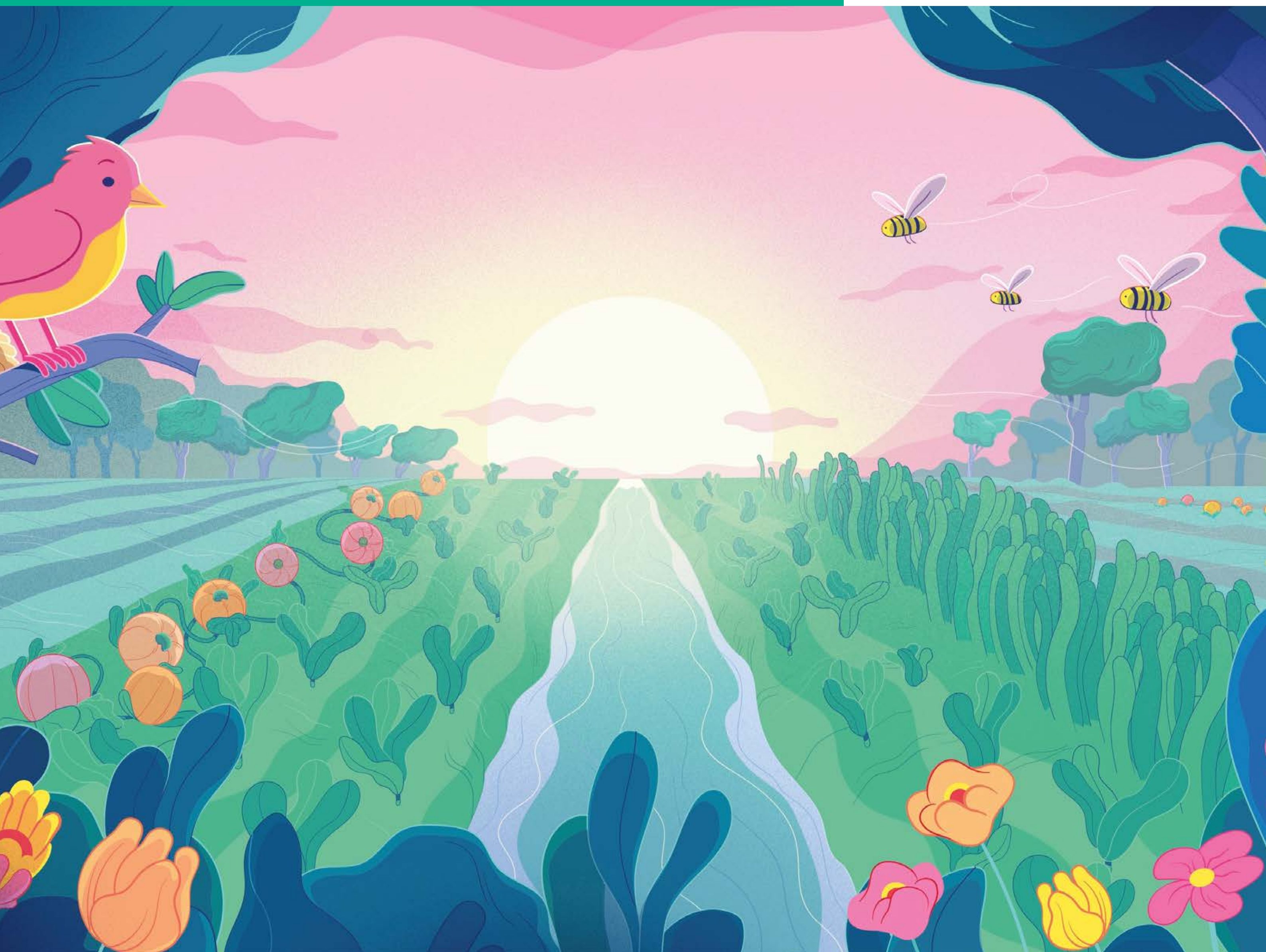
The Unilever regenerative agriculture principles

