our understanding of belowground ecology and plant-soil interactions increases, new ways of how soil microbiomes support crop production and ecosystem functioning are discovered that can provide the basis for well-informed management recommendations, breeding endeavours and other strategies. Soil biological processes have sustained agricultural production for millennia and there is no reason to believe that this should not be possible again.

Soil ecological engineering

The concept of ecological intensification seeks to draw benefits from ecological processes for agricultural production. This concept has been further elaborated to specifically include soil biological processes into agricultural management schemes through the concept of soil ecological engineering, which aims at harnessing the potential of soil biological communities for sustainable agricultural production. This can happen through direct or indirect approaches. The latter comprise creating soil conditions that are beneficial for overall soil biological communities so that their abundance, diversity and activities can be increased. Importantly, a permanent soil cover and presence of living roots enable thriving soil biological communities. Plant roots release root exudates into soil that form the nutritional basis for entire soil food webs. Microbiomes on root surfaces take up these compounds and transport them further into soil. The microorganisms themselves provide a feed source for protists and nematodes, which again supply food for larger organisms. Decaying plant material is pulled belowground by earthworms, thereby distributing organic matter in soil, creating hot spots of microbial activity and soil pores for improved water infiltration and aeration. Reducing disturbance through tillage operations and more diverse plant covers can strongly benefit the abundance and diversity of soil communities. Crop diversity can be increased spatially (several crops on the same field) or temporarily, e.g. through crop rotations.

Why soil biodiversity matters

A high soil biodiversity can have several benefits. Firstly, a high diversity acts as a biological insurance policy. If, for example, increasing temperatures prevent one species from surviving and performing a certain function (e.g. biological pathogen control), diversity increases the chance that another organism able to cope with the changed environmental conditions can step in and perform the respective function. In a less diverse system, such a function might be lost when an organism disappears. Moreover, soils with higher biodiversity can more effectively prevent pathogenic organisms from spreading and establishing themselves in soil. Model studies have shown that reductions in soil biodiversity lead to reduced plant productivity, impaired nutrient cycles and an overall decline in ecosystem functioning. Different crops have different effects on soil communities. Even within the same crop species, different varieties associate with beneficial soil organisms, such as arbuscular mycorrhizal fungi, to different extents. While breeding efforts have to date focused on yield and disease resistance, breeding for crop associations with beneficial soil organisms is a field that bears huge potential for enhancing agricultural productivity in a sustainable way. Years of intensive agricultural management can lead to reduced abundance or even the extinction of certain soil organisms. By culturing and directly applying beneficial organisms to soil ('inoculation'), their abundance and benefits can be enhanced or restored.

Earthworms are important soil engineers and decomposers.

Photo: Gabriela Brändle

Nodules on the roots of a legume plant containing nitrogen-fixing bacteria.

Photo: Marcel van der Heijden

Nematodes play a key role in regulating soil microbial communities and nutrient cycling in soil.

Photo: Andy Murray

Trials with arbuscular mycorrhizal fungi have repeatedly shown that crop yields can be increased through inoculations. However, the effects are inconsistent and appear to depend on local conditions. The exact reasons for this context-dependency are a matter of current investigations. Moreover, the market for biological inoculants is still hardly controlled, and some products offered are of poor quality.

Encouraging sustainable practice

Traditional farming systems that have existed long before the onset of the Green Revolution often use agro-ecological principles that harness the potential of soil biology for crop production. Still, scientific advancements, an increased understanding of plant-soil interactions, new breeding efforts and inoculation products could serve to further optimise such systems to make them more resistant to climate changes, increase their nutritional values, protect soils and assure sustainable agricultural productivity for current and future generations. Industrialised food systems pose high demands on cropping systems in terms of quality, consistency, and availability of produce, making the transition to soil biology-based farming more challenging. Moreover,

some farmers are hesitant to adopt more sustainable practices since they often require more work and planning efforts and bear the risk of reduced income, at least during an initial phase of transition. Here, policy needs to step in and set the right incentives to give producers the opportunity to invest in the long-term sustainability of their soils instead of sacrificing their most important resource for short-term profit. Moreover, external costs of intensive agriculture (e.g. soil erosion, polluted drinking water, soil carbon loss) need to be accounted for.

Agricultural activities have a major impact on soil health and the ability of soils to provide the crucial ecosystem services our society depends on. If managed accordingly, soil biology can release a huge and currently under-utilised potential to produce agricultural yields in a sustainable way, so that the soils of today can still nourish the generations of the future.

Sebastian Franz Bender is Team Leader for soil ecological engineering in the research group Plant-Soil Interactions at Agroscope and the research group Agroecology and Plant-Microbiome interactions at the University of Zurich, Switzerland. His team investigate how ecosystem services provided by soil organisms can be promoted in agricultural systems to enhance the sustainability of production.

Marcel van der Heijden heads the Plant-Soil Interactions research group at Agroscope. He is Professor for Agroecology and Plant-Microbiome interactions at the University of Zurich, and Professor for Mycorrhizal Ecology at the University of Utrecht, the Netherlands. His team investigate the importance of soil biodiversity for ecosystems and test a wide range of tools to enhance the sustainability of agricultural systems, including soil ecological engineering, mycorrhiza and compost application, cover crops, organic farming and conservation agriculture.
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“The private sector is keen to invest in soil”

The Coalition of Action 4 Soil Health has set itself the goal of improving soil health globally. Co-Leader Leigh Ann Winowiecki explains the barriers which have to be cleared on the way there and why she is optimistic about achieving this goal.

Ms Winowiecki, in a nutshell, what is the Coalition of Action 4 Soil Health?

The CA4SH took root in the United Nations Food Systems Summit last year – as part of the stakeholder engagement process. Dr Rattan Lal and I were leading the restore package under Action Track 3 and brought together all game-changing solutions submitted by the stakeholders related to soil health. Based on this, we formed the Coalition of Action 4 Soil Health. It is anchored in the UN Convention to Combat Desertification, the UNCCD, and we have a core team made up of the Inter-American Institute for Cooperation on Agriculture, the IICA, CIFOR-ICRAF, the World Wildlife Fund and the UNCCD. Right now, we have over 100 members – from NGOs and farmers organisations through countries and private sector to research. And the Coalition is continuing to grow.

What do you seek to achieve with the Coalition?

The goal is to scale soil health globally. We aim to do this by recognising that there are key barriers that must be addressed. These include implementation barriers, policy barriers, monitoring barriers and financial barriers. In order to address these, we have four targets – very simple ones. One, we want policies to incorporate soil health, and that’s using the best available evidence. Two, we want to overcome the remaining research gaps that exist around practices and soil health indicators by doing that with research and development. So it’s not research for the sake of research, but really doing applied research that can support development initiatives. Three is scale – the number of hectares under healthy soil practices. And four is to increase financial incentives five- to tenfold, and that includes public and private finance. Studies have shown that between 20 and 40 per cent of our Earth surface is degraded. This is severely limiting the soil’s ability to provide essential ecosystem services, which includes water holding capacity, water quality, carbon storage, nutrient cycling for plants … So we see the Coalition as bringing people together, aligning the SDGs with the three Rio Conventions – the UN Framework Convention on Climate Change (UNFCCC), the UNCCD and the Convention on Biological Diversity (CBD) – to scale soil health.

These Conventions are now 30 years old. How is it possible that, despite these international agreements, we see more land being degraded every year?

One of my theories is that we take soil for granted and that we really tend to overlook it. So much of the beauty of soil is unseen, because to do so, you really have to dig into it, and sometimes you need a microscope. In a recent interview, Dr Rattan Lal said: “Everyone should know what healthy soil looks, feels and smells like.” There are so many people who never have put hands in the soil or thought about soil. Also, soil has not been officially recognised in the UNFCCC. That’s why I’m really excited about this Soil Health Resolution that we drafted to support Member States who want to take soil health forward. Now is the time, we have growing momentum around soil, and we have to tap into that and use it, so that we really can raise awareness and support farmers to scale soil health practices.

Can you share success stories of your work?

Yes, definitely. Here, we can mention three different pillars. One is: we know how to monitor soil health. It is no longer “Oh, we don’t know how to monitor, we don’t know the indicators, let’s talk about indicators.” We know how to do it, and we are doing it. At ICRAF, we developed a robust monitoring framework that samples landscape-scaled variability, because we know that soils vary with space. They also vary through time with the management. One of the key indicators we use is soil carbon because it is quantifiable and responses to management, so we can track changes over time and map this. And monitoring has become less expensive. Today, with soil spectroscopy, which uses light to analyse soil, we can get multiple properties in 30 seconds for four dollars compared to one sample with one property for hundreds of dollars. These advances in monitoring and technologies provide the evidence that the policy sector needs.

What else?

The second success story is that the private sector is really keen to engage in soil health. We have the World Business Council for Sus-

tainable Development, or WBCSD for short, which actually already launched its Soils Investment Hub back in 2014, but it was just lingering around because it didn't have the evidence and the awareness and the momentum that we have now. Ten private companies have signed on to the Coalition with the commitment to support soil health. This is a very different story from that of the past. And looking at their commitment letters, you see that they want evidence-based solutions. For the private sector to get involved and to de-risk investments, we need the evidence, and that's fantastic.

And the third pillar?

We have this massive collaboration. This is really a story of everyone letting their guard down and supporting with a unified voice. We actually say soil is a unifier. We don't say "agroecology", we don't say "regenerative agriculture", although we can list all of that. But unfortunately, some of these terms have become so political. And soil is a unifier. Who is going to say that he hates soil? No-one. We all depend on it. With the CA4SH, we have a multi-stakeholder partnership, where the scientists learn how to speak to the private sector, and we have the farmers organisations, so everyone is unified around the table, recognising the importance of soil.

What are the main challenges farmers are faced with regarding soil health?

Let's take the example of Kenya, where I'm based. Here, population pressure has moved farmers into marginal lands – we are talking about drylands where soil fertility is often low. Now, with climate change, we can't predict the rains anymore. They are erratic, and that's a huge challenge. Moreover, in the initial stage of conversion, you can lose up to 50 per cent of your carbon in the soil. Then, with continuous mining of the nutrients, your fertility just continues to drop. So it's really critical that farmers are re-building the soil. And often they are not the first ones converging, they are actually inheriting problems of the past. So you have climate change, you have fertility status, and the third point is the financial incentives. That's why one of our targets is to increase financial incentives. These incentives need to be transparent, and they need to be equitable. We need women, we need youth involved to make that transition to healthy soil practices.

Do you feel that there are different challenges for small- and large-scale farmers?

Well, although I cannot really speak for large-scale farmers, I'm from the US, and I don't think anyone would say that US farmers are rich. They are really struggling, and that's why they had to become so large. They just couldn't make money on a small scale. It is stressful, and it's such hard work. I think we really need to build the respect for farmers again, as a profession. Most people seem to want their kids to be doctors or lawyers or something like that. And until we change this perception and increase the reputation of farmers globally, we are going to have these same struggles, large-scale and small-scale. This is one of the underlying challenges that farmers face.

What is your work on the ground like?

We have several flagship initiatives. IICA, for example, is working with the "Living Soils" initiative in Latin America, and we as ICRAF are working on farmer-centred land restoration here in Kenya. We have a set of criteria for what constitutes a flagship project, and our partners are registering for the Coalition. Then we start connecting them with the farmers and ensure that their voices are heard.

You mentioned some of the barriers on the way to healthy soils – what about political will?

We absolutely have to work on this. A recent study that examined more than 300 nationally determined contributions revealed that less than 30 even mention soil – whether it was soil fertility or soil health. In one of our projects, we were looking at six African countries and were interviewing the high-level officials asking: "Why wasn't this included?" Well, to be fair, these governments are dealing with a lot. So our pathway for communicating with them is to bring in some awareness-raising, showing how central soil is to the restoration commitment they've made, the climate commitment, the food security commitment, the biodiversity commitment. I think if they see how investments in soil health can help achieve these other targets, we will be able to change a lot.

Are there countries that could serve as a role model?

Oh yes. For example, the Australian government has a soil health strategy which is fantastic. They have a national soil advocate, and that person sits in the Prime Minister's office. They are members of the Coalition and are big supporters. We showcase them to demonstrate to countries that it is possible to develop a soil health strategy, and what are the steps to get there. The European Union are putting soil in the forefront now, too. They released their soil strategy last year. It is also interesting to see that several African countries have signed on the Coalition early. They are aware of the urgency that land degradation is presenting. So I am actually quite positive here.

What are the next steps?

Well, getting more stakeholders involved is one. Anyone who wants to join us can sign a very simple support letter, and then they are included in the partners' meetings, the newsletter and the logo. The next step is getting the Soil Health Resolution through. 2022 is the year of the Conferences of Parties, and we want to make sure that soil is recognised in the UNFCCC. It is also already loosely in the CBD, and we had a huge success in the UNCCD with the final declaration, which includes the commitment to accelerate the restoration of one billion hectares of degraded land by 2030. Resource mobilisation is another step, so that we can have more interaction on the ground with farmers, which is critical. And then there is really showcasing how this public-private partnership can lead to transparent and equitable financing for farmers. The final step is getting some of these agreements on course that keep performance indicators for soil health agreed upon by all the stakeholders, including the private sector. I think that's where things are really getting interesting.

Interview: Silvia Richter

Leigh Ann Winowiecki is Soil and Land Health Global Research Lead at CIFOR-ICRAF, the merger of the Center for International Forestry Research and World Agroforesty. A soil scientist, her research focuses on scaling farmer-centred landscape restoration, understanding drivers of degradation and quantifying the impacts of land management on soil organic carbon. Leigh Ann co-leads the Coalition of Action 4 Soil Health (CA4SH). She is based in Nairobi, Kenya.
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Fernando Henrique Kohlmann Schwanke is Project Director of the Inter-American Institute for Cooperation on Agriculture (IICA). A qualified forestry engineer, he was Head of Department for Family Farming and Cooperatives at the Brazilian Ministry of Agriculture from 2019 to 2021. Fernando Schwanke grew up in Brazil as a son of German immigrants.
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Photo: Adriana Rodrigues

“We are helping family farms to adapt to climate change”

More than 40 per cent of soils in Latin America and the Caribbean are classified as degraded. Fernando Schwanke describes how the Inter-American Institute for Cooperation on Agriculture (IICA) is supporting governments at the interface of climate change and sustainable land use and the role of family farming in rural transformation.

Mr Schwanke, in late 2021, the international initiative “Living Soils of the Americas”, which is backed by the IICA, was officially launched. What does it incorporate?

“Living Soils of the Americas” was initiated in December 2020 by the IICA together with the Carbon Management and Sequestration Center, or C-MASC for short, of Ohio State University, USA. Its overarching goal is to enable recovering the quality of this natural resource in order to facilitate the transformation of our agricultural and food systems, taking the One Health Approach into consideration. World Food Prize Laureate Rattan Lal, who heads C-MASC and is assisting us with the programme, sums things up appropriately: restoring soil health is a crucial element of combating poverty, enhancing biodiversity and reducing greenhouse gas emissions, the cause of climate change. World-wide, more than a third of all soils are degraded to a certain extent. In Latin America and the Caribbean, this share has even reached more than 40 per cent. So restoring our soils is of fundamental importance to regional and global food security. And here, the multi-institutional initiative, in which both the public and the private sector are involved, is to help with concrete projects as well as awareness-raising regarding the problem of soil degradation.

What is the IICA doing in this area?

It is the IICA’s mission to promote rural development and the wellbeing of the rural population in Latin America and the Caribbean. Here, it has to be borne in mind that the Institute is governed by the Inter-American Board of Agriculture, which consists of the 34 associated governments. So our work is guided by the requirements of the ministers of agriculture in these countries and is closely linked to the governments there.

How does soil conservation figure in this context?

Soils are a key component of food and climate security and therefore also play a major role in IICA activities. Last year, we conducted a number of high-ranking events addressing this topic. In addition, we have compiled various publications with international contributions in which we demonstrate the impacts of introducing good agricultural practices on soil changes. This is very important in helping the countries to prepare and implement corresponding measures.

Another aspect of soil conservation and sustainable land use is that of globally boosting the position of Latin America and the Caribbean as one of the most important regions for producing and exporting food. After all, 30 per cent of all food exported comes from Latin America. Improving soil quality is also crucial to food and nutrition security world-wide. For example, countries such as Argentina and Brazil could raise their wheat production, which currently, with view to consequences of the pandemic and the war in Ukraine, would be of considerable importance. Moreover, soils rich in nutrients contribute to mitigating the harmful impacts of climate change. The IICA is very intensively working on this topic.

What exactly does this work look like?

In the context of our programme “Climate change, natural resources and risk management”, we have carried out numerous measures in close collaboration with the countries, ranging from promoting more active and more qualified participation of the agricultural sector, through publications, webinars, workshops and virtual training, consulting and guidance, supporting the preparation of proposals, to inter-departmental dialogues. In June, for example, the IICA supported a meeting of ministers in which a common standpoint of the ministers of agriculture of the Americas and the Caribbean for COP 27 was discussed.

And at field level?