with Implementation Guides 2021

Unilever



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Content

Introduction

Unilever introduced the Sustainable Agriculture Code (SAC) in 2010 as the basis for our sustainable sourcing programme for renewable raw materials. SAC2010 provided a collection of good agricultural practices which together were intended to ensure that crops were grown to give the right yield of the right quality, that non-renewable farm inputs were minimized, that harm to the environment was reduced and positive impacts on biodiversity were created, and rural communities were supported. SAC2010 was updated in 2017 to include a commitment to zero deforestation, to introduce Climate Smart Agriculture, and to cover the requirements of the Unilever Responsible Sourcing Policy. SAC2010 and SAC2017 have been the major tools in our sustainable sourcing programme. Hundreds of suppliers and hundreds of thousands of farmers have been reached, helping them implement the SAC. We remain committed to drive sustainable sourcing for key crops to 100% on the basis of SAC and we will use these Regenerative Agriculture Principles to set up programmes with selected suppliers for key crops to explore ways for generating more positive impacts on soil health, biodiversity, farm profitability, water quality and climate resilience.

THE UNILEVER REGENERATIVE AGRICULTURE PRINCIPLES

The Unilever Regenerative Agriculture Principles provide guidance on how to further deliver positive outcomes in terms of nourishing the soil, increasing biodiversity, improving water quality and climate resilience, capturing carbon and restoring and regenerating the land. The scope and ambition of the Principles reflect the Unilever New Compass objectives, making the delivery of these Principles in practice fundamental to our business. In tandem with positive partnerships along our supply chain, the Principles will inspire our Business, Divisions, Brands, our suppliers and peers and form the basis for regenerative programmes for ingredients in our supply chain.

OVER-ARCHING PRINCIPLES OF REGENERATIVE AGRICULTURE

Unilever adopts the following principles of regenerative agriculture:

- Have positive impacts from agricultural practices on soil health, water and air quality, carbon capture and biodiversity
- Enable local communities to protect and improve their environment and wellbeing
- Produce crops with sufficient yield and nutritional quality to meet existing and future needs, while keeping resource inputs as low as possible.
- Optimize the use of renewable resources while minimizing the use of non-renewable resources.

IMPLEMENTATION OF THESE PRINCIPLES

Unilever will set up a suite of Lighthouse Programmes to trial implementation of the Regenerative Agriculture Principles. We will invest in and work with farmers, suppliers and partners on different crops in different geographies in order to find locally adapted solutions.
While we do this, we will continue to use SAC2017 as the basis for our sustainable sourcing programme.

CHANGES AT SYSTEM LEVEL

Making farming regenerative requires changes to farm practices and management at a systems level. Soils respond to the type and diversity of crops that are grown on them and to the type and amount of nutrients that are added to them. Systems level changes in perennials are necessarily slower but regenerative management in the non-cropped land, such as alley ways, and introduction of increased above-ground-diversity through companion planting can also improve soil health, biodiversity and thereby increase the resilience of the systems.

Unilever's footprint in agriculture is dominated by perennial crops such as oil palm, forest[1], tea and cocoa. Applying regenerative principles to perennials clearly cannot focus on crop rotation, but still focuses on soil health e.g. composting and mulching as well as managing riparian and buffer zones for biodiversity, reducing carbon footprints, restoring pockets of forest within plantations, and supporting smallholder livelihoods.

Applying regenerative principles in arable cropping systems, includes the use of long and diverse crop rotations, using both deep rooting and shallow rooting plants, with live roots in the ground at all times help to restore soil health. Application of conservation tillage also helps soils to establish new equilibriums with respect to soil microbial life which in turn helps nutrient cycling and storage of carbon. Reconnecting animal husbandry with arable farming can help close nutrient cycling.

Changes in farming systems will also need to be met with changes in market dynamics. Farmers respond to market signals. To help them move to longer and more diverse crop rotations, there has to be a market demand for each of those crops. In order for the farmer to reduce dependency on imported animal feed, there has to be a supply of crop residue and food processing waste. In order to use farmyard manure rather than synthetic fertilizer, there has to be animal husbandry in the proximity of the arable farm. Reduced carbon and water footprints associated with crops should also be rewarded by the market.

THE EMPHASIS OF THE PRINCIPLES

Unilevers' emphasis is on bringing regenerative practices into the forefront rather than outlining a specific set of practices that must be used. The most appropriate regenerative practices are likely to be region, climate and crop specific. However, changing to a regenerative focus is likely to include, for instance, improving crop rotations, adoption of cover cropping, composting, mulching and conservation tillage practices. Regenerative agriculture also includes actions to prevent pollution such as prevention of erosion, nutrient runoff and leaching to improve water quality and reduction of greenhouse gas emissions by improving the farm carbon footprint. It also includes taking measures to improve biodiversity, preferably at farm and landscape level, and a strict prohibition on conversion of natural habitats. The latter is line with Unilever's commitment to protect natural ecosystems, with a cut off point for conversion of natural ecosystems of December 31st, 2015.

We have developed specific implementation guidance for Soils, Water, Climate, Biodiversity and Livelihoods.

1 Production forest for paper & board

POTENTIAL IMPLEMENTATION CHALLENGES

The Principles represent a holistic approach to regenerative agriculture. They are wide-ranging in scope and apply to diverse geographies and farming systems (from smallholders to large plantations). The ethos of the Principles is that farmers need a fair return for their labour, while nature thrives, and food security can be met. Implementation challenges vary enormously. In the developed world, farmers struggle to make a return on investment and to cope with the impacts of climate change. So, they need support to understand the need for, and the benefits of, applying regenerative practices, including developing new income streams through e.g. payments for ecosystem services. Elsewhere, the problems are different. Smallholders, in particular, need support to organize themselves, get access to the necessary training and farm inputs, and to provide a living income for their families. We operate several programmes with smallholders in different crops.

SOILS

Principles

- Keep living roots in the ground at all times
- Apply zero-till or conservation till practices
- Prevent erosion through e.g. cover cropping, mulching, terracing
- Apply crop rotations with both shallow and deep rooting crops

Regenerative metrics

- Soil Organic Matter/Soil Organic Carbon
- Total soil microbial biomass
- Soil microbial biomass diversity
- Number of earthworms

EXPLANATION

Soil is not renewable in a short time and under most conditions; around 1cm is formed every 100 to 400 years, rendering active soil management critical to securing increased productivity, enhanced resilience and lowering emissions. The mapping of on-farm soil characteristics will inform appropriate measures for adoption.

Crops and pasture need nutrients – Nitrogen, Phosphate, Potassium and Micronutrients – as we are continually removing them from farmland with the products we take from the land, as well as there being losses to both air and water. Nitrogen supplies are particularly problematical as chemical N fixation involves the expenditure of a great deal of energy and over-application leads to the production of particularly potent greenhouse gases (N_2O) and the pollution of waterways. Regenerative agriculture requires adoption of techniques to avoid overapplication of nutrients, losses to air and water are minimized, and that measured amounts of crop residues, compost and animal manures are used wherever practical to substitute for inorganic fertilisers. By doing this, soils will be nourished and water quality improved.

Regenerative agriculture requires active soil management to improve soils, to invigorate soil ecosystems and reduce erosion to minimal levels. Where organic matter levels are sub-optimal techniques to improve the quantity and quality of soil organic matter (such as reducing the frequency or depth of tillage or using green or animal manures) will usually improve the water-holding capacity and structure of soil and enable slower-release of nutrients as well as increasing the sequestration of carbon.

Erosion is a major cause of soil loss, a reduction in soil quality and water-holding capacity (and increases GHG emissions), as topsoil is inevitably preferentially lost. Monitoring soil cover and effectiveness of land management systems in place (reducing depth or frequency of tillage, cover crops, green manure, ley crops, crop residue retention, drains, bunding, terracing, contour planting, windbreaks, above-field tree planting, living fences, hedgerows etc.) to minimise erosion should then be incorporated into the management plan.

For large-scale farms on appropriate soils, the adoption of controlled traffic farming should reduce the level of overall compaction.

The potential for improving Soil Organic Matter by using compost, organic material additions (e.g. mushroom farm waste,) or by retaining crop residues should be evaluated where soil organic matter is less than optimal. In perennial cropping systems in particular, it is important to leave prunings in the fields (e.g. for tea and cocoa), windrowing palm fronds in oil palm estates for slow release of nutrients and, in oil palm estates, to apply co-composting of Empty Fruit Bunches with Palm Oil Mill Effluent, using this compost on the estates near the mill to reduce the need for fertilizer inputs. Retaining water in the soil will become more important as short or prolonged droughts become more common, dryland agriculture more difficult and irrigation water scarcer.