What is exciting here is, for example, a project on Sustainable Rice Intensification in Ecuador which aims at enhancing productivity and resilience in rice cultivation through modified plant, soil, water and nutrient man-

agement while reducing the employment of external inputs. In the context of our climate programme, cattle farming and rice cultivation are of particular importance since these are the biggest sources of methane emission. In Mexico, for example, we are developing a low-emissions and sustainable livestock project with the aid of which greenhouse gas emissions are to be reduced by 28 per cent. This is intended to enhance the productivity and competitiveness of the livestock sector in the context of a value chain based on productivity, sustainability, inclusion and a territorial approach.

We are also developing a knowledge management approach supporting family farms in adapting to climate change. The aim here is to boost the capacity of family farm members in semi-arid areas and mountain range systems who currently bear only a low level of resilience to the impacts of climate change. This is meant to enable them to actively participate in the rural transformation processes in Latin America and the Caribbean – through the implementation of practices tailored to locations in regions with similar biophysical and socioeconomic conditions. Bolivia, Brazil, Colombia, Ecuador, Honduras, Guatemala, Mexico and the Dominican Republic are involved in this project.

Are there pioneering countries in the field of sustainable land use?

There are many tried-and-tested examples of sustainable land management in the region. Here, for example, systems featuring the integration of agricultural livestock and forest management can be referred to in Brazil. The catchword in this context is zero carbon beef. And then there is sustainable coffee growing in Central America, for instance in Costa Rica and Guatemala. Costa Rica's implementation of its policy on payment for ecosystem services is also very interesting for other countries. But there are numerous other examples as well.

Until recently, you were Head of Department for Family Farming and Cooperatives at Brazil's Ministry of Agriculture. How is the Ministry supporting family farms with regard to sustainable production?

First of all, it is important to point out that nearly 80 per cent of Brazilian farmers are family farmers. They manage 3.9 million farms and account for 30 per cent of Brazilian agricultural production, which boasts considerable diversity. It has become apparent that if these family farmers are integrated in a private enterprise or a cooperative, they are technologically far more advanced than farms which are not integrated, also regarding soil conservation. Moreover, cooperatives facilitate market access for smallholders. Production chains such as coffee, vegetables, fruit, milk, pork, poultry and tobacco are mainly maintained by family farms with very sustainable production methods.

> Restoring our soils is of fundamental importance to regional and global food security

Brazil supports family farms in three ways: through an extensive credit programme which awarded eight billion US dollars worth of credits for family farms at interest rates of between three and four per cent per annum in 2021, through technical support, which is especially important for non-integrated farmers, and through public policies for marketing which above all comprise buying food from family farms for the national school meals programme and the food procurement programme for poor households.

Are there special support programmes with a focus on sustainability issues?

This is starting now. For example, there is a certification scheme for integrated production supported by the Ministry of Agriculture. The tobacco sector has accepted this certification and implemented it among about 25,000 producers. We are also witnessing this development in the coffee sector, as well as in all other export crops. This is a result of pressure exerted by customers on the international markets, who have been calling for sustainable production. The internal market is not so sophisticated, so that the corresponding value chains have not yet reached such a level.

Which markets is Brazil mainly supplying?

Today, most of Brazil's products go to Asia, but Europe used to be our largest market. And it is still true that Europe sets the course, for example in terms of sustainability. This is what makes international exchange, for example with Germany's Ministry of Agriculture, so important in our work. In Brazil, for instance, enormous developments have become apparent over the last 20-30 years. I know people whose parents had a 30-hectare farm in the South of the country, where many immigrants have settled, and where I live too. Today, these farmers grow 80,000 hectares of soy in the Mato Grosso region. Now pressure is mounting to stop such trends.

You yourself are a forestry engineer. How has knowledge on sustainable land management changed since your studies?

I can still remember well that when I was studying in the 1980s, the rivers would become red when there was heavy rainfall because so much soil had been washed into them. The cultivation system was conventional. In other words, soil was ploughed and tilled several times, exposing it to rain, and hence to erosion. Since the 1990s, Brazil has drastically changed its mode of production, opting for no-tillage. This technology was pioneered by Herbert Bartz, a son of German immigrants who introduced it in 1972 on his 180-hectare farm. This figure was to rise to 35 million hectares by 2020. According to the Brazilian research corporation Embrapa, unprotected soil can lose up to 29 tonnes of its content per hectare and year. Just imagine Brazil not having introduced direct seed. Then the country would be losing a billion tonnes of soil each year.

Interview: Silvia Richter

About the IICA

The Inter-American Institute for Cooperation on Agriculture (IICA) was founded in 1942 and is seated in San José, Costa Rica. It is the specialised agency for agriculture of the Inter-American System and has 34 member states, 18 observer countries (including Germany) and one associated country (Spain). IICA fields of activity include technology and innovation for agriculture, agricultural health, food safety and quality, international agricultural trade, family farming, rural development, natural resource management and the bioeconomy.

Celso Moretti is President of the Brazilian Agricultural Research Corporation (Embrapa). He is an Alumnus of the Harvard School of Government and Associate Professor at the University of Florida, USA. Prior to working for Emprapa, Celso Moretti was Advisor to the United Nations Development Programme (UNDP) on China and the Inter-American Development Bank (IDB).

Photo: Jorge Duarte/ Embrapa

“Sustainable soil management can be adopted by any and all Brazilian producers”

In January 2020, Brazil's Ministry of Agriculture presented guidelines for the sustainable development of its agriculture. In addition to "land governance and environmental compliance", they refer to "innovation and sustainable production" as a guiding theme. The role which strategies and technologies developed by the Brazilian Agricultural Research Corporation (Embrapa) play in this context is described by its President, Celso Moretti.

Mr Moretti, in Brazil, more than 80 million hectares are affected by soil degradation. What are the main reasons?

According to the United Nations Food and Agriculture Organization's Report published in 2015, soil degradation is affecting at least 33 per cent of the world's soils. Thanks to its continental dimension and great diversity of environments, Brazil has a considerable variety of soils, climate, relief and vegetation. So it is normal to find areas that are more susceptible to – and affected by – degradation than others, for a wide range of reasons. First, there are the natural conditions, when soils naturally have a greater susceptibility to degradation, which is the case with areas degraded by desertification processes and degraded areas suffering from the formation of sandy patches. Both conditions may be aggravated by inadequate land use and land management. This may be too intensive land use exceeding the agricultural production potential, as well as overgrazing, usually caused by cattle, in particular in places with high susceptibility to water erosion. A further reason is physical soil degradation due to the intense transit of heavy agricultural machinery, intense revolving of soil and soil exposure, leading to soil compaction and reduction of soil carbon stock, reduction of biological activity and loss of soil and nutrients by erosive processes.

What is being done to counter these processes? Und what is Embrapa's role here?

At policy level, the Brazilian Forest Code of 2012 can be referred to, which governs the protection of native vegetation in areas of permanent preservation and legally prescribed reserves. The aim is to reconcile agricultural production with conservation. In this New Forest Code, the Rural Environmental Register (CAR) and the Environmental Conformity Programme (PRA) were established. The institutionalisation of the Brazilian Soil Survey Program – PronaSolos – in June 2018 is a further example. Embrapa offers planning tools, such as Climatic Risk Agricultural Zoning and the PronaSolos Technology Platform. Another recent contribution to public policies was made with the formulation of the National Fertilizer Plan, launched this year by the Federal Government, providing the technological basis of the plan's design. Our research also allowed the Ministry of Agriculture, Livestock and Food Supply, MAPA, the proposition of the Low Carbon Agriculture Plan (ABC Plan) and its current version, the ABC+ Plan, which, among others, uses practices and techniques that enable the recovery of degraded pastures, planted forests and the treatment of animal waste. It also includes metrics for verifying and proving expansion in the adoption of these mitigation technologies, based on sustainable soil and water management and their efficiency in mitigating greenhouse gas emissions, on the path of decarbonisation and adaptation of Brazilian agriculture to climate change.

Let's briefly get back to the Soil Survey Program you mentioned – what exactly does it incorporate?

PronaSolos is the largest research programme on Brazilian soil. Initiated in 2015, the programme is to establish a network of research, development and innovation to expand national and competitive capacity in science and technology and to generate and improve knowledge and technologies related to the survey of soils and their use on scales of at least 1:100,000, with the aim of making it compatible with state, municipal and watershed rural planning, in order to ensure Brazil's sustainable agro-environmental development. The Programme covers the entire national territory and encompasses all soil classes and their variations. The focus is to expand knowledge of Brazilian soils, both in territorial extension and in detailed scales. Regional specificities and those specificities concerning Brazil's six biomes will also be addressed, as well as the training of new soil scientists.

How is the Program organised?

Today, six Ministries and the Office of Institutional Security of Presidency of the Republic and its subsidiaries form the governance structure. In addition, it has around 40 institutions and public agencies as partners. The project's executing team has researchers and technicians from all over the country, representing the national institutions participating in the project with expertise in soil sciences, geomatics, spatial modelling, land use and management, ecosystem services, geological and environmental resources, database, teaching, rural research and extension, statistics and artificial intelligence. The team also has specialists and reference technicians in pedology, analytical chemistry, spectroscopy, quality management, soil physics and other related disciplines.

This sounds like a multidisciplinary approach. Is it a general characteristic of Embrapa's activities?

Embrapa maintains 34 project portfolios, 93 genetic improvement programmes and international scientific cooperation actions through Labex United States, Embrapa's Virtual Laboratory Abroad, and Europe's agencies. The scope of our research is focused on the multifunctionality of the agricultural landscape. For this purpose, Embrapa built up a network linking several researchers in the different national biomes, creating the Environmental Services Portfolio in 2018. This portfolio integrates Embrapa's research, development and innovation actions with the productive sector and with public policies, aiming to generate and disseminate innovative solutions to enable the sustainability of agricultural and forestry production systems in line with the provision of ecosystem services in Brazilian biomes.

Examples of practices that Embrapa recommends for soil protection and rehabilitation include minimal cultivation, no-tillage, green and cover fertilisation, reduction of grazing pressure, organic agriculture, suppression of deforestation, management of cultural remains, agroforestry systems and integrated crop-livestock-forestry, among others. All these good agricultural practices tend to generate environmental support and regulatory services, such as increased nutrient cycling and water infiltration in soil and erosion control, as well as increased carbon stock and greenhouse gas reduction.

How does your research knowledge reach the farmers?

We cooperate closely with the Ministry of Agriculture, Livestock and Food Supply as well as other ministries providing technical-scientific knowledge learnt by our researchers and associated institutions so that farmers and rural entrepreneurs have access to this knowledge. The knowledge imparted to farmers on sustainable land management includes mechanical practices, such as terraced and contour cultivation, draining channels, vicinal roads, bus, dams, underground dams, etc. and vegetative practices, such as strip crops, soil cover, green fertilisation and crop rotation, etc. Good agricultural practices which are disseminated include biological nitrogen fixation and the use of bioinputs which have been developed at Embrapa, slow-release organo-mineral fertilisers, traffic control and mitigation of soil compaction, integrated management of pests, diseases and invasive plants, reforestation of recognised fragile areas such as riparian forest, declivious areas and ressurgence areas. The No-Tillage System or NTS that is today applied on 35 million hectares in Brazil brings together mechanical and vegetative practices, meeting three basic principles – no soil disturbance, permanent soil cover through using species dedicated to straw formation and rooting in the soil, and the multiannual rotation of annual crops, forage and forestry. Also noteworthy are the systems derived from the NTS, which are the integrated systems – agroforestry systems and crop-livestock-forestry integration systems, which can be adopted in all types, area sizes and activities, without environmental degradation. This implies the maintenance of both soil health and quality, the water resources involved and biodiversity.

In the context of the National Fertilizer Plan, the Embrapa FertBrasil Caravan is visiting the main agricultural regions of Brazil with researchers and experts to bring to the rural producer technologies and knowledge in order to increase the efficiency of fertiliser use, emphasise the importance of sustainable soil management and improve productivity.

And how are the technologies received by the farmers?

It is essential to regard Brazil as a continental and highly diverse territory, considering the peculiarities of each of its six biomes, not to mention regional characteristics and access to information and technical assistance. These factors alone already reveal part of the challenge that represents ensuring the adoption of sustainable land management methods. No-tillage, integrated crop-livestock-forestry systems, biological nitrogen fixation and planning tools such as the Climatic Risk Agricultural Zoning are some of the deliveries that have resonated. According to the 2021 Social Report, alone the biological nitrogen fixation in soybeans, adopted in more than 38.5 million hectares, accounted for savings of more than 36 billion Brazilian real for producers. During the period, Embrapa's solutions developed for soil management were adopted in more than 97.6 million hectares.

And are there differences in the approaches elaborated for small-scale and large-scale farms?

Indeed, the best practices for the care and sustainable management of soils are the same, regardless of the size of the property. Embrapa's research and innovation are not different for these two audiences and are accessible to all producers, but purchasing power can be decisive in the adoption of certain higher cost practices, regarding aspects such as technological level and producer investment capacity, etc., as well as in the type of crop and breeding chosen, weather it be crop, forest species or, livestock. Sustainable soil management can be adopted by any and all Brazilian producers. Access to rural credit and knowledge can, however, be a differential in the adoption of these practices.

What do you regard as the greatest asset of science?

The outlook for the future is uncertain regarding hunger in the world, so the role of science in raising productivity becomes even more preponderant. And science enables us to ensure that we no longer need to cut down trees to maintain food production with sustainability. Research regarding the crop livestock-forest integration system that supports the carbon neutral beef concept, research to reduce emissions in the pig and poultry chain that allows differentiating the difficulties of emission control in the production, processing and distributing networks of meat, and land-saving technologies, focused on the search for increased productivity, such as soybean, corn and cotton production systems are pioneering examples of this.

Interview: Silvia Richter

About Embrapa

The Brazilian Agricultural Research Corporation (Embrapa) was established in 1973 by the Brazilian Ministry of Agriculture, Livestock and Food Supply (MAPA) to develop the technological foundations for a genuinely tropical model of agriculture and animal farming. The corporation currently employs over 8,200 people, of whom more than 2,200 are scientists.

How investing in soil-related inputs and services pays off

Numerous techniques, practices and concepts for soil protection and rehabilitation are being tried and tested globally. Using the project "Soil protection and rehabilitation for food security" as an example, our authors demonstrate what counts in enabling such approaches to unfold impact at scale.

By David Kersting, Stephanie Katsir and Julia Doldt

Agroecological means of production prioritising the utilisation of locally available resources to replenish nutrients, improve soil structure and enhance below-ground biodiversity are paramount for sustainable agricultural productivity. Healthy soils allow for a higher fertiliser-use efficiency, hence lowering the costs for farmers and the economy. The project "Soil protection and rehabilitation for food security" (ProSoil; see Box) run by Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) fosters different approaches to sustainable soil management in Benin, Burkina Faso, Ethiopia, Kenya, Madagascar, Tunisia and India. The aim is to improve the food situation of smallholders and to open up new sources of income. In the following, some examples and lessons learnt are presented.

Many ways to create healthy soils

Vermiculture as an alternative or complement to mineral fertiliser

In Western Kenya, maize is the main staple crop. It is usually grown by smallholder farmers using a sequence of diammonium phosphate and calcium ammonium nitrate. Both fertilisers are also applied when cultivating sugar cane and tea, which are the most common cash crops in the region. However, their continuous application, in combination with leaching of soil organic matter, has led to soil acidification. In such cases, mineral fertilisers have lost much of their effectiveness, and farmers tend to produce at a loss – even more so since fertiliser prices in Western Kenya have doubled over the past year, reaching a point where agro-dealers even shy away from procuring a product which most of their customers cannot afford.

In such a scenario, compost production using earthworms has proven to be a viable alternative. Earthworms significantly decrease the time frame required to produce quality compost and generate a liquid by-product that can be used as biofertiliser. In the maize-growing systems of Western Kenya, the application of compost at planting and of the liquid biofertiliser at the growing stage proved highly effective in replacing the conventional mineral fertiliser sequence. The biomass required for compost production is usually generated from green manure cover crops, agroforestry trees and shrubs as well as purchases from neighbouring farms. This way, smallholders in Western Kenya can cushion themselves against volatile input prices and similar shocks to their livelihood systems.

Demand creates supply – lime as a game changer

A total of 3.5 million hectares of Ethiopian soils is acidified. Lime can alleviate this type of soil degradation and increase fertiliser use efficiency but has been largely unknown in Ethiopia. Farmer-led trials and capacity development have created awareness and demand among farmers and the development of different supply chains with varying degrees of public and private sector involvement. Currently, specific intervention areas are trialling the sales of lime via private agro-dealers, with local government agents facilitating the process. Additionally, the Ethiopian government distributes lime sourced mainly from cement factories at a subsidised price. Completely government-run supply systems are slowly receding as crushers have often proven inefficient and produced beyond market price. The government has also decreed that no-one should distribute lime for free in order to wean farmers off dependencies and encourage the development of sustainable supply chains. To achieve impact at scale, this is supported by the introduction of lime spreaders, soil pH testing, policy advice on tax reductions and the involvement of micro-finance institutions.

Urban compost – from recyclable waste to a profitable soil enhancer

In India, more than 54 million metric tons of municipal solid waste is generated each year, 50 per cent of which is organic. Without treatment, organic waste, containing valuable nutrients and carbon originating in agricultural fields, accumulates in urban environments where it produces harmful greenhouse gas emissions from landfills. There is a potential to recycle urban organic waste into compost and other soil enhancing products to return nutrients and carbon to rural agricultural soils to counteract degradation. This has resulted in a viable business model for the public and private sector in the State of Maharashtra in western India, which has turned out to be a triple-win contributing to economic gains, the national land degradation neutrality targets and climate goals.

Piloted from 2019 to 2021 in selected cities near the programme locations, the "Urban Rural Nutrient and Carbon Cycle" (URNCC) is a multi-sectoral and multi-stakeholder circular economy scheme practicing an end-to-end approach addressing supply chain, institutional and policy gaps by supporting research, capacity development, product branding and the establishment of market linkages using digital solutions. The state government provides subsidies as incentives for the production and sale of certified compost, while compost producers organised in farmer producer organisations (FPOs) work together with selected villages and farmers to establish demonstration plots to showcase city compost application on various crops. The key element is a specially developed digital marketing platform called "Harit Ticker". "Harit" means "green" in Sanskrit. Currently, 30 FPOs with a potential of around 10,300 farmers, and 396 municipal compost producers (100 per cent in the State of Maharashtra) are registered on the digital marketing platform. In Maharashtra alone, there is a

ProSoil

The programme ProSoil is part of Germany's special initiative "One World – No Hunger". It is co-funded by the European Union and the Bill & Melinda Gates Foundation. In addition to small farming businesses and the relevant state institution players from the academic and research communities, the private sector and civil society are involved. Since the beginning of the programme in 2014, soil degradation has been reversed on 500,000 hectares of land, resulting in an average yield increment of 40 per cent.

potential to produce 350,000 metric tons of city compost each year, representing a business potential of around 20 to 25 million euros for compost producers.

Key principles for effective advisory services

Much agronomic evidence has been generated around soil management concepts and practices. Yet, these may still seem novel in a certain context, causing land users to at first be hesitant to adopt them. Especially in smallholder farming, with its widely differing realities, "one-size-fits-all solutions" do not exist. Nonetheless, experience from ProSoil suggests that it makes sense to employ the following key principles when providing agricultural advice to smallholder farmers:

Start with quick wins. Immediate returns within the first growing period encourage the adoption of new practices and prepare the ground for long-term investments. Soil protection certainly is an investment in the future, making it all the more important for promoted technologies to yield visible impacts. Agricultural advisors can then build trust among farmers, and farmers can satisfy immediate needs regarding food security and income before investing in long-term solutions.

Seeing is believing. Realistic demonstrations are key to convincing farmers and encouraging transfer of knowledge among them. Smallholder farmers are highly risk-averse and hence often reluctant to adopt new technologies. It is therefore of utmost importance that demonstrations take place in the vicinity of the farmers concerned instead of at peri-urban research stations. Multiple new practices are introduced at once to have a combined effect. Through comparative demonstrations along with studies, increased yields, improved quality of the produced crops and a higher net profit compared to the farmers' practice become more apparent when a whole new set of improved practices is applied during the first season.

Feed the soil, not the plant. A holistic understanding of the soil ecosystem enables farmers to discover soil health aspects beyond nutrient replenishment. The importance of soil organic matter and soil biota often remains underestimated. In some instances, grasping the soil topic in its totality can be achieved by linking it to human nutrition in narratives. An acidic stomach needs treatment, and so does acidic soil, for instance applying lime. In addition, so-called Soil Health Cards in conjunction with providing access to local soil testing facilities allow for a better understanding of critical soil parameters and macronutrient status. Along with this information, farmers receive recommendations on suitable practises such as recycling of on-farm organics, organic manures and bio-fertilisers in conjunction with reduced chemical fertilisers.

In Kenya, vermicompost is for example used in horticulture.

Photo: GIZ/ Goudian

A lime crusher. The Ethiopian government distributes lime at a subsidised price.

Photo: GIZ/ Abinet Shiferaw

In Maharasthra, urban organic waste is recycled to compost and other soil enhancing products.

Photo: GIZ/ Ronny Sen

Make local knowledge count. Agricultural advice considering local conditions and expertise is most effective. Farmers are not only recipients of trainings but innovators and a testing authority for the project assumptions; they make their own decisions and adopt, adapt and reject technologies based on what is suitable under the natural and socio-economic conditions of a given location. Project monitoring and knowledge management systems need to capture such lessons learned. In the long term, the necessary improvement of science-extension-farmer interaction requires time and financial investments – especially in the context of soil rehabilitation.

Public and private sector investment in equal demand

Healthy soils support ecosystem services such as carbon sequestration and water retention, which benefit society as a whole. Hence, much emphasis in land management programmes is placed on strengthening the public sector's capacities and resources. Its commitment is of particular importance where the merits of sustainable soil and land management to society outweigh the immediate benefits for individual farmers (e.g. erosion control). Soil amendments fast-tracking the improvement of soil health, on the other hand, often entail a business case and thus qualify for private sector engagement. As the examples show, both sectors contribute to import substitution, domestic employment creation and food security. Against this background, increasing awareness and ownership for soil health among both private sector investors and political decision-makers is equally important. Determined efforts to reclaim and conserve soils world-wide are necessary to acknowledge their key role in food production, agriculture's adaptation to climate change and carbon sequestration.

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Jochen Flasbarth is State Secretary in Germany's Federal Ministry for Economic Cooperation and Development (BMZ). He was previously State Secretary at the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety, President of the German Environment Agency and President of the Nature and Biodiversity Conservation Union (NABU).

Photo: BPA/ Steffen Kugler

"Preserving and restoring fertile soils is a global responsibility"

Healthy, productive soils are a prerequisite for global food security – one of the priorities of German development cooperation. State Secretary Jochen Flasbarth on Germany's efforts to support sustainable land management, the results of UNCCD COP 15 and why the Voluntary Guidelines on the Responsible Governance of Tenure of Land are more important than ever today.

Mr Flasbarth, climate and environmental politics has been a focal aspect of your entire career. Do you have the impression that the perspective of the role which soils and sustainable land use play in these closely linked policy areas has changed in the course of time?

It is perhaps not so much the way we view their role that has changed, but rather that the individual Rio Conventions have become more inclusive and integrative. The United Nations Convention to Combat Desertification is the only binding agreement on sustainable land management. So it needs to have an equal role in the interaction with its sister conventions on climate change and biodiversity. The UNCCD unites environmental and development agendas through a common denominator: sustainable land management for the benefit of all. None of the climate and biodiversity targets will be achieved without sustainable land management. Land and soil are the central foundation for food, development and prosperity. Preserving and restoring fertile soils is also a global responsibility. Today, almost everywhere on the planet, land is becoming a scarce commodity, and competition for it is creating source of conflicts. Land degradation causes immense costs for our society and for future generations that we can ill afford. With Sustainable Development Goal 15, the international community and the UNCCD want to work explicitly towards halting the global loss of healthy land by 2030. That brings us full circle to the other conventions.

So soils are receiving the attention they deserve in today's international politics?

Soil-based production accounts for over 95 per cent of our food – making it crucial to providing food for a growing world population. At the same time, a third of the world's land area is already significantly degraded. This directly affects 3.2 billion people, especially rural communities, small farmers and the very poor. Awareness of this nexus is growing, but action must quickly follow. We need binding agreements, and above all, a commitment to create enabling conditions for sustainable and efficient farming.

What is Germany doing to achieve this?

For more than ten years, Germany has been supporting awareness-raising among decision-makers through the Economics of Land Degradation Initiative, which provides the economic arguments for harmonising national agricultural and environmental agendas. And through the partnership Group on Earth Observations, Germany helps support governments in identifying land degradation and making decisions for inclusive land use planning. German development policy priorities are guided by three core concerns: First,

Ethiopia is one of the African countries in which German development cooperation is supporting soil rehabilitation.

Photo: GIZ/ Michael Martin

crisis management, especially combating climate change and beating the Covid-19 pandemic, and tackling their consequences. Second, fighting the crisis of hunger and poverty. If soils get degraded and fertile land is lost, people also lose their livelihoods. Leaving no-one behind means investing in sustainable agriculture which protects the land, feeds more people, provides jobs and is resilient to the growing number of adverse weather conditions. This involves promoting healthy soils and functioning ecosystems as an important development policy approach. The third concern is promoting a feminist development policy, in which gender justice is a strong lever for land degradation neutrality. Secure access to land is a source of women's empowerment, and secure land tenure rights create incentives for better long-term land management.

How is Germany influencing the international agenda in this area?

Germany is one of the UNCCD's strongest supporters – not only as a strategic partner, major contributor and host of the UNCCD Secretariat in Bonn, but also through a strong portfolio of UNCCD implementation activities aimed at achieving land degradation neutrality. The UNCCD is often spoken of as a desert convention. However, it is about much more than deserts. It is in fact a convention on sustainable land management, and it is about protecting the state of our soils and ecosystems world-wide, including in Germany. And as part of its G7 presidency, Germany is currently forging a new global alliance for food security in which soil protection and rehabilitation also play an important role.

And at project level?

We are currently engaged in more than 200 projects with our partner countries and we are working, for example, with communities in Africa to help them protect their land from erosion and preserve soil fertility. With our projects, we are promoting sustainable land use in many countries through very practical measures: erosion control, planting trees, using compost and other means to improve the soil, and also creating better enabling environments for sustainable land management. Through the "One World – No Hunger" initiative, more than half a million hectares of land have been rehabilitated in six African countries and in India, and one million people have benefited from yields increasing by an average of 40 per cent and from rising incomes. Even more importantly, seeing that degradation can be reversed convinces farmers and local and national decision-makers to work together to generate more food and income for a better future.

At UNCCD COP 15, 38 resolutions were adopted on the future of land use. What are the most important ones, in your opinion?

Sustainable land management and the restoration of degraded land are the main answers to the triple crisis of climate change, biodiversity loss and land degradation, as land is at the heart of achieving many of the SDGs – and the conference responded to this. For me, three aspects are central here. First, acknowledging that secure land tenure rights are the basis for sustainable land management. Second, exploiting synergies, i.e. bringing together what belongs together. International agreements on climate change, biodiversity, wetland protection and disaster risk reduction all stress sustainable land management and ecosystem restoration and conservation. Their implementation requires coordination in the countries concerned, but also better international anchoring. When talking about efficient implementation in this context, for example reducing institutional barriers and disincentives, we cannot ignore joint planning, implementation and monitoring. The third central aspect is the awareness that sustainable land management makes agriculture more resilient to drought. Germany is committed to internationally coordinated and proactive drought risk management with the framework of the UNCCD. This means coordinating with partners on action at all levels to ensure that healthy soils and ecosystems work for mitigation and adaptation to climate change. Furthermore, progress towards more sustainable land management requires the involvement of civil society organisations. They have been strengthened by the COP.

So you are satisfied with the outcome of COP 15?

We have made important progress on the question of how to make agriculture sustainable worldwide in order to tackle the food crisis, climate change and biodiversity conservation. There is certainly always room for more ambition, but everything must be done by consensus in the UN arena. A lot of coordination work is required at the negotiating table with almost 200 parties involved under the Rio Conventions, all of which have different structures and do not always share ideas. But for the first time we have managed to anchor the concept of Nature-based solutions in the negotiation process, laying the foundation for future biodiversity negotiations. The ball is now in the court of the Biodiversity Convention, and it is up to the individual signatory states to implement the decisions. We in Germany must also become much more sustainable, as we are not only one of the drivers of climate change but have also suffered from its consequences in recent years.

This year, the Voluntary Guidelines on the Responsible Governance of Tenure of Land are celebrating their tenth anniversary. Are they a success story?

Yes, the VGGT are a success story, and Germany supports their implementation under the UNCCD. Secure land rights are the basis for healthy soils. Farmers will only invest in land if they have legal security. Only when parties take legitimate land tenure rights into account and resolve land use conflicts is land degradation neutrality possible, effective and profitable for those concerned, such as smallholder farmers. There can be no land degradation neutrality without secure land tenure. It is worth noting that the Guidelines came into being in the context of the food crisis in 2008 in response to ever more widespread land grabbing. The Committee on World Food Security has followed up on them, and in the current crisis, they are more relevant than ever. That is why I consider it a great step forward that the Guidelines have now been included in the UNCCD decisions for achieving land degradation neutrality.

With Russia's invasion of Ukraine and fears of a new food crisis, the discussion over conflicting aims in land use is set to gain momentum again. Is this going to affect BMZ policies addressing land use issues?

The challenges of population growth, declining biodiversity and ecosystem services, and climate change require a fundamental rethinking of our current food systems. To achieve this, we are advocating for an end to using land for agrofuels, and for more transparency and sustainability in global supply chains, and we are raising awareness about consumption patterns, as high meat consumption, for example, puts a strain on the land, above all because of global feed production. This way, consumers can consciously make sustainable purchasing decisions that also bring benefits for the soil and for the livelihoods of farmers around the world.

Interview: Silvia Richter

Full-length interview: **www.rural21.com**

Building land and drought resilience – UNCCD's work

Land is our lifeline on this planet. Yet "business as usual" in how we manage land resources puts our own future on planet Earth in jeopardy, with half of humanity already facing the impacts of land degradation. The United Nations Convention to Combat Desertification (UNCCD) has addressed desertification, land degradation and drought for the last 30 years. Here is a short overview of topics it has recently focused on.

By Xenya Scanlon, Jeroen Van Dalen and Wagaki Wischnewski

When camels, which typically survive longer on a lot less water and food than people, are dying in large numbers, you know the situation is desperate. This is exactly what is now happening in the Horn of Africa. This is the fourth year without rains in the region. Millions of people, especially children, are on the brink of starvation. Five years ago, a similar drought in Southern Africa affected 20 million people. Early this year, Chile marked a record-breaking 13th year of drought. And the two-decade drought in the United States of America is now considered the country's driest period in over 1,200 years.

Making ecosystems and people resilient to drought is of utmost importance for the survival of humankind.

Photos: UNCCD

Shifting from reactive to proactive drought management

Droughts have always been a part of nature and the human experience but are now much worse, largely due to human activity. The frequency of droughts has risen by up to 29 per cent since 2000, with 55 million people affected each year. The devastating consequences are not confined to drought-stricken areas but reverberate around the globe, putting stress on food security, water and energy systems, as well as on international borders. According to the *Drought in Numbers 2022* report released at the 15th session of the Conference of the Parties to the United Nations Convention to Combat Desertification (UNCCD COP 15) in May, by 2050, droughts may affect an estimated three-quarters of the world's population. Making ecosystems and people resilient to drought is therefore of utmost importance for the survival of humankind and is also the core of UNCCD's work.

Some examples: At COP 13 in Ordos, China, UNCCD Parties set up the Drought Initiative on the premise that the impact of a drought is not determined solely by its severity. The ability of communities and countries to anticipate and prepare for it also matters. The Drought Initiative promotes a shift in drought management from a reactive and crisis-based mode to a proactive approach. Rooted in a green recovery, it prioritises prevention and preparedness. It is focused on setting up drought preparedness systems, particularly national drought plans, regional cooperation to reduce drought vulnerability and risk, and sharing tools that stakeholders can use to boost the drought resilience of both people and ecosystems. To date, the Global Mechanism, which was established as the operational arm of the UNCCD, has supported over 70 countries in developing and implementing targeted national drought plans focused on preparedness, response and resilience. The Global Mechanism provides advisory services in the context of the Drought Initiative and works with countries and global partners to mobilise resources. Through the UNCCD Drought Toolbox (see top Box), people and communities anywhere in the world can assess their drought vulnerability and access practical tools to mitigate drought risk.

At UNCCD COP 15 in May of this year, too, drought resilience was a top agenda item. Countries agreed on a set of actions to address this increasingly urgent and global issue. Specifically, they established an Intergovernmental Working Group for 2022–2024 to evaluate all options for the Convention (see bottom Box) to support a shift from reactive to proactive drought management. For instance, they have set themselves the goal of identifying new areas that could turn into drylands, improve early warning, monitoring and assessment, share knowledge, coordinate action, and mobilise drought finance. The Desertification and Drought Day marked world-wide on the 17th June was a good opportunity to make people aware of the new drought resilience agenda.

Towards land degradation neutrality

Land degradation often exacerbates the impacts of drought, with disastrous outcomes for people and nature. According to the second edition of UNCCD's *Global Land Outlook*, released in April 2022, up to 40 per cent of land is already degraded – meaning its benefits have been lost to varying degrees, with dire

The Drought Toolbox

The UNCCD-led Drought Toolbox provides easy access to tools, case studies and other resources for stakeholders to design National Drought Policy Plans to boost the resilience of people and ecosystems to drought. It is developed jointly by a broad range of partners, including UN agencies and scientific institutions. A large number of tools are organised in three pillars:

Pillar 1: Monitoring and early warning. The focus here is data, both from the ground and through remote sensing, to better understand how and when droughts develop.
Pillar 2: Drought vulnerability and risk assessment. This pillar provides insight into the risks of drought because some areas, populations and economic activities are more vulnerable than others.
Pillar 3: Drought Risk Mitigation Measures. This pillar looks at what measures, including sustainable land management, can be applied to mitigate the risks identified.

consequences for our environment, economies and societies. At current rates, 90 per cent of land will bear our imprint by 2050, resulting in the further degradation of 16 million square kilometres – an area almost the size of South America. The impacts of land degradation will be felt by most of the world's population and often results in social and political instability, which drives poverty, conflict and migration. By regenerating soil and ecosystems and reducing the human toll on land, we can build a natural barrier against the perils of drought.