Pasture land should be protected by planning grazing in relation to grass growth, soil condition and the carrying capacity of the land. This will usually mean some form of managed intensive or rotational grazing.

WATER

Principles

- Protect water ways from erosion and runoff, e.g. through maintenance of riparian areas or buffer zones along waterways
- Select the most efficient irrigation technology and equipment (e.g. drip irrigation
- Optimise irrigation plans in accordance with water availability in the watershed and the water needs of other users in the watershed

Regenerative metrics

- Nitrate levels in tile water
- Turbidity or sedimentation rate in water bodies adjacent to farmland
- Water footprint of irrigated crops

EXPLANATION

In a warmer world, with more unreliable rainfall and more frequent floods, and where there are more conflicting demands for water, farmers must adapt by using scarce water more efficiently, managing floodwaters and drainage as well as possible, and minimizing water pollution from farm runoff.

Nutrification and eutrophication of surface waters is a problem in many parts of the world, partly through erosion, partly through runoff. Nitrate levels in groundwater are often above recommended limits and lead to disturbance of aquatic biodiversity. For example, the hypoxic zone in the Gulf of Mexico is caused by erosion and runoff in the Mid-West of the USA, more than 1,500 miles north of the Gulf.

Certain Crop Protection Products can also impact aquatic biodiversity since they act as endocrine disruptors for fish.

Sustainability considerations for irrigation systems include water-use efficiency/water saving, impacts on soils, impact on pests, diseases and weeds (and associated controls), integrating sensor technology to refine timing and location of irrigation, "future-proofing" to adapt to foreseeable changes in water availability or quality (for example if aquifers are becoming more saline) or the availability of more salt-tolerant crop varieties.

CLIMATE

Principles

- Keep living roots in the ground at all times
- Apply zero-till or conservation till practices
- Avoid nitrogen fertilisers with a high potential for nitrification (e.g. ureum)
- Plant trees for different purposes, e.g. timber, shade, windrow, animal feed, bird habitat

Regenerative metrics

- Do not convert natural habitats
- Nitrogen Use Efficiency
- Crop Carbon Footprint
- Fossil Fuel Use on farm

Deforestation contributes to about 15% of global warming, since it brings additional carbon dioxide in the air (by burning forests) and it reduces the potential for carbon sequestration if the forest had been left standing.

Farming is responsible for 20% of all Greenhouse Gas Emissions in the world. Most of that is caused by use of nitrogen fertilizer, which, through natural processes in the soil, is partly being converted to nitrous oxide, N_2O (so-called nitrification). N_2O has a Global Warming Potential of 290 times that of carbon dioxide (CO_2). Overapplication of any nitrogen fertilizer therefore needs to be avoided at all times. Some GHG emissions are from farm machinery fuel use.

Regenerative Agriculture requires not only that farmers improve their energy efficiency and reduce GHG emissions, but also move towards net carbon sequestration on their farms. Carbon sequestration in soils happens through incorporation of plant material in soils, through earthworms and microbial activity. In order to optimize this process it is essential to have crops in the rotation with different rooting depths. Deep rooting crops (i.e. over 50 cm) leave more plant material in the soil and build carbon stocks which are less susceptible to being lost through shallow soil disturbance.

Trees in particular have great capacity for storing carbon, both in their above ground biomass and in their root system. It is recommended to consider different types of trees for different functions, e.g. as windrows, for providing shade, as fodder for cattle (from fallen leaves or prunings).

BIODIVERSITY

Principles

- Do not convert natural habitats
- Create conditions and apply practices which increase plant and animal species numbers
- Create specific habitats for predatory insects which can control pest insects
- Only apply crop protection practices which have no influence on non-target species
- Apply planting patterns which avoid monotony (e.g. intercropping, strip farming, pixel farming)

Regenerative metrics

- Number and variety of crops in the rotation
- Number and abundance of species, i.e. insects, earthworms, birds, rodents, predatory birds
- Presence of landscape elements which provide habitats for animal species (e.g. field margins, ponds, hedges, windrows, shadow trees, pockets of forest or coppice)
- Soil microbial biomass and diversity