With the aim to achieve a state of no net loss of healthy and productive land, at COP 12 in Ankara, Turkey, in October 2015, UNCCD country Parties agreed on the land degradation neutrality (LDN) concept. The concept has been developed to encourage the implementation of an optimal mix of measures designed to avoid, reduce and/ or reverse land degradation. LDN aims to balance anticipated losses in land-based natural capital and associated ecosystem functions and services with measures that produce alternative gains through approaches such as land restoration and sustainable land management. At COP 12, the Parties decided to formulate voluntary targets for LDN to ensure by 2030 that any land degradation is matched by land restoration. That same year, LDN was enshrined in the Sustainable Development Goals (Goal 15.3). The LDN Target Setting Programme was created to enable countries to follow a structured process that leverages, assesses and measures the achievement of their LDN commitments. Currently, 125 countries have set (or are in the process of setting) voluntary targets to achieve LDN, protect and restore land resources, build resilience of land-dependent communities and promote responsible land governance. Sharing lessons learned and policy-relevant knowledge is an important pillar of this process.

By identifying shared visions, proven solutions, priority hotspots and monitoring baselines, countries have already shaped a new data-driven approach to tackling land degradation. The international community has so far pledged to restore one billion hectares of degraded land by 2030. Half of these pledges come from UNCCD Parties. The UNCCD's Global Mechanism assists countries to reach their ambitions to achieve LDN and hopefully go beyond by generating new healthy land.

Science and knowledge for transformative action

Science and knowledge have always guided UNCCD's work through mechanisms set up to develop and share scientific evidence around sustainable land management and its role in addressing land degradation and drought. The UNCCD Science-Policy Interface was added in 2013 to translate relevant scientific findings and assessments into policy-relevant recommendations, such as the conceptual framework for LDN published in 2016. It is the foundation for understanding, implementing and monitoring LDN, including its response hierarchy of avoiding, reducing and reversing land degradation. The report guides the activities of the LDN Target Setting Programme and the achievement of LDN. Countries share best practices and stories of sustainable land management through various channels. For example, the report *Restoring Life to the Land*, published in 2021 by UNCCD and the World Overview of Conservation Approaches and Technologies (WOCAT), shows how sustainable land management ties into the UN Decade on Ecosystem Restoration 2021–2030 (see also page 24). Drawing from a global database of over 2,000 projects, it underscores the role of sustainable land management in creating thriving ecosystems and generating economic benefits.

Many proven ways are available to restore land and reduce drought risks. The ongoing UN Decade must be one of transformative action, pulling together governments, scientists, policy-makers, the private sector and communities, to achieve our shared vision of a land degradation-neutral world and rise up from drought together.

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About UNCCD

The United Nations Convention to Combat Desertification (UNCCD) is one of the three global treaties – along with climate change and biodiversity – that emerged from the Rio Earth Summit 30 years ago. As the only legally binding framework that addresses desertification, land degradation and drought, UNCCD is the global voice for land. It rallies governments, scientists, policy-makers, the private sector and communities around a shared vision to restore and manage the world's land.

The Convention is made up of 197 Parties (196 countries and the European Union) that collaborate based on the principles of participation, partnership and decentralisation. The work is organised around ten-year strategic frameworks, and supported through UNCCD institutions, partners and other relevant stakeholders. The parties meet every two years at the Conference of the Parties (COP) to agree on the actions to take at national or sub-regional levels and review progress in implementing past decisions. The most recent, COP 15, was held in May 2022, in Abidjan, Côte d'Ivoire.

WOCAT – spreading sustainable land management world-wide

The World Overview of Conservation Approaches and Technologies – WOCAT – has been promoting sustainable land management (SLM) for nearly three decades. A global database was set up in 1995, underpinned by a standardised reporting format and quality assurance. WOCAT's network has flourished, and evidence-based decision-making is boosting uptake of SLM across the world.

By Nicole Harari, Rima Mekdaschi Studer and William Critchley

The United Nations Convention to Combat Desertification (UNCCD) was established in 1994, and the problem was clear: how can we put a halt to land degradation? WOCAT took on that challenge with its mandate to uncover success in sustainable land management (SLM) and bring together like-minded people in a global network. Over the years, WOCAT's Global SLM Database has grown to nearly 2,200 entries from over 130 countries. The database holds a vast and detailed resource of "how-to-do". What's more, it is recognised by the UNCCD as the primary global database for the reporting of SLM. This constitutes a formidable toolbox, helping to achieve Land Degradation Neutrality – a concept enshrined in the sustainable development goals (SDG 15.3). It's no exaggeration to say that the database already houses the majority of the ways and means to achieve this goal. Around 850 of the database entries relate directly to soil management. The majority of these are grouped either as "improvements in cover" (by vegetation or mulch), or "cross-slope measures" (e.g. terraces and contour grass strips).

When the UN Decade on Ecosystem Restoration was launched in 2021, WOCAT came together with the UNCCD to show what role SLM could play. The publication *Restoring Life to the Land* demonstrated that already documented SLM practices could contribute to each of the eight ecosystems: from tillage practices in farmlands to community management of forests, from rehabilitation of rangelands to agroforestry on mountain slopes, from wastewater management in freshwater systems to preventing drainage of peatlands, from creating green spaces in urban areas to adopting a "ridge-to-reef" approach to protect the coast.

As SLM has been gradually documented from around the world, so has our understanding of its multiple benefits. It has moved a long distance from simply "saving the soil" under its original name of "soil conservation". Sustainable land management embraces environmental welfare and human prosperity. Restoring health to the land helps to achieve these goals through its multiple co-benefits. Thus, SLM assists in climate change mitigation by building up carbon in the soil and vegetation, and it strengthens climate change adaptation by making land use systems more robust. Through focusing on biodiversity, it fortifies ecosystem function. Better soil structure and vegetation cover improve hydrological function. Most of all, SLM has been shown to directly benefit people and their livelihoods by making the land more productive.

Bio-digested cow manure is used as an organic fertiliser for the cultivation of crops. It is thoroughly decomposed, does not smell and contains no living weed seeds, fungi or viruses. The slurry-rich organic matter provides a rich source of plant nutrients.

Photo: Royal University of Agriculture (RUA)/ Kim Soben

Apiculture is a non-problematic enterprise promoted by small-scale farmers who are supported by extension agents. Modern beehives are installed to conserve the environment, provide honey and diversify income.

Photo: Uganda Landcare Network

To illustrate how WOCAT can work in the field, here is a recent example from a three-year collaboration with the International Fund for Agricultural Development (IFAD). WOCAT methodology was piloted to show how SLM could be uncovered, selected and spread in Cambodia, Laos and Uganda. The methodology was based on WOCAT's strategy of "proof" (building up a knowledge base), "priority" (decision-support) and "pull" (creating conditions for scaling-up). Smallholder's clear priorities – especially women's – were practices that led to improved yields and economic gain. Thus, conventional engineering solutions such as terraces or cross-slope barriers were rarely chosen for upscaling. Most attention was given to practices that involved affordable ways of, for example, improving soil fertility, increasing water availability to plants and diversifying sources of income. Case studies from Cambodia and Uganda illustrate these choices.

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WOCAT is helping to put sustainable land management on the global agenda through its global network.
More information: www.wocat.net

Highlighting the true value of land

Since 2011, the Economics of Land Degradation (ELD) initiative has been making the economic case for investing in sustainable land management to prevent and restore soil degradation around the world. For one thing is certain: preserving and restoring land pays off.

By Nina Bisom, Richard Thomas, Naomi Stewart and Hanna Albrecht

Almost a quarter of the world's land area has been degraded over the past 50 years. The resulting damage in terms of lost ecosystem goods and services is estimated to cost the world 6.3 trillion US dollars (USD) per year – equivalent to 8.3 per cent of global GDP in 2016 according to the World Resources Institute. Numerous economic analyses so far have shown that preserving and restoring land pays off. For instance, according to the authors of the *Global Land Outlook 2* from 2022, every dollar invested in restoring degraded land results in a return of 7–30 USD in economic benefits. But despite growing awareness of the need for action, political will is still missing, and so is investment. One reason for this is the missing of a clear understanding of the context-specific options that lead to the desired changes (e.g. with effective legal, political and economic instruments), and how to balance conflicting interests. Action is taken when decision-makers feel well-informed about their range of options and the anticipated effectiveness, and when strong partners are involved. This is where the Economics of Land Degradation (ELD) initiative comes in. It was established in 2011 between the United Nations Convention to Combat Desertification (UNCCD), the German Federal Government and the European Commission in order to understand the costs and benefits of sustainable land management. The Initiative developed a methodological approach to assess the economics of land management ("6+1 Steps approach") and applied it in over 30 country case studies and two continental studies covering 86 Asian and African countries (also see Box). The aim was to estimate the total economic value of the ecosystem services of changes in land management. In addition to the pilot studies, national teams that include NGOs, academics and local and national government officials have been trained to conduct further studies.

Based on this, the initiative is now entering the "ELD Decade for Action". Our vision for this new decade is to promote global understanding of the true value of land and its dynamics and to direct action and investment towards sustainable land management (SLM) that secures the livelihoods and resilience of people and nature and contributes to integrated land use planning. The ELD initiative supports policy action by demonstrating that investments in SLM, conservation and restoration pay off – and by providing scenarios that reflect land dynamics under the influence of policy decisions. For this purpose, the initiative and its network partners will focus on the following topics:

- liaising globally with relevant actors in the field to inform policy- and decision-making;
- further developing the ELD "6+1 Steps approach", seeking to harmonise and pool ELD data with those from other research entities;
- generating evidence and knowledge on economic consequences related to decisions on land use management and land restoration, alongside tangible, scalable and cost-effective solutions for SLM that preserve and enhance ecosystem services in all land use systems;
- improving holistic and transdisciplinary ecosystem service valuation approaches and methods;
- providing tools and data for integrated land use planning;
- designing new institutional arrangements for better management of natural capital;
- facilitating and building partnerships with academia, policy, business and civil society across institutional boundaries and political agendas;
- developing and strengthening human capacities in countries to use economic valuation to implement SLM.

Achieving economically and sustainably informed policy-making will require collective action from a range of different players, including policy-makers, land users, academics and civil society organisations covering multidisciplinary inputs, particularly integrating the ecological, economic, agricultural, societal and climatic perspectives. The ELD Initiative invites all those with an interest in progressing into an era of collective prosperity to join our efforts.

Nina Bisom is coordinating the Economics of Land Degradation (ELD) initiative since 2021. **Richard Thomas** is ELD Scientific Coordinator, and **Naomi Stewart** is ELD Communications Consultant. **Hanna Albrecht** is responsible for ELD's capacity building activities.
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The costs and benefits of soil erosion control in Africa and Asia

ELD's continental study of 42 African countries, carried out in 2015, revealed that the cost of inaction against soil erosion-induced nutrient depletion to all countries would amount to about 127 billion USD per year from 2015 to 2030. In comparison, benefits of action against this degradation from the 105 million hectares of croplands in all countries over the 15 years to 2030 would generate benefits of about 2.48 trillion purchasing power parity (PPP) USD, or 62.4 billion USD per year, in net present value.
In Asia, the annual aggregate crop production loss was 1.31 billion tonnes, amounting to 732.7 billion USD based on an average rate of soil loss for Asian countries of 11.91 tonnes per hectare per annum during 2002 and 2013. Investments in and development of sustainable land management technologies over the span of 2018 to 2030 in all Asian countries could create a net present value of about 3,008 billion USD, equal to 6,169 USD per hectare, with a benefit-cost ratio of around 3.5.

Photo: GIZ/ Dirk Ostermeier

The Great Green Wall – Africa's green world wonder?

The African Union wants to create new prospects for the people of the Sahel and halt desertification with a Great Green Wall. But halfway through the time envisaged for the concept, the ambitious initiative is not yet where it should be. A brief stocktaking.

By Geert van Dok and Patrik Berlinger

In 2007, the African Union (AU) initiated the project of a "Great Green Wall of the Sahara and the Sahel" (GGW). The plan was to create a green belt 15 kilometres wide and 7,775 kilometres long by 2030, stretching from Dakar in Senegal to Djibouti on the Red Sea. Trees, plants, and grassland will one day cover an area of 100 million hectares – at least that is the goal. Eleven countries were initially involved.

The green wall is intended to help stop desertification. The main driver of desertification is soil erosion, which occurs when the fertile soil surface is blown away by wind or washed away by floods or heavy rain. Climate change-induced droughts are also driving the desertification of the Sahel.

The food security and livelihoods of many of the 232 million inhabitants of the Sahel are threatened. Thus, the AU is also seeking social and economic improvements through the initiative. This includes the creation of ten million "green" jobs for tree planting, irrigation, and monitoring of the greened areas, which would allow agricultural use of the renaturalised land.

Mixed results at the halfway point

Now that more than half of the project's timeline has passed, those responsible for the GGW have presented an interim evaluation. The results are mixed, although progress has certainly been made. Politicians from Senegal to Djibouti are working together to find answers to the problems which climate change is causing, such as droughts, food shortages, conflicts over resources and migration. However, when measured against the project's ambitious goals, the successes are rather modest in terms of numbers. Between 2007 and 2019, just under 20 million hectares were restored – 20 per cent of the 100 million hectares targeted by 2030. In the same period, about 350,000 "green" jobs were created – out of a hoped-for 10 million. Around 220,000 people have been trained in sustainable agricultural, pastoral and non-timber management. And the land area restored so far will sequester over 300 million tons of CO_2 by 2030.

Meanwhile, the number of countries participating in the initiative has nearly doubled. This will increase the impact of the Green Wall. North African countries are now involved, as are other West African countries. In addition, the joint commitment of all GGW member states against climate impacts could strengthen solidarity among them in the fight against poverty and the causes of flight.

Thanks to the AU's close collaboration with the UN Convention on Desertification

Photo: FAO/ Giulio Napolitano

(UNCCD, also see article on pages 22–23), financial support has also been advanced. In January 2021, a corresponding acceleration mechanism (The Great Green Wall Accelerator) was adopted at the One Planet Summit. Meanwhile, more than 19 billion US dollars (USD) has been raised by several multilateral and bilateral organisations for 2021–2025 for the GGW initiative – nearly 60 per cent of the 33 billion USD needed to meet the 2030 targets.

Moving forward with traditional methods

GGW officials know that ultimately the initiative can only succeed if it focuses on diverse greening and sustainable land management instead of a fixed belt of trees across the Sahel. Arbitrary afforestation, as practised in many places in the past, is of little use; many seedlings soon die. With a continuous wall, trees would also be planted where there are no people to care for them. To be successful, the GGW initiative must draw on local knowledge and involve local people as well. Studies such as *Restoring African Drylands* by the European Tropical Forest Research Network (ETFRN) show how natural and climate-adapted farmer-led regeneration projects, simple water collection methods, and binding community land use rules have restored productivity in degraded soils.

The GGW initiative has had to contend with difficult conditions. Its success is threatened not only because of global warming, but also because of political corruption and insurgent groups. And the region has a long history of escalating violence. Governments working together to fight corruption and terrorism, investing in the education of their people, and providing money for irrigation will be crucial for the success of the Great Green Wall. If such measures are taken, a green landscape could indeed blossom across Africa.

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Photo: AFROTO/ WRI

“More cohesion across existing frameworks is desperately needed”

It's been nearly 15 years since a vanguard of African countries first committed to restore degraded farms, forests, grasslands and other ecosystems through the Great Green Wall movement. Salima Mahamoudou, a Research Associate at the World Resources Institute, gives an account of challenges facing restoration efforts, what has already been accomplished and strategies needed to still achieve the goals which have been set.

Ms Mahamoudou, given the scale of the challenge and country commitments, many are asking critical questions about progress made with the GGWI. Are locally led land restoration movements in the context of the GGWI on track to achieve their promise?

Answering this question is difficult because monitoring restoration – in Africa and elsewhere – is notoriously complicated. It will still be difficult to estimate the real state of restoration across GGW countries due to a lack of cohesion across tools and methodologies by partners and research centres. Furthermore, one has to bear in mind that it takes years for trees to grow to the point where they can be counted as part of a viable restoration project. We can't expect to see positive restoration data in the early years of these projects – that's just how nature works.

Do you believe it is at all still possible to achieve the goals set by 2030?

Reaching GGW targets by 2030 is indeed going to be challenging, but it is far from being impossible. In fact, we have a clear roadmap consisting of six items for how to achieve this goal. First, accelerate the adaption and implementation by local communities of tree planting practices, farmer-managed natural regeneration – FMNR – and other soil/water conservation methods. Second, establish strong tracking systems for measuring

the biophysical and socioeconomic progress and impact of restoration. Third, build local ownership of restoration efforts at the national and local level. Fourth, create an enabling environment, with the right strategies, policies and local bylaws to incentivise land restoration at scale. Fifth, increase investment in grassroot restoration projects and businesses, including in agroforestry value chains. And sixth, investment in communication and knowledge sharing. Communication at the landscape, national and global level can shed light on innovative grassroot methods and champions.

Do you see a policy failure in the countries participating in the GGWI?

This isn't really about policy failure. Every country has its own approach based on its contexts, including economic, cultural, social and so many other factors. In reality, the places where restoration efforts are faltering are those places where in some cases there are insufficient policies that could otherwise create incentives and a vision for smallholder farmers and landowners to restore degraded land at scale.

Salima Mahamoudou is a Research Associate for the Africa Forest team within the Food, Forest and Water programme of the World Resources Institute (WRI).

Photo: World Resources Institute

The World Resources Institute is a global research organisation that works with governments, businesses, multilateral institutions and civil society groups to develop practical solutions that improve people's lives and ensure nature can thrive. The Institute organises its work around seven global challenges: Food, Forests, Water, Energy, Climate, the Ocean and Cities.

You mentioned smallholders. How can they contribute to the success of the initiative?

One indeed has to admit that top-down reforestation efforts have failed. If we want to achieve GGW goals by restoring millions of degraded landscapes, we will need to further support bottom-up approaches by investing in smallholders to protect and restore their lands and ecosystems, while building resilience to climate change and ensuring food security. If we want to increase the contribution of smallholders in the restoration movement, we must first of all clarify land ownership: Land and resources rights can be challenging in many African countries, especially across the Sahel, where resources are scarce. In addition, resource rights have to be secured. In many Sahelian countries, if a smallholder plants a tree, he automatically owns that tree. But if he naturally regenerates that tree, it is owned by the government. This is particularly problematic because one of the most promising restoration options for the Sahel is Assisted Natural Regeneration. As a result, if the smallholder does not have the right to harvest the trees he has protected, there will be little incentive to do so. But, by working with various government agencies and decision-makers, an enabling environment can be created, thus ensuring that farmers can be allowed to legally harvest and sell their tree products and thus benefit from their efforts.

One further important aspect is extensive sharing of knowledge. Our experiences of large regreening efforts show that sharing knowledge, especially at the local level, is a key element of promoting the adoption of good practices and creating change at scale. And as a final issue, afforestation has to be made lucrative as a viable business enterprise. Today, restoration practices are still seen as humanitarian and development solutions, but not as business ventures. But if we want to reach our goals, we need to promote restoration as a business option, and grow commercially-viable products out of restored landscapes to further incentivise communities to invest in land restoration practices.

Can you give an assessment of which countries have been particularly successful?

It is hard to give a fair assessment because efforts across GGW countries are underreported. At the global and regional level, we often talk about the success of Niger, with more than five million hectares restored since 1985 using Assisted Natural Regeneration. But there are millions of other small-scale examples and successes across the Sahel. Unfortunately, these smaller successes are often hidden in project reports and as a result are barely known by the larger public. Communication is increasingly being recognised as a key element of a successful GGWI.

Do you think "The Great Green Wall Accelerator" will help to make the initiative a success?

The creation of the GGW Accelerator provided new momentum to the initiative. A multi-actor approach has the potential to create a shared vision and targeted actions across restoration actors. It involves learning from our past challenges and linking up dispersed efforts which may now be without a clear or shared pathway. But to increase its functionality, it needs to work closely with the Pan-African Agency of the GGW – if not transfer the accelerator responsibilities entirely to them – for greater ownership of the processes and durability of efforts.

At the UNCCD COP 15 meeting, participants summarised that the biggest challenge is the scale of the project. How do you see this?

Building solid alliances and cohesion across monitoring systems is one of the biggest challenges for the GGW and other restoration initiatives. During COP 15, there was a recurring discussion around the existence of "Too many reporting frameworks and insufficient cohesion". There are a lot of different monitoring or reporting frameworks, with various indicators and requirements, and as a result, definitions of success depend on which measure is used. Countries and some partners are concerned that we'll get to 2030, with 80 million reporting frameworks, but with no clarity on how much progress has been made. More cohesion across existing frameworks is desperately needed to reduce the burden on countries and make reporting user-friendly and achievable.

How can this be accomplished?

To break that cycle, countries need to make their own assessment of what indicators and frameworks are most appropriate to their needs and ecosystems. With a shared understanding on what to measure, how to measure, the costs associated, the frequency of collection and the entities in charge of that, it becomes easier to build cohesion across various stakeholder and contributors.

Interview: Patricia Summa

Ten years of VGGT – a stocktaking

May 2022 marked the 10th anniversary of the endorsement of the Voluntary Guidelines on the Responsible Governance of Tenure of Land, Fisheries and Forests (VGGT). Our authors provide examples from various countries to demonstrate what has been achieved with the Guidelines so far and where there is still need for action.

By Samuel Mabikke, Francesco Pierri, Adriano Campolina, Vladimir Evtimov, Javier Molina Cruz and Francesca Romano

The Voluntary Guidelines on the Responsible Governance of Tenure of Land, Fisheries and Forests (VGGT) in the Context of National Food Security were launched in 2012 by the UN Committee on World Food Security (CFS). In addition to the overarching goal of "achieving food security for all" and "supporting the right to adequate food in the context of national food security", the Guidelines intend to contribute to achieving sustainable livelihoods, social stability, rural development, environmental protection, and inclusive social and economic development.

In the context of VGGT implementation, particular effort was given to making the voices of marginalised groups heard – by providing a framework for civil society organisations, smallholder farmers' groups, Indigenous Peoples and pastoralist and fisherfolk communities to contribute to policy discussions and by supporting inclusive multi-stakeholder engagement. In order to enhance global, regional and local processes to improve governance of tenure through collaborative partnerships, over the last ten years, the UN Food and Agriculture Organization (FAO) provided technical assistance, training and capacity development, as well as supporting the assessment, formulation and implementation of relevant national policies and laws in around 60 countries in Africa, Asia, Latin America and Europe, with women's land rights always playing a large role in the design and implementation of the initiatives.

Secure land rights are of vital importance for women in particular.

Photo: IFAD/ G.M.B. Akash

Some success stories ...

Senegal was one of the first countries to set up a national platform for multi-stakeholder dialogue in 2014, as suggested in paragraph 26.2 of the VGGT. The platform, which includes actors from civil society organisations, academia, the government, the private sector, local authorities and producer organisations, established a representative steering committee, *Comité de Pilotage des Directives Volontaires pour une gouvernance responsable des régimes fonciers* (COPIL DV/ GF), the technical arm of the national platform. COPIL will facilitate the dialogue process on tenure governance with a dialogue mechanism created in 2014 which drives the country implementation of the VGGT. The multi-stakeholder platform (MSP) provides a deep analysis of land issues, including agribusiness developments, environmental issues, land degradation, land negotiation and conflict resolution. Very concretely, the local MSP supported the setup of a land conflict management committee comprising mayors willing to gather and advise community members on conflict resolution.

In **Sierra Leone**, the VGGT were introduced in 2014 through a national workshop and the establishment of a multi-stakeholder platform. A critical mass of stakeholders from government, civil society, the private sector, academia and traditional authorities was mobilised and a community of practice was built around governance of tenure of land, fisheries and forests. The VGGT principles have been integrated in the National Land Policy (NLP). For implementing them, the government of Sierra Leone received support in the use of new low-cost technologies, such as the "Open Tenure/ Solutions for Open Land Administration (SOLA)" application, with which 11,750 hectares of customary tenure rights were demarcated and validated, and the geo-referenced property maps were approved by the Ministry of Lands. These technologies, easy to use by farmers, particularly by rural youth, and the participatory approach adopted helped facilitate conflict prevention and resolution. With about 90 paragraphs making direct reference to the principles, the country's land policy is widely viewed as one most closely adhering to the VGGT principles. Moreover, FAO is supporting Sierra Leone and the Technical Working Group of the MSP in the drafting process of new Customary Land and Land Commission Bills.

Uganda has been actively engaging in the implementation of the VGGTs since the approval of its National Land Policy in 2013. A series of national workshops facilitated a multi-stakeholder dialogue on tenure issues, especially in land and forestry sectors, and a VGGT Secretariat was established in the Ministry of Lands, Housing and Urban Development to coordinate implementation in the country. FAO's support to the government on forest tenure resulted in 56 Forest Management Plans (FMP). The District Local Councils approved the FMPs following a participatory validation process by local communities and private forest holders. With the help of SOLA, more than 4,700 parcels were mapped and 4,000 Certificates of Customary Ownerships registered.

In **Mongolia**, the VGGT were introduced in 2014 and translated into Mongolian, along with a *Technical Guide on Pastureland*, to reach out to local communities. As the term "tenure" did not exist in Mongolian, the translation of the VGGT required reaching consensus around new concepts, resulting in a change of mindset, as seen from reference to customary rights made for the first time in the decree on the Soum Territorial Development Plan. Furthermore, Mongolia was one of the first countries to assess forest tenure governance using an approach based on VGGT principles, which have also accelerated the preparation of formal legislation related to pastoral land, securing the legitimate tenure rights of nomad herders.

The government of **Colombia** initiated a land regularisation programme based on the VGGT which involved joint administration of national park territories by the National Parks Agency and indigenous communities. Practical training courses on the community tenure geospatial recording tool "Open Tenure" have been organised. Following the VGGT, a transparent and inclusive process was put in place to identify stakeholders and rights-holders throughout the steps of tenure rights recording. The Afro-descendent community partner, Cocomasur, used the tool to support land use planning and forest governance, as well as updating the internal census. Users were interested in how Open Tenure can allow a household to register both husband and wife as 50 per cent owners of their land and resources – an initial step in addressing discriminatory inheritance practices.

In **Guatemala**, the Government integrated the VGGT in the new land governance policy, which is part of the overall Rural Development Policy promoting sustainable development through access to land and land tenure security. The new land policy recognises and strengthens indigenous communal systems of land tenure and management, including land law and jurisdiction. It also recognises and promotes women's rights to land and seeks to promote the rural economy and contribute to the competitiveness of rural areas and their full integration into the national economy. Improving the capacity of people and organisations and their understanding of land policy issues has been a theme throughout the process.

Remaining challenges

While important achievements were made over the ten years of VGGT implementation, old and new challenges have been affecting secure tenure rights and inclusive land governance at global, regional and local levels. No doubt one of the most important of these is climate change, the consequences of which (increase of climate-related disasters, limited access to water, reduction of water quality, increase of land-related conflicts, land degradation, displacement, etc.) are very likely to cause severe adverse impacts and consequences to tenure arrangements, potentially harming the poor and vulnerable in particular. Armed conflict can also lead to the disintegration of property rights, as can peace-building processes, in the course of which the affected population will start to (re-)claim or access properties, lands and land-based resources.

Moreover, unequal access to land, insecurity of tenure and non-favourable policy environments continue to affect many rural households in a number of developing countries and emerging economies, with huge disparities in the control of agricultural land. Within households, gender inequalities are particularly persistent. Women, who are often the ones most engaged in food-related agricultural production and sustaining household food consumption, usually have less access to natural resources. Tenure insecurity for women reinforces patterns of social exclusion, especially for girls, and reduces food security, income generation and employment prospects.

Further, while countries remain committed to implementing the VGGT, the global community is not achieving change at the scale required to fulfil the ambitions of the Sustainable Development Goals (SDGs). Many countries have adopted new land legislations and policies, but they continue to struggle to implement these reforms. Very few countries have officially reported on the land SDG indicators: twenty-four on SDG 1.4.2, twenty-seven on SDG 5.a.1, thirty-five on SDG 5.a.2 (see also article on page 31), and only five on all three core land SDG indicators.

Taking advantage of momentum

The celebration of the VGGT's tenth anniversary is a unique opportunity to achieve equitable land tenure and promote the required changes at scale to address the challenges mentioned above. First and foremost, all actors must reaffirm their commitment to promoting and supporting the VGGT and increasing mutual coordination and collaboration with a view to change and tenure security for everyone. Here, FAO and many partners seek to raise the profile of the Global Land Agenda, taking concrete actions at global, regional, national and local levels within a common Framework for Action (F4A).

Moreover, an evidence-based assessment of the trends regarding land tenure and governance is required to help all stakeholders progress towards the SDGs and other frameworks, and to highlight challenges and best practices. Here, FAO and several partners will build a Global Land Observatory to generate evidence and data on the status of land tenure and governance, as a reference point for policy-makers, intergovernmental organisations, civil society, the private sector and academia, linking global and country initiatives in the frameworks of the SDGs, the VGGT, the F4A and the New Urban Agenda.

Changes and interactions between ecosystems have to be analysed to provide knowledge and technical guidance on aspects such as climate change, loss of biodiversity, land degradation and zoonotic diseases, and land tenure and uses. Here, FAO will expand corporate coordination to address land use planning and tenure rights, protected areas, landscape and biodiversity restoration, land, water and forestry conservation and management.

Mainstreaming the link between securing tenure rights and equitable access to land and inclusive rural transformation and poverty eradication will develop knowledge and strengthen partnerships and advocacy. It will also provide technical support and capacity development to women, youth, Indigenous Peoples, pastoralists, small-scale producers and the rural poor for access to natural resources and tenure rights.

Only if these key areas of action are addressed can inclusive, fair and secure ownership rights be achieved and progress made towards rural transformation leaving no-one behind.

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The views expressed in this article are those of the authors and do not necessarily reflect the views or policies of the FAO.

The SDG Land Tracker – easy access to land-related indicators

In 2015, UN member States endorsed the 2030 Agenda for Sustainable Development and committed to implement the 17 Sustainable Development Goals (SDGs) in a 15-year period. More than a dozen land-related indicators were housed over five SDG goals. To document progress on the indicators in one place and make it easily accessible to the public, the Land Portal launched the SDG Land Tracker in September 2017.

By Laura Meggiolaro and Anne Hennings

Land is a key economic resource inextricably linked to access to use of and control over other economic and productive resources and is thus critical to achieving the SDGs. Despite various efforts and some positive developments, land rights have not yet been prioritised in many countries. As such, continuing to document the process of land-related SDGs proves to be particularly important to coordinate stakeholder efforts and prioritise actions.

The SDG Land Tracker provides easy access to official data and information on all 13 land-specific SDG indicators:

- 1.4.2 on perceptions of tenure security;
- 2.3.1, 2.3.2 and 2.4.1, relating to food security;
- 5.a.1 and 5.a.2 on gender and land rights;
- 11.1.1., 11.3.1 and 11.7.1 on housing and urban tenure, and
- 15.1.1, 15.1.2, 15.2.1 and 15.3.1, relating to forests, conservation and degradation (also see screenshot).

The very cross-cutting nature of land data and the fact that it is scattered across different governmental and non-governmental organisations and institutions make it hard to monitor progress related to the achievement of the SDGs. To address this problem, the Land Portal has launched a new SDG Land Tracker in February 2022.

The SDG Land Tracker concisely explains each indicator, outlines data collection and methodology, clarifies report standing and terminology, and tracks their progress. More specifically, it seeks to document and monitor land data in a collaborative way, opening a space for custodian agencies to complement and scrutinise the information provided by the Land Portal. As a cross-cutting issue, this collaboration is encouraged across organisational silos and sectors.
The new tracker provides a better overview, and new maps and data sets were added. Also, each indicator was reviewed by at least one custodian agency. The major challenge in revamping the SDG Land Tracker lay with the complexity of land-related SDG indicators and the multiple agencies involved. Moreover, for some indicators that rely on multiple data sets, no data was available, such as for some urban indicators (e.g. 11.3.1 and 11.7.1) or for land under sustainable use (e.g. 2.4.1).

It has been shown that discussions increasingly centre around the improvement of national data management, harmonising data sets that may vary considerably across countries or the disaggregation of data at regional level. While the availability of forest-related data has further improved, more efforts are needed to capture SDG land data in urban settings. However, the SDG Land Tracker shows that all land-related indicators have progressed in defining their terminology, outlining the methodology, and/or in data collection. In this light, the newly re-launched SDG Land Tracker provides an accessible starting point and space for an informed debate and critical analysis.