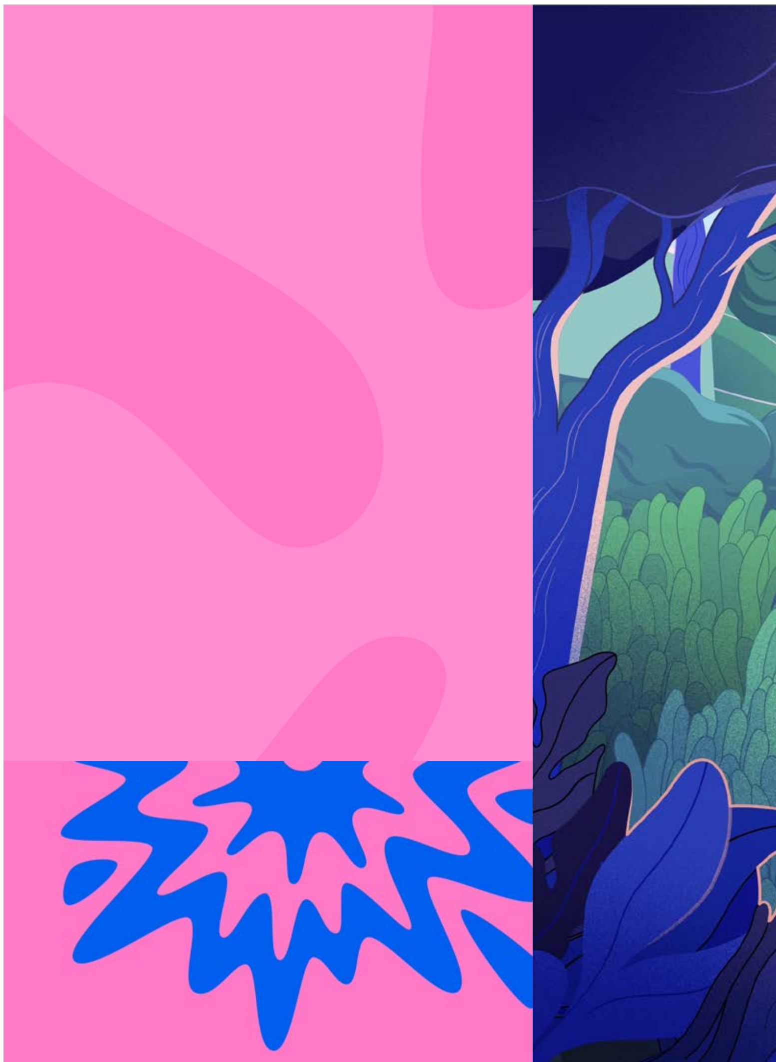
Many palm oil estates have pockets of remaining forest, and many have riparian strips along rivers. These can and should be managed for optimum biodiversity values. Consideration should be given to creating wildlife corridors between remaining areas of nearby forest. Tea estates in many cases maintain strips of natural vegetation between fields, either as windrows to protect from low temperatures in winter or to provide shade in tropical climates. These strips should be managed for optimum biodiversity value, e.g. by monitoring presence of apex species (such as Colobus monkeys in Kenya). Cocoa production in West Africa can be made more regenerative by implementing agro-forestry programmes, with a mixture of trees for shade, for timber value, for fruit, or leguminous trees for fixing nitrogen from the air.

EXPLANATION

Ecosystems support climate stability, water supplies, soil structure, pest and disease control. But they are degrading at an unprecedented pace world-wide. Species are being lost at a scale described as a "Mass Extinction". Farmers – as large-scale land managers – are in a unique position to help slow this alarming decline, but may not be aware of the best actions to take locally, and need to be valued by their communities and customers for the work they do.

Interventions that will enhance the farmed land-scape for biodiversity and also have positive impact on carbon sequestration and/or reduce emissions e.g. perennial plantings to reduce wind damage, provide shelter for animals and reduce soil erosion) are particularly important for regenerative agri-culture. Biological pest control can be enhanced by maintaining field margins with wild plants and flowers to support pollinators and predatory insects.

Natural regeneration of trees, and tree planting is encouraged because of its biodiversity and carbon sequestration values.