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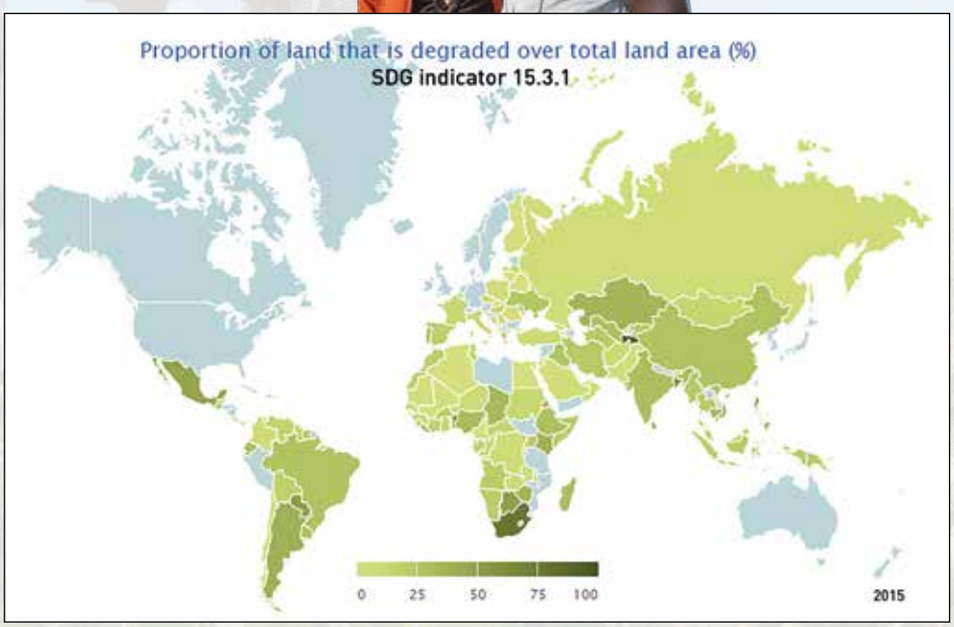
The Land Portal Foundation was established to create, curate and disseminate land governance information by fostering an inclusive and accessible data ecosystem. Over the last decade, the portal has evolved from a simple information gateway to become a knowledge broker, a resource base, a vibrant online community of users and a trusted voice within global land governance.

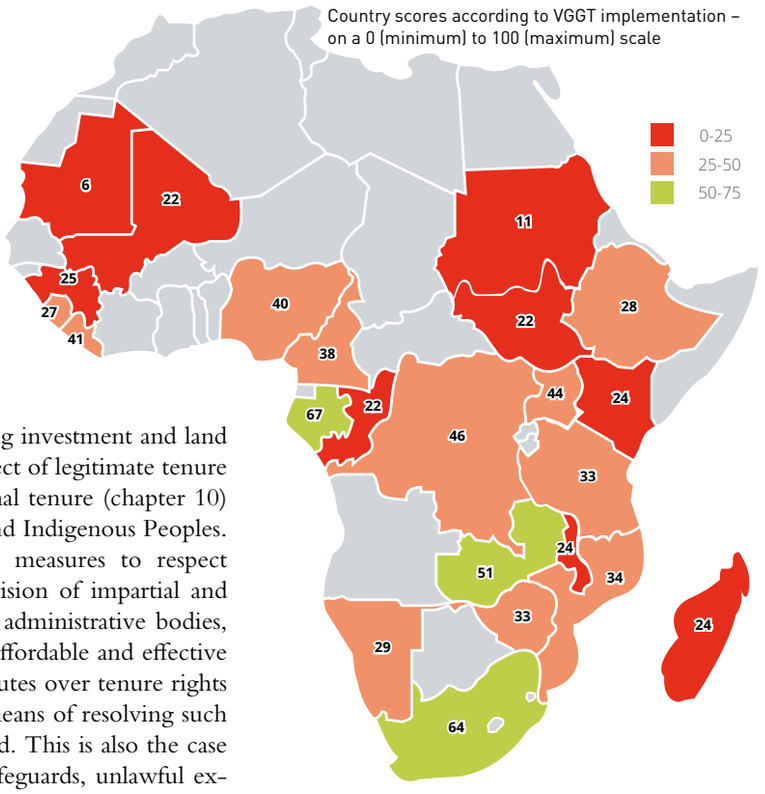
Photo: Icrisat



Little change in land governance practice

Without doubt, the Voluntary Guidelines on the Responsible Governance of Tenure (VGGT) have promoted development and uptake of global and regional land policy frameworks and guidelines. But what about implementation on the ground? In order to assess this, the Land Matrix Initiative has examined large-scale land acquisitions and investments in 23 African countries – and arrived at a sobering result.

By Ward Anseeuw, Jeremy Bourgoin and Angela Harding



Demand for land and natural resources has significantly accelerated in the last decade, and this trend is likely to continue, leading to a surge in large-scale land acquisitions (LSLAs) – a phenomenon which has been dubbed the "rush for land". But decision-making processes over land and natural resources often lack transparency, which, together with weak and deficient governance, commonly create conditions which negatively impact local stakeholders. This state of affairs was to change with the adoption of the Voluntary Guidelines on the Responsible Governance of Tenure of Land, Fisheries and Forests in the Context of National Food Security (VGGT) in 2012 (see also article on pages 29–30). The guidelines are intended "to serve as a reference and to provide guidance to improve the governance of tenure of land, fisheries and forests with the overarching goal of achieving food security for all and to support the progressive realisation of the right to adequate food in the context of national food security". The Land Matrix Initiative (see Box) recently assessed the compliance of large-scale land acquisitions and investments with the VGGT in Africa. While acknowledging the progress made in terms of investment guidelines and land policy reforms at national and global levels over the last ten years, the findings of this assessment reveal staggeringly low VGGT compliance – an indication of the lack of change in land governance practice by foreign as well as domestic investors – across the African continent. In Africa, for example, 78 per cent of all LSLA deals assessed show unsatisfactory levels of VGGT uptake and implementation, and 20 per cent do not comply with any of the VGGT principles at all. Likewise, when LSLA deals are aggregated at country level, 87 per cent of countries assessed present unsatisfactory results regarding VGGT implementation.

Deficits in several areas

The VGGTs include 25 chapters, each composed of several articles, ranging from legal recognition of tenure rights to the administration of tenure. Taking a deeper dive into the thematic areas represented by the chapters (also see Box), results show, at a continental level, that overall land deals in Africa are the least performing with regard to i) consultative processes, ii) respect of national law and legislation, including investment and land legislation, and iii) respect of legitimate tenure rights, including informal tenure (chapter 10) of local communities and Indigenous Peoples. Against this backdrop, measures to respect human rights and provision of impartial and competent judicial and administrative bodies, which include timely, affordable and effective means of resolving disputes over tenure rights (as well as alternative means of resolving such disputes), remain limited. This is also the case for aspects related to safeguards, unlawful expropriation and application of agreed-upon compensation measures. One transversal challenge to this assessment is access to information on land overall and on land deals in particular. Although the results of the evaluation show relatively positive results with regard to the improvement of publically available information and data concerning land transactions (in certain countries, for example Liberia and Sierra Leone), sectors (forestry) or through particular initiatives (OpenLandContracts, Land Matrix), LSLAs remain characterised by a continuous lack of information.

There is still a long way to go by governments and, more particularly, by investors to make contracts public and transparent. Based on the data used for the monitoring presented in this report, only few deals and countries have extensive information for the aspects covered by the VGGT principles with regard to land investment. Just one country (Liberia) has data for about 30 per cent of the variables covered in this VGGT monitoring exercise; most countries cover between 5 and 20 per cent. This gives a concrete picture of the lack of data and dire state of transparency in terms of information surrounding LSLAs – one of the primordial guidelines of responsible investments in general and the VGGTs in particular (chapter 12 of the VGGTs). It also exposes the factualness of the results we are presenting, and of LSLA overall, which will remain incomplete as long as transparency does not improve.

Possible empty pledges and lack of enforcement

These results are all the more alarming since governments and private funders of the countries from which numerous of these investors originate just pledged 1.7 billion US dollars at the COP 26 in Glasgow in the UK, in support of Indigenous Peoples and local communities' role in preventing deforestation that fuels climate change. These global pledges and policy changes are meaningless if they are not accompanied by compliance mechanisms and do not lead to effective (sustainable and inclusive) transformation on the ground.

The European Commission's adoption of the long-awaited proposal for a Directive on corporate sustainability due diligence (CSDD),

aimed at addressing human rights and environmental abuses in global value chains, is promising. But here again, while the text represents a historic opportunity to enhance protection of affected communities and the planet, as the draft stands, it might fall short of expectations. The compliance-based mechanism, relying on company codes of conduct and contract clauses between companies and suppliers, risks weakening the directive when applied in total darkness. Fast-tracking land reform and imposing more stringent and binding corporate and investor country accountability, both supported by increased transparency and monitoring, are thus indispensable.

Monitoring of the VGGTs by the Land Matrix

Launched in 2009, the Land Matrix Initiative monitors large-scale land deals involving conversions of land over 200 hectares from either local community use or important ecosystem service provision to large-scale commercial production in the food, biofuel, mining, tourism, timber and carbon-trading sectors. To do so, the Initiative uses official data as well as non-official data such as company reports, contracts, analytical and research reports, press articles, etc. Since 2019, the variables captured have been expanded to incorporate data on conflicts, consultation, involvement of actors etc. – variables that are crucial for the monitoring exercise of global frameworks such as the VGGTs. In this VGGT implementation assessment, 16 Land Matrix variables align with 18 VGGT articles focusing on LSLA. Although mainly covering articles of chapter 12 on investments, they also address issues related to rights and responsibilities regarding tenure (VGGT chapter 4), safeguards (chapter 7), Indigenous peoples and other communities with customary tenure systems (chapter 9), informal tenure (chapter 10), markets (chapter 11), expropriation and compensation (chapter 16), valuation (chapter 18) and resolutions of disputes over tenure (chapter 21) – also see bottom figure.

Towards more inclusive and sustainable investments in land

Hence, despite the progress made regarding the development of global and regional land policy frameworks and guidelines, and their uptake into policies at national level, land governance practices on the ground have yet to change. This goes beyond questioning and pinpointing the shortcomings of the frameworks and tools deployed to accompany these changes, such as the VGGTs referred to in this article. It is about how to mobilise these relevant global frameworks, guidelines, and references in view of achieving effective change overall, and more responsible land investment and increased accountability in particular. Three indispensable follow-up actions and reforms seem to be needed if effective change in investment practice in land is to be achieved:

Fast-track land reform: Overall, besides some progress as highlighted in the report, the results show that there is still an urgent need for a large number of countries to engage in land governance reforms, and more particularly their effective implementation, aimed at sustainable, equitable, and inclusive land investments. This calls for all countries, and in particular those that ratified the VGGTs as well as other global frameworks, such as the Principles for Responsible Investment in Agriculture and Food Systems (RAIs), to effectively fast-track their implementation as a necessary and prerequisite step.

Corporate and investor country accountability: This needs to be accompanied by corporate accountability measures throughout global value-chains in all investor countries to hold investors (and their suppliers) to account with regard to investments abroad. Legislation will need to be combined with voluntary sustainability standards and go beyond compliance-based approaches, such as company codes of conduct and contract clauses, which could allow parent companies and investors to avoid responsibilities.

Increased transparency and monitoring: All countries should continuously monitor land ownership and control, land transactions and land use change. In particular, all actors engaged in LSLAs must increase transparency around agricultural investment projects. When public institutions and public capital are involved, this should be made compulsory. It applies to investor and recipient countries as part of their commitment to the implementation of the VGGTs and RAIs. This can also be done by providing a mandate to and support for independent transparency and monitoring initiatives, such as the Land Matrix, to ensure that the information can be used by relevant stakeholders and in more inclusive decision-making processes, such as multi-stakeholder platforms, to hold investors and governments to account.

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Food security is more than production volumes and high yields

Taking Biodiversity Focus Areas under production or abandoning lower yielding, more extensive production systems is the wrong approach to mastering the looming global food crisis, our authors maintain.

By Adrian Muller, Catherine Pfeifer and Jürn Sanders

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The war in Ukraine has brought the debates on food security, land use and yields to a new level. Suddenly, for some, any means seems adequate to increase production to compensate for production drops in Ukraine and export insecurity from there and Russia. The European Biodiversity area targets and the Farm-to-Fork-Strategy with its goals of 25 per cent organic agriculture, 20 per cent less fertiliser inputs and halving pesticide use by 2030 are suggested to be put on hold. Organic agriculture is claimed by some to be problematic, as with its lower yields, it would contribute to increased hunger in the world. This production focus is not new. Increasing yields to assure food security and the potential danger of hunger from extensive production systems have been debated again and again. Similarly, high yields are claimed to improve the environment, while extensive systems with lower yields and higher land demand would result in net environmental losses.

Here, we mull on these issues, bring some results from recent research together and ask whether such focus on yields helps to face the current challenges or does not address symptoms rather than causes.

What are yields?

Crop yields are a central indicator for farmers. Higher yields usually lead to higher revenues and food availability. However, they are not a measure for food security, which requires much more complex concepts. Next to food availability, food security encompasses access, use and utilisation, as well as stability of these over time.

Production and yields of single crops are not even of primary importance from a food availability perspective. More relevant is the quantity of food nutrients, i.e. protein, fat, micronutrients and calories provided by a given area. Wheat produced as animal feed contributes differently to food security than wheat directly consumed as food. Maize lost or wasted, or even used for biofuel, does not contribute to food availability. For duly assessing the contribution to food availability, temporal aggregation is needed to address the total food output from complex crop rotations. Crop and livestock production need to be addressed together to account for the feed use of some crop rotation elements. Spatial aggregation is needed to capture the total food production from a territory, where animals graze and where food and forage is produced.

Use less land and get more from existing cropland

Neglecting these complexities hinders thinking beyond yields and intensification. Some scientists argue that using genetically modified crops in Europe to the extent practised in the US could reduce European agricultural greenhouse gas (GHG) emissions by 7.5 per cent. The assumed yield increases for maize are a key driver behind this. However, what is neglected here is that in almost all European countries, way over 50 per cent, and in many more than 80 per cent, of this maize is used as feed for livestock, producing even more GHG and contributing less to food security than direct food production from croplands.

Neither do high yields just come from anywhere. Fertilisers, plant protection, water and other inputs are needed to grow crops. In intensive systems, these usually stem from external sources. Arguments for high production for food security thus work only if these inputs are available. In the context of the war in Ukraine, this has particular importance, given that Russia is both a central exporter of mineral fertilisers and fossil energy. Furthermore, high yields are not only based on the availability of external inputs, but also on many ecosystem services that in turn are threatened by intensive production systems. This is not to say that yield increases and efficiency should not play a role. But resource use could often be organised more efficiently. For example, too much fertiliser is applied in many high-input systems, and some reduction would often be possible without yield losses. Production factors such as soils could be improved to achieve higher yields with similar inputs and without increased environmental impacts. Then there is the case

of input use being low not because of explicit management decisions for extensive production, embedded in a corresponding agronomic and systemic context, such as for organic agriculture, but because of a lack of financial means to buy more inputs, without adapting other management aspects to this situation.

Suggestions for yield increases usually change production systems in given locations. A complementary strategy focuses on changing locations of given production systems by optimising crop location based on climatic and soil characteristics to realise maximally attainable yields. This has a high potential for improvement. Modelling studies show that with this strategy, cropland use could be reduced by 20 to 30 per cent and agricultural GHG emissions could be cut by 30 to 50 per cent. This is promising but requires flexibility in the most inflexible crop production input, which is croplands with their fixed location. Choosing production systems in given locations to maximise yields fits much better into the current economic and institutional organisation of agriculture than choosing the location for a given production system. For farmers, the location usually is not flexible due to property rights, while the choice of production systems and management is. Nevertheless, knowing the potential for improvement of such a reallocation of cropping activities is important. Given the usually large financial and institutional involvement of governments in agriculture, setting some incentives for such improvements may be investigated in more depth.

Providing room for less intensive production

Efficiency increases and production changes do not utilise the flexibility we gain when adopting such a broader understanding of yields as presented above, focusing on the nutritional value and not on the single crop yield. Thus, consumption changes come into play. First, food that is not eaten because it is lost or wasted along the value chain should ideally never have been produced. Second, reducing feed production, e. g. forage maize, which is in many industrialised countries one of the most important cultures, or barley, maize and other grains that are to a large extent used for feed, can free large cropland areas for direct food production – if consumers with high animal source food consumption are prepared to eat less of these products. Such a reduction could also lead to health benefits for many of these consumers. Model-based assessments of such and related scenarios show that optimising healthy diets for minimal environmental impacts or even sourcing food protein from novel alternative sources rather than classical livestock and crops could reduce cropland use by 80 to 90 per cent without compromising food nutrient supply. These shifts in consumption and corresponding shifts in cropland production lead to a smaller food system in terms of material, nutrient and energy inputs and outputs. This reduces the pressure on agriculture to produce high yields to meet a certain nutritional goal and thus provides the space for more extensive production, with fewer inputs and lower yields. Extensive systems tend to have lower environmental impacts at territorial level and to be associated with the provision of many ecosystem services, including those supporting agricultural production and hence food security in the long term, such as pollination, healthy and fertile soils, or water provision.

Clearly, as relocation of cropland use, such consumption changes require a thorough transformation of the food system, not just some incremental short-term adaptation. It is thus much more difficult for policy-makers and businesses to commit to such a vision than to mere production and yield increases.

Of prices and trade

Food commodity prices and trade are at the centre of the debate on food security. Ukraine is a key exporter of wheat and other bulk commodities. Some countries are heavily dependent on such imports, and the huge price increases could lead to famines. However, short-term activism to increase production elsewhere to compensate for potential losses is not the best answer. Food commodity prices are driven only partly by total production. They correlate strongly with energy prices and also depend on the demand for bioenergy and feed. Also, the reduced storage capacities over the past decades, relying on global markets and economising on expensive storage infrastructure play an important role, as do speculation and psychological aspects of market players.

Obviously, action has to be taken to assure food security for the regions heavily dependent on imports from Ukraine. For this, the debate needs to not only relate to quantities and prices, though. Rather, the interplay between self-sufficiency in commodity production, yields, the allocation of commodities between food, feed and energy and the dependence on food and feed imports and inputs such as fertilisers and energy needs to be critically assessed, ideally within a long-term strategy for food security.

What does this mean for future food production?

It is crucial to ask for which use we produce what, where and how to take action with regard to the big challenges food systems face today, including the immediate crisis. The debate needs to go beyond production quantities and yields, and decisions should be taken based on all potential options and accounting for all crises, including droughts and heatwaves and further climate change impacts. Only then is it possible to develop a diversification strategy that mitigates risks and ensures the resilience of the global and national food systems. For such, we have many options to take action, all with their respective advantages and drawbacks. Intensification and yield increases can reduce land use and environmental impacts per unit of product. But where applied, their aggregate impacts within a local ecosystem context bear the danger of transgressing carrying capacities. Extensive systems such as organic or agro-ecological approaches rather avoid this. Due to the relatively lower yields, though, the impacts from higher land use are curbed only when such is avoided by reducing the size of the whole food system. This necessitates changes on the consumption side and along value chains towards reduced waste and losses and reduced consumption of animal source food, all very challenging to achieve. Optimising production locations for highest yields has big potential to reduce land use without the drawbacks of intensification, but it requires huge interventions in production decisions. The potential benefits of novel food also face reservations, as these are mostly still in a prototype phase and consumer acceptance is often an issue. Finally, there are many aspects we have not even touched on yet. Examples include vertical farms and soilless production or new breeding technologies, the central role of training, knowledge and information requirements and provision, as well as the role of power relations and inequality.

The bottom line is to not be dogmatic. None of the named approaches will solve the problems alone; none may be banned on ideological grounds or pushed naively, and exercising due caution is always warranted. Let us embrace this complexity and wisely build on the rich basis for solutions, with which all these approaches together provide us.

References: **www.rural21.com**

Biochar – a soil enhancer for (nearly) all cases

Increasing pressure on farming systems has severely affected soil health and fertility. Biochar, a multifunctional carbon material, is being actively explored globally for simultaneously addressing the concerns related to improving soil fertility and mitigating climate change. The authors of this article present research results of the effects biochar has on soil health and crop productivity, but also of where the limits lie in its use.

By Vandit Vijay and Komalkant Adlak

Soil health is more important today than ever before. Carbon and the structure of soil go hand in hand. Soil fertility results from the presence of organic carbon, i.e. carbon-based molecules which have their origin in everything that was once alive. Healthy soils need a carbon content of nearly five per cent, and without sufficient solid carbon, soil tends to lose basic structure and properties. Carbon present in soil is a major active pool of terrestrial carbon. Total carbon in terrestrial ecosystems is estimated to be around 3,170 gigatons, of which nearly 80 per cent (i.e. 2,500 gigatons) is found in soil. Converting land under natural or unmanaged vegetation to crop production releases large amounts of carbon from standing biomass and soil. As a result, soil organic carbon targets, policies and measures will play a pivotal role in the intended nationally determined contributions (INDC) set by the countries for the United Nations Framework Convention on Climate Change in achieving the global climate targets.

Biochar permanently sequesters carbon and returns nutrients to the soil to bolster soil microbial activity.

Photo: NRCS/ Tracy Robillard

Biochar as a soil activator

There is a need to explore materials that can simultaneously help in soil health improvement and climate change mitigation. Biochar is a carbonaceous material with unique physicochemical properties. It has received significant attention in the last decade thanks to its multifaceted benefits related to the broader fields of climate change, agriculture, wastewater treatment and soil health. Biochar is reported to significantly enhance the soil quality and crop yield, carbon sequestration and reduction of greenhouse gases (GHG) emissions (carbon dioxide, nitrous oxide and methane). It is produced through the pyrolysis process by heating biomass (namely tree and crop residues, grasses, manures, agricultural wastes and wastewater sludge, etc.) at temperatures between 350 and 600 °C in the absence of oxygen. Biochar is a great source of carbon sequestration as this carbon can be stored in the soil ranging from a few years to an excess of 1,000 years. It would otherwise end up being in the environment acting as a cause of greenhouse gases. It is estimated that one ton of biochar added to the soil can sequester approximately 2.2–3.0 tons of carbon dioxide (CO_2). Research revealed that around 12 per cent of the total anthropogenic carbon emissions (0.21 petagrams) resulting from change in land use could be offset annually in soil, if slash-and-burn was substituted by slash-and-char practice.

The technique of using biochar to improve soil health has been known since ancient times. The indigenous people of the Amazon Basin produced biochar and thus improved the soil, which was not very fertile. The discovery of this high fertility in ancient dark, carbon-rich soils called "Terra Preta" has made researchers world-wide curious about biochar and its impact on soil. Researchers are increasingly investigating the effect of biochar on soil properties with large-scale field trials as it acts as a carrier for nutrients and a habitat for microorganisms present in the soil.

Carbon makes essential nutrients such as nitrogen, phosphorous and potassium available to plants and decomposing microorganisms. Soil carbon is known to manage the efficient nutrient supply to the plants. It reduces nutrient loss in groundwater, thus enhancing transfer to the plants. Scientific investigations also indicate positive effects on water retention capacity, which ultimately results in a lesser requirement of water for crop production, as well as reducing energy requirement for irrigation. Furthermore, the presence of biochar lowers soil bulk density, which provides a better environment for seed germination and root expansion. In addition, biochar can immobilise toxic elements in contaminated soils.

Loss of soil carbon induced by agriculture is the second-highest anthropogenic source of global carbon emissions after the energy sector, with a 20 per cent contribution to total greenhouse gas emissions. Therefore, sustainable

Biochar production, its properties and effects on soil

Biochar production feedstocks

Agricultural residues
Forest residues
Municipal waste
Post-harvesting processing waste

Characteristics of biochar

Porous surface
High carbon content
Adsorbent
Aromatic structure
Mineral-rich

Soil properties impacted by biochar

pH, CEC, EC
Bulk density
Water holding capacity
Salinity, sodity
Microbial community
Crop yield/ growth
Nutrient leaching
Atmospheric carbon removal

Photos: FAO

and zero-emission agricultural practices are urgently needed that can increase soil organic matter while capturing greenhouse gases from the environment and fixing them in the soil. This fixation of the carbon in the soil would benefit the soil's health and lower the climate impacts. Soil carbon plays a vital role in establishing the right balance between chemical, physical and biological properties. Biochar becomes an essential tool for maintaining crop productivity in addition to soil health. It helps in improving water holding capacity, redox properties, sorption capacity, maintaining pH and nutrient retention. Biochar amendment presents a cyclic approach where it would help in higher crop production, and this enhanced production would utilise more CO_2 from the environment and produce higher biomass quantity which can then be converted to biochar. Therefore, soil can act as a carbon sink, which is a win-win situation for all.

Soil type and agro-climatic zone crucial for success

However, the use of biochar also has some disadvantages that need to be taken into account. So it is noteworthy that biochar does not always increase productivity. The type of soil, agro-climatic zone and biochar application rates are essential in determining the positive or negative impact. If the soil is already nutrient-rich, then biochar tends to have a negative or neutral effect due to nutrient immobilisation. For instance, in general, biochar is highly useful in tropical regions or degraded soil, whereas it only has moderate effects in temperate regions. The application of biochar produced from different biomass feedstocks cannot always provide the same effect for the same soil property in less fertile soils. Thus, the application of suitable biochar to the appropriate soil type should be carefully considered when improvement in a particular soil function is desired.

The impact of biochar amendment on the chemical, physical and biological properties of soil, as well as soil health and agricultural productivity, depends upon the existing soil characteristics, such as pH levels, water retention, cation exchange capacity (CEC) – i.e. the soil's ability to absorb positively charged ions, nutrient transfer, etc. Opposite effects on physical properties of soil, such as water retention, compactibility, and air transport properties, are reported for biochar application to coarse-grained and fine-grained soil due to the fundamental differences in structure-forming potential (leading to macro-porosity), pore-size distribution and connectivity of the pores. The advantages of biochar application on chemical properties of the soil, for example, get influenced by the soil's original buffering capacity, surface charge type and density, amount and stability of soil organic matter. Thus, the effects are always specific to the soil and the application site.

State of the science regarding biochar and future scope of work

The type of biomass which biochar has been produced from is another important aspect. For example, it should not be gained from sewage sludge and placed in the soil, as the heavy metals from the sewage sludge can contaminate the soil and lead to food contamination. Furthermore, some researchers report an increase in methane (CH_4) and nitrous oxide (N_2O) emissions from the soil during the crop cycle, especially for paddy where the water logging creates less aerobic conditions, leading to an increase in these emissions. However, there is a need for more scientific evidence here. Research and development in biochar has been vast. Its advantages are obvious. It is a cheap, sustainable, easy to prepare biomaterial which can also be produced by farmers locally. Its applications related to adsorption have been primarily focused upon in industries, and the same adsorptive properties can also play a vital role in soil health improvement for agriculture by holding more nutrients, preventing leaching and increasing water retention. Biochar production through the pyrolysis process is also a sustainable process which produces bio-oil and synthesis gas (a fuel gas mixture). This bio-oil can be utilised for running engines whereas part of the gases can be used during the pyrolysis of biomass.

There are many laboratory-based experimental studies that indicate positive effects of biochar on soil. But there are also studies which have indicated that biochar amendment effects on soil properties and crop productivity faded with time. Hence, there is a need for well-designed long term (>one year) field trials on varied representative soils to facilitate useful recommendations to farmers and researchers on the suitable biomass feedstocks, biochar production parameters, biochar application rates and appropriate soil types.

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Traditional extensive coastal aquaculture of shrimp and milkfish in Kalimantan, Indonesia. Photo: Roel H. Bosma

A mixed mangrove-shrimp system in the Mekong Delta, Vietnam. Photo: Tran Thi Phung Ha

Towards more sustainability in integrated mangrove systems

The Vietnamese and Indonesian types of silvo-aquaculture with mangroves produce mainly shrimp, but also some timber. These integrated or mixed systems do not provide most of the services which mangrove ecosystems offer. In Java, farmers tested the system of Associated Mangrove Aquaculture, an alternative practice inspired by those adopted in Colombia and the Philippines – with promising results.

By Roel H. Bosma

In Rural 21's recent issue, *The land-sea interface* (01/22), four articles referred to integrated mangrove aquaculture systems as an option to improve the sustainability of traditional coastal shrimp culture. Since about 1980, such mixed systems, also called silvo-aquaculture systems with mangroves (SAM), have been practised mainly in Indonesia and Vietnam (see left Photo). In these systems, the mangroves are planted either on one large platform (separated) or on several parallel narrow platforms (mixed), respectively, in a pond separated from the shrimp pond or within the same pond (see right Photo). In Indonesia's most commonly practised SAM, the trees are planted only on the dykes of the ponds, and although they provide timber and habitat for birds of prey as well as snakes, after major floods, most dykes disappear, and the tree roots do not trap sediments. In a review of SAMs, we found that none of the above designs contribute to coastal protection, biodiversity or habitat for marine species. In all the above systems, designed to produce timber, the mangroves are not submitted to the daily tides, and the water going out of the ponds is filtered with nets to keep the shrimp, fish and other marketable products inside them.

Advantages turn into disadvantages

Young mangrove trees on the platforms within the aquaculture ponds provide some shade and shed only a few leaves, which decompose and become natural feed for the shrimp. But shading from older trees hampers growing of the pond's own natural shrimp feed, and the many fallen rotting leaves deplete its oxygen and produce toxic ammonia, making the water unfit for shrimp.

As the mangroves in the above-mentioned SAMs are used for timber, the main species planted is *Rhizophora apiculata*. This is not a good choice for aquaculture because the tree's leaves have low nitrogen content, which hampers nutrient recycling due to the high carbon-nitrogen ratio, and thus results in poor water quality. In Bangladesh, Rahman Khandkar-Siddikur and colleagues (2020), together with farmers, ranked more appropriate species for SAMs, such as *Sonneratia apetala* and *caseolaris*, *Avicennia officinalis*, *Bruguiera sexangula* and *Heritiera fomes*.

Our above-mentioned review found that in SAM with mangroves inside the pond, owing to poor water quality, the shrimp yields remained below 400 kg per hectare. While farmers also earn from timber and other products, they need at least six hectares of silvo-aquaculture farm to maintain a fair livelihood. Most farmers, however, have less than two hectares. In contrast, surveys in the Philippines have shown that farmers harvest about 6,000 kg per hectare or 15 times more in sustainably managed green-water ponds with tiger prawn (*Penaeus monodon*). Nevertheless, the average net margin from these green-water ponds mostly remains lower than the total economic value of intact mangrove forests (see Box).

A climate-smart mixed system

To contribute to coastal protection, biodiversity and habitat for marine species, a silvo-aquaculture with mangroves should provide the main ecosystem services attributed to mangrove forests (see Box). Our review proposed an ecosystem design that can provide these services: Associated Mangrove Aquaculture or AMA. It is based on SAMs described by Primavera (2012) and Gautier et al. (2001)

Economic value of mangrove forests

The total economic value (TEV) of mangrove forests varies depending on their share of ecosystem services. These services include timber and fruits, habitats for breeding and nursing marine fish, sedimentation and flood regulation, and tourism.

An analysis of 112 studies world-wide (Russi et al., 2013) shows the minima and maxima of the total economic value of the mangrove's four ecosystem services (in USD/hectare/year):

Provision services:	44 – 8,300
Habitat services:	17 – 68,000
Regulation services:	1,900 – 135,400
Cultural services:	10 – 2,900

A survey by Mankay et al. in South Minahassa Regency/ North Sulawesi shows that the TEV of mangrove was 36,000 USD per hectare, which is about the average found globally.

In muddy coasts, permeable dams trap sediments and gradually create habitat for natural mangrove rehabilitation.

Photo: Kuswantoro/ Wetlands International

for the Philippines and Colombia, respectively. In the Philippines, these systems emerged after the government banned the cutting of mangroves along the coast in 1982, and in Colombia to counteract the abrasion along the Caribbean coast. In both cases, the aquaculture farms are located behind a wide mangrove greenbelt, separating, i.e. protecting the farms from sea or river.

To create an AMA, the pond is split in two sections: one for aquaculture activities and the other, along the waterway, for the mangroves. Once the new dike separating the two sections has settled, farmers can neglect maintaining dike and gate along the river. Recently, in the Demak district of Central Java, over 100 farmers tested this alternative design, AMA, under guidance of the project Building-with-Nature-Indonesia (BwNI). Those farmers had volunteered after a training in Aquaculture Field Schools (see Box).

To prevent planting failure and disturbance of restoring the mangrove habitat, BwNI told farmers not to actively plant mangroves but to wait for natural recruitment to occur. Without planting, within one year, more than 10,000 mangroves were recruited naturally in AMA's mangrove section measuring on average 1,500 m^2. Two thirds of these mangroves were still seedlings shorter than 1 m, but one third were taller saplings. Most recruits were *Avicennia marina*, a pioneer; *Rhizophora* dominated among the 20 other species. Mangrove recruitment fluctuated according to season and locations, and depended on the duration and timing of opening the gate and on proximity to the river, but not on the water level in the mangrove section. In the latter section, on average, 10 cm of sediment accumulated in one year. The quantity of sediment was about the same in the ditches as that on the platform.

Catch and value of fishery in both the AMA and the nearby estuary improved after recovery of mangroves in AMAs. In the first year, the farmers lost most of their stocked fish because of floods, but the higher volume and value of the catches in the netted gates compensated their financial losses. As in AMAs, pond water quality is not limited by shading and falling leaves, so that the ponds can be managed more intensively. Moreover, thanks to higher ecological qualities, the financial risks of shrimp culture in AMA are much lower than that in intensive monoculture. Thus, in AMA, the shrimp yield can become identical to that in the above-mentioned intensive green-water farms.

Hence the mangrove section, covering 10–20 per cent of the AMA, already provides ecosystem services that are crucial for climate change adaptation. AMA's accumulated economic values can contribute more to national economies than tiger prawn monoculture.

Rehabilitate mangroves and aquaculture simultaneously

A preliminary social cost-benefit analysis confirmed that BwNI's innovative approach is beneficial in the long term. Instead of losing land, an investment of less than 1,000 US dollars per hectare in permeable dams for coastal mangroves (see Photo) gives a more than 100-fold return over 25 years. The return on a similar investment in AMA and aquaculture is close to 40-fold over 25 years. Investing in both greenbelts and aquaculture gives an even higher benefit than the sum of the individual actions taken. While rehabilitating coastal and riverine mangrove forests contributes to climate change mitigation, making space for mangroves along the waterways and allowing them to interact with the waterflows and its tides are crucial in achieving climate change adaptation.