LIVELIHOODS

Principles

- Provide smallholder farmers access to training in regenerative agricultural practices, farm inputs, finance, land tenure and technology
- Provide smallholder farmers access to markets
- Support smallholder farmers in income diversification
- Support women economic empowerment
- Provide men and women with training in business skills
- Support professionalization of farmer cooperatives

Regenerative metrics

- Number of farmers organized in cooperatives
- Number of farmers trained
- Number of women engaged in economic empowerment programmes
- Number of farmer household incomes at the Living Income benchmark

EXPLANATION

There are approximately 500 million smallholder farmers in the world (with land holdings of 2 – 25 ha). They are characterized by using mainly family labour, limited training, limited access to capital and inputs, lack of formal land tenure, and limited access to improved technology. In many cases, particularly in Africa, they exhaust their soils almost by default, since all parts of the crops they grow are being used, either as food, feed, roof thatching or timber. This leaves them vulnerable to poverty, hunger and the impacts of climate change. As such, smallholder farmers present a huge challenge and a huge opportunity to adapt and introduce the principles of regenerative agriculture.

Implementation guide for Soils, Water and Greenhouse Gases/Climate

SOIL

Soil results from the interaction of biological processes with the weathering of underlying geology and soils are therefore not renewable in a short time. When forming from rocks and sediments around 1cm of mineral soil is formed every 100 to 400 years, rendering active soil management critical to securing increased productivity, enhancing resilience and lowering emissions. Peat soils (also known as histosols) contain more than 20% organic matter (by weight) formed primarily from incompletely decomposed plant remains. This often occurs where near-permanent wetness (sometimes coupled with high acidity or cold conditions) almost completely stops decomposition. The mapping of on-farm soil characteristics will inform the selection of the most appropriate regenerative practices for adoption.

A healthy soil is able to sustain crop and livestock productivity as well as maintain or enhance environmental benefits. A healthy soil is able to deliver, over the long term, a range of important functions linking climate, water and biodiversity:

- Exchanging gases, such as carbon dioxide, with the atmosphere;
- Regulating the flow of water and rainfall in the water cycle;
- Providing nutrients for plant growth by degrading organic matter and transforming chemical fertilizers;
- Storing, degrading and transforming organic materials and contaminants that are applied through animal and human activities or deposited by flood waters and aerial deposition.
- In healthy soils, interactions between chemistry (pH, nutrients), physics (soil structure and water balance) and biology (earthworms, microbes, plant roots) are in balance for each particular place, environment and cropping system. Different measures of soil health are used in different regions and cropping systems, because soils in any location are the unique result of the specific local interactions of climate, geology, hydrology and management. For example, healthy peat soils have different properties and functions than healthy mineral soils. However, there are some general principles that can be used to aid selection of management approaches that help maintain healthy soils.

Regenerative agriculture requires active soil management to improve soils, to invigorate soil ecosystems and reduce erosion to minimal levels. There is a growing amount of evidence that shows increasing inputs of organic matter (through plants and other organic materials) and reducing soil disturbance can act together to promote improvements in soil structure and increase the activity of the soil biology. Where organic matter levels are sub-optimal, techniques to improve the quantity and quality of soil organic matter (such as reducing the frequency or depth of tillage or using green or animal manures) will usually improve the water-holding capacity and structure of soil and enable slower-release of nutrients as well as increasing the long-term storage of carbon. Regenerative agriculture also requires adoption of techniques to avoid overapplication of nutrients and minimize losses to air and water. It also requires measured amounts of crop residues, compost and animal manures to be used wherever practical to substitute for inorganic fertilizers. By doing this, soils will be nourished and water quality improved. Increasing benefits for soil health are likely to occur where soil-improving practices are adopted in combination.

WATER

Over the last century the natural hydrological cycle in most river basins has been subjected to extensive human changes with the construction of reservoirs, land-use changes, river abstractions, groundwater abstractions, inter-basin diversions, etc. Such changes significantly alter river flows and the hydrology of the basin. Demands on water are multi-sectorial and, in most watersheds, irrigation is already in competition with drinking water, industrial, power generation, recreational and environmental uses: most of which command a higher price. Within many Near East and African countries, current water resources are almost fully exploited, and supplies will have to double over the next 20 to 30 years to maintain the current level of provision. Global warming is likely to have a major impact on the hydrological cycle often leading to less predictable rainfall patterns and more frequent floods, therefore the conflicting demands for water will increase. Understanding the hydrology of the local watershed will inform the selection of the most appropriate regenerative practices for adoption.