Project context

Building with Nature Indonesia (BwNI) is a programme by the network Ecoshape, the NGO Wetlands International and the Indonesian Ministries of Marine Affairs and Fisheries (MMAF) and Public Works and Housing (PU). It received financial support from the Dutch Sustainable Water Fund and the German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU).

The learning process from Aquaculture Field Schools (AFS) was developed by the Blue Forests Foundation. It inspired on the Farmer Field Schools for Integrated Pest Management that the UN Food and Agriculture Organization (FAO) started in the 1980s. During 12 to 16 half- or full-day sessions in one production cycle, farmers learnt, among others, aquatic ecology and pond management with low external input sustainable aquaculture (LEISA). The AFS programme aimed for dominance of vulnerable households and equal gender participation; the first was easy to reach, but the second needed an extra round of female-dominated schools.

The gross margin of the Agriculture Field School alumni who adopted LEISA was estimated to be more than 900 USD per hectare and year higher than that of non-adopters, and more than 700 USD/ha/year higher than the margin found before the project had started. Owning an average of about two hectares of ponds, farm households using LEISA gained around 1,400 USD more each year. The internal rate-of-return of BwNI's AFS programme was more than 130 per cent, meaning that the project's investment was recovered within one year. Widowati et al. (2021) showed that such a high return is rarely reached by agriculture innovations.

For more information and guidelines on building AMAs, see: **indonesia.buildingwithnature.nl**

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References: **www.rural21.com**

Putting gender upfront in vaccine delivery systems

While developments in vaccine technology have helped eradicate some of the most devastating livestock diseases, women livestock smallholders in particular face barriers to accessing existing livestock vaccines and benefiting from them. To adapt vaccine delivery systems to better serve women smallholders, policy-makers and local leaders need to have a better understanding of these issues, backed by evidence. The Livestock Vaccine Innovation Fund has set itself the goal of delivering such evidence.

By Evelyn Baraké and Wendy Manchur

Demand for animal-sourced food is projected to increase in the coming decade, particularly in low- and middle-income countries. But in many of these areas, preventable and curable livestock diseases continue to harm the livelihoods of smallholder farmers, especially women, who make up two-thirds of livestock smallholders.

Livestock rearing has many benefits for individuals and households. Livestock are a financial asset and a source of income, and they provide nutritious food. While local contexts differ, smaller livestock species, including sheep, goats and chickens, are more commonly reared by women. These generally require less land, and land ownership is not a requirement for animals to forage. In settings where it is more difficult for women to own land or where they do not benefit from land tenure security, these are significant advantages. Consequently, endemic diseases of small livestock in low- and middle-income countries – including Peste des petits ruminants and contagious caprine pleuropneumonia in sheep and goats, as well as Newcastle disease in chicken – tend to disproportionately disadvantage women. These diseases can be managed using existing veterinary husbandry practices, including vaccines.

Sixty-one-year-old "Mama" Zaina Said, right, is head of the local dairy goat organisation in Kunke Village, Mvomero District, Morogoro Region of Tanzania. Photo: IDRC/ Brian Sokol

Agricultural technology development is not gender-neutral

Vaccines are among the most cost-effective and sometimes the only means to protect livestock against devastating diseases. Developments in vaccine technology have helped eradicate some of these, such as rinderpest. But like most agricultural technologies, vaccines do not benefit everyone equally. Dominant social norms, power relations, beliefs, institutions and other social structures affect how they are developed, commercialised, marketed and distributed. When these processes do not consider the gender-specific needs, preferences, and constraints of women livestock smallholders, inequalities in vaccine access and uptake emerge. Not only can this harm women's livelihoods and economic security, it also poses risks to the health and food security of families, communities and nations.

In some communities for instance, gender norms can constrain where a woman goes and when, limiting her access to vaccination services requiring her to travel to a specific location with her livestock. They may also restrict her livestock management choices, including around vaccination, in settings where a male head of household traditionally makes these decisions. Other common obstacles for women livestock keepers include limited knowledge about livestock vaccines, their benefits and how to use them, as well as their costs. To adapt vaccine delivery systems to better serve women livestock smallholders, policy-makers and local leaders need to have a better, evidence-based understanding of these issues.

Gender norms are informal rules that define what is socially acceptable behaviour for adults and children, based on a person's gender. This, in turn affects their choices, privileges, and abilities. Inequitable gender norms echo the uneven power relations that exist in a society, and they often put women at a disadvantage.

Gender and livestock vaccine value chain research in practice

Currently, there is limited research on the different roles that women and men have in livestock vaccine systems and on the factors that affect their ability to participate in and benefit

from them. Smallholders' perceptions of livestock vaccines and their value, as well as their willingness to use them when available also need to be better understood.

To fill this gap, a cohort of four research projects working in six countries – Ghana, Kenya, Nepal, Rwanda, Senegal and Uganda – and funded by the Livestock Vaccine Innovation Fund (LVIF; see bottom Box) were specifically designed to generate new evidence on how women can better benefit from vaccines for small livestock and participate in these vaccine systems, and to address the myriad of barriers women face. These projects support the empowerment of women as livestock farmers, entrepreneurs and veterinary service providers along the livestock vaccine value chain for chicken and goats. Their design was informed by past research programmes which have yielded important lessons on how to effectively integrate gender considerations in development research (see upper Box).

In research that involves challenging inequitable gender norms, transforming social roles and power relations, the process is as important as the findings, including decisions of who to involve as stakeholders. Researchers must be mindful of how their presence and interventions could negatively affect community relationships and select approaches to minimise these risks. For instance, it is especially important for researchers to engage women and men together, rather than singling out women for interventions. This avoids potential negative backlash and provides the opportunity for men to become facilitators for women's empowerment in their communities beyond the lifetime of the research. Facilitated group discussions are essential to this work. They create important spaces for critical reflection where men and women can openly discuss gender norms in their community or work environment, as well as the changes they would like to see.

Measuring changes in behaviour can be challenging and requires a variety of innovative methods and tools. Researchers use a combination of approaches, both qualitative and quantitative, to determine what worked, what did not, and why. The cohort of LVIF projects working on women's empowerment in livestock vaccine value chains has involved diverse groups from their early stages, including local government officials, ministerial representatives as well as women and men farmers, representatives of community groups and co-operatives, community animal health workers, agro-vet shop owners, animal vaccine distributors and importers, and veterinarians, to name a few. By fostering dialogues between groups that normally would not interact, this engagement process has helped spark attitude shifts and raise awareness of the inequalities in livestock value chains. In turn, this can influence decision-makers to make changes to extension services and policies.

Lessons on how to do action research for women's empowerment

Dedicated approaches for integrating gender in research and development programmes:

1. **Gender experts should lead the research.** In natural sciences research, consultants or female junior staff are often tasked with the responsibility to integrate gender in research. This can effectively sideline gender integration as an objective, limiting progress on gender equality outcomes.
2. **Include systematic processes to integrate gender at every stage,** consistently and continually from design to evaluation. Participatory action research and gender transformative approaches help us understand the inequalities and power dimensions in a context and contribute to a stronger foundation for more equitable and lasting contributions of research to the development process.
3. **Develop robust management frameworks to measure gender outcomes and impacts at the research project and programme levels.** This should include common quantitative and qualitative indicators to enable cross-project learning, data collection for greater impact, and opportunities for reflection and challenging assumptions.

Transforming food systems for gender equality is necessary work

Inevitably, building trust with different stakeholders and understanding what motivates their behaviours that contribute to the status quo is sensitive work that cannot be done overnight. The time and resources required to do this type of research may explain why it remains so rare. It is certainly easier to work on traditional, more technical, livestock programmes that are not gender transformative than to engage with the socio-economic and political dimensions of women's empowerment. But taking the easier route has risks. Gender-blind interventions can widen existing inequalities by redistributing power and resources, dispossessing women and other marginalised groups of their assets and their decision-making power. And interventions for livestock disease control cannot be effective when they systematically overlook certain groups, such as women smallholders. Eradicating vaccine-preventable diseases then becomes very difficult, as animals managed by women could remain reservoirs of disease.

Women livestock smallholders are critical players in food systems all around the world, yet they continue to be underserved by current livestock vaccine delivery systems. To promote gender equality and improve the lives of rural women, as well as to increase the long-term resilience of food systems, research and development initiatives must recognise the critical need to empower women and other marginalised groups in livestock programmes.

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The Livestock Vaccine Innovation Fund (LVIF)

The Livestock Vaccine Innovation Fund (LVIF) is an initiative funded by the Bill & Melinda Gates Foundation, Global Affairs Canada and Canada's International Development Research Centre (IDRC) with 57 million Canadian dollars for the development of vaccines that are affordable, available and acceptable to livestock smallholders and to facilitate their use at scale. LVIF targets livestock diseases that have the most impact on both women and men livestock smallholders in sub-Saharan Africa and South and Southeast Asia.

More information:
www.idrc.ca/en/initiative/livestock-vaccine-innovation-fund

Machinery rings – an innovative approach to mechanising Kenyan agriculture

Organisational and digital innovations can facilitate smallholder farmers' access to mechanisation. Through the Fund for the Promotion of Innovation in Agriculture (i4Ag), the self-help model of the machinery ring, which originated in Germany, is being adapted to the conditions of smallholders in western Kenya. As the following article shows, the model has met with success.

By Claudius Bredehöft and Johanna Zimmermann

Mechanisation in the agri-food sector remains a pillar of rural development in Africa. It helps to ensure a sustainable increase in production and to promote employment for young people, among others. However, smallholder farmers often still lack access to sustainable, modern and appropriate agricultural technology. This is exemplified by the situation in Kenya. According to a 2019 study, 26.3 per cent of Kenyan farming households had access to ploughs, 12.8 per cent to tractors and 4 per cent to combine harvesters. While the use of agricultural machinery is increasing, it remains at a low level. This is due to a number of factors that are interconnected (see Figure).

A machinery ring manager (r.) showing a driver how to use a rotavator.

Photo: sequa gGmbH

A business model driven by smallholder farmers

The continuing low level of mechanisation in the country is mainly due to the smallholder farmers' low level of capitalisation as well as the small size of the holdings and the associated high fixed costs for purchased agricultural machinery. This is precisely where the package of measures comes in that the Fund for the Promotion of Innovation in Agriculture (i4Ag – see Box on page 43) has been implementing in western Kenya since June 2021 in cooperation with sequa gGmbH and the *Bundesverband der Maschinenringe e.V.* (BMR, the German federation of machinery rings). Through direct contact with a local machinery ring and a digital platform, smallholders gain access to spare machinery capacity in exchange for a service fee.

Machinery rings are agricultural self-help organisations that focus on community and innovation. They provide machinery or machinery-based services and labour. A machinery ring does not normally own any machinery and does not employ its own staff – apart from management staff. The machinery provided usually belongs to individual farms or agricultural contractors. The organisation coordinates the individual members' supply and demand (machinery and labour capacities) and sets charges and standards for the completion of works. This creates transparency and brings economic (e.g. fair mechanisation costs and higher labour productivity) as well as social benefits (e.g. support during peak workloads or illness). In the event of a dispute between contractor and client, the machinery ring acts as an arbitrator. The organisations may also take on other business aspects for their members, such as the placement of labour or access to agricultural markets. The members decide on business activities and statutes. Farmers participating in farm machinery organisations have two options. Either they procure machinery themselves and contract out free capacities (e.g. via the digital platform), or they use other members' services, for example for soil cultivation.

It is crucial for the success of the business model that the transaction costs for providing the service are kept low. In addition to the spatial proximity of the members, a sufficient infrastructure is indispensable. This is confirmed by John Rotich, chairman of a newly established local machinery ring in Kenya. For him, the great advantage of machinery rings for all parties involved is providing a time-saving medi-

Benefits of the implements provided by machinery rings

Implement	Benefits
Rotavator	Weed control and incorporation of coarse crop residue
Chisel plough with roller	Breaking the capillarity to conserve soil water; weed control; loosening the soil structure; increasing the soil's water retention capacity and reduced erosion through recompaction; improved seedbed preparation
Disk harrow with roller	Breaking the capillarity; shredding and incorporation of crop residues and weeds; improved seedbed preparation

ated interface between the supply and demand sides. He sees the participants' efficient organisation as the key to success. The baseline study conducted prior to implementation showed that 91 per cent of the smallholder farmers surveyed would join a machinery ring; among providers of machinery-based services, the figure was as high as 97 per cent. The high demand was confirmed on foot of the first awareness-raising events, so that the project has been able to register 19 farm machinery syndicates at village level to date. Women constitute 51 per cent of the 3,800-strong membership.

In order to also make the service accessible to the more remote micro-farms despite the geographical distance involved, booking requests are to be bundled by the platform in future. Service providers will then only need to cover the distance once to serve multiple farms. All fields can be worked in one day, thus saving time and reducing costs.

Focus on soil cultivation

In many countries of sub-Saharan Africa, mechanised soil cultivation consists of a single, usually deep pass. Few farmers are aware of the benefits of more shallow soil cultivation, for example for incorporating crop residues or for seedbed preparation, or no-till techniques and the associated mechanical weed control. The requisite implements are therefore difficult to find on the market. This bias towards ever-repeating deep tillage is not only a reason for low yields, but also for progressive soil degradation. Without the incorporation of crop residues, organic material cannot decompose in the soil. This increases the spread of soil-borne plant pathogens and reduces humus formation, which in turn tends to lead to increased use of chemical pesticides.

In order to meet these challenges, the farm machinery rings provide their members with implements for conservation tillage on a rental basis (see Table) and also offer training on climate-resilient agriculture. Smallholder farmers and micro-enterprises, most of whom tend to only own one tractor and one tillage implement, can thus expand their range of services, increase capacity utilisation of their machinery and implements, and impart and apply knowledge about conservation tillage techniques.

Gender strategy included

In its National Policy on Gender and Development, the Kenyan government aims to increase women's income, and specifically so in the agricultural sector. However, although women account for up to 75 per cent of the agricultural labour force in Kenya, they are still getting side-lined when it comes to mechanisation solutions, as at a societal level the operation of agricultural machinery continues to be perceived as a "man's job". The machinery rings have set themselves the goal of creating sustainable income potential for smallholder farmers by actively involving women and tailoring services to their needs. Alice Chepkorir Mabwai, a farmer and member of a machinery ring in western Kenya, welcomes the gender strategy: "Empowering women in farming is the greatest thing that we should achieve," she says. The strong support offered by the machinery rings for the transformation to mechanised agriculture motivated her to become a member. As a manager of an agricultural holding, knowledge transfer is particularly important to her.

Ensuring sustainability by adopting a holistic approach

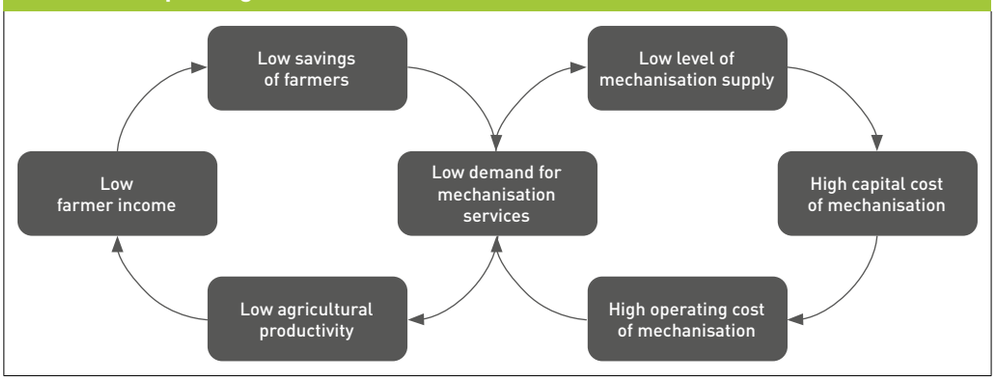
Instead of creating new dependencies, the project builds on strengthening smallholder farmers' communities and mobilising existing resources. The machinery rings in western Kenya are based on statutes and business principles that ensure equal benefits for all members. Membership fees and agency commissions, which cover the organisations' running costs, are calculated and set collectively. Capacity-building on climate-resilient cultivation techniques is combined with business management topics, with a focus on the profitability of purchased agricultural machinery and its refinancing. In addition to the provision of machinery capacities for crop production, new business areas have already been identified in transport, processing and market access for agricultural products.

In the project area, increased demand for innovative mechanisation solutions and additional services in the value chain is already evident. The establishment of the machinery rings offers great potential to promote business opportunities for third parties (e.g. workshops, trade, contractors) and employment.

The Fund for the Promotion of Innovation in Agriculture

The Fund for the Promotion of Innovation in Agriculture (i4Ag) was launched in September 2020 by the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH on behalf of the German Federal Ministry for Economic Cooperation and Development (BMZ). Its aim is to develop gender-sensitive and sustainable innovations with partners who have a positive impact on food security, income and employment and/or on the environment and climate. The package of measures, which has been implemented in Kenya as part of i4Ag since February 2021, aims to reduce the capital costs of mechanisation with the help of inter-farm concepts. An additional aim is to increase the low productivity of smallholder farmers through business management training and knowledge transfer on issues of climate-resilient cultivation techniques.

Feedback loops in agricultural mechanisation



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