Water quality in both surface and groundwaters has also changed markedly as a result of agricultural intensification. Nutrification and eutrophication of surface waters is a problem in many parts of the world, partly as a result of erosion (moving soil-adsorbed pollutants such as phosphate), and partly through runoff and drainage (moving soluble pollutants such as nitrate). 38 percent of water bodies in the European Union are under pressure from agricultural pollution[1]. This is not just a local problem as the impact can accumulate as you move downstream. For example, the hypoxic zone in the Gulf of Mexico is caused by erosion and runoff in the Mid-West of the USA, more than 1,500 miles north of the Gulf. Certain Crop Protection Products can also impact water quality, causing problems, especially where it is abstracted for drinking, and may also directly harm aquatic species or disrupt the food chain. Nitrate is also the most common chemical contaminant in the world's groundwater aquifers.

Regenerative agriculture requires careful attention to water management on farm with a focus on maintaining or improving the watershed for both water flow and water quality, rather than depleting or damaging them. Consequently, farmers will need to adapt by using water more efficiently, managing floodwaters and drainage as well as possible, and minimizing water pollution from farm runoff. Irrigation plays a strategic role in increasing productivity and rural livelihoods. Currently 16% of the global cropped area is irrigated. Therefore, regenerative agriculture will require a focus on adoption of practices that maximize water use efficiency in both rainfed and irrigated systems and adopt irrigation only where it is sustainable to do so. Careful irrigation management is required to circumvent problems of salinization, and the water consumption rate must not exceed the natural recharge rate of the water source. A wider range of factors need to be taken into account within irrigation systems such as water-use efficiency/water saving, impacts on soils, impact on pests, diseases and weeds (and associated controls), integrating sensor technology to refine timing and location of irrigation, "future-proofing" to adapt to foreseeable changes in water availability or quality (for example if aquifers are becoming more saline) or to adopt more salt-tolerant crop varieties. By taking an integrated approach to water management, farmers can ensure they have the water needed for optimum irrigation and support a healthy aquatic ecosystem.

1 FAO. Water pollution from agriculture report. http://www.fao.org/3/a-i7754e.pdf

CLIMATE

Farming is responsible for 20%[2] of all Greenhouse Gas (GHG) Emissions in the world. Although agriculture produces carbon dioxide (CO_2) directly as a result of fossil fuel use by machinery (e.g. in cultivation), very significant amounts of methane (CH_4) and nitrous oxide (N_2O), two powerful greenhouse gases, are also emitted. N_2O has a Global Warming Potential 265 times[3] that of CO_2, so relatively small N losses from agricultural systems, as N_2O, have a large impact. A major source of N_2O is nitrogen fertilizer, which through natural processes in the soil, is partly converted to nitrous oxide, (during processes of nitrification and denitrification). Optimizing nitrogen supply is important to optimize photosynthesis which captures CO_2 from the atmosphere but overapplication of any nitrogen fertilizer needs to be avoided at all times.

Land use change is equally important as a cause of climate change. Deforestation contributes to about 15%[4] of global GHG emissions, since when trees are felled they release the carbon they are storing into the atmosphere (often as a result of burning) and the loss of forest area reduces the potential for on-going carbon sequestration into the trees. Understanding land use potential requires mapping of high diversity forests, wetlands and basin peats, as well as the factors that determine crop production potential so that the farmed landscape is considered as an integrated whole. This will enable improvements in resource use through sustainable intensification to be targeted to land with the highest potential and will inform the selection of the most appropriate regenerative practices.

Regenerative agriculture requires a multi-pronged approach with improvements in on farm energy efficiency and reductions in GHG emissions, together with actions that promote long-term net carbon storage on farms. Long-term carbon storage in soils happens when inputs of organic materials, via crops (residues and roots) and recycled organic materials (e.g. food processing wastes) exceed losses via decomposition. Where organic matter levels are sub-optimal, there is good evidence that increasing inputs of organic matter (through plants and other organic materials) and reducing soil disturbance can act together to increase the long-term storage of carbon. In addition, deep rooting crops (i.e. over 50 cm) leave more plant material in the soil and build carbon stocks which are less susceptible to being lost through shallow soil disturbance. Trees have great capacity for storing carbon, both in their above ground biomass and in their root system. Regenerative agriculture should integrate different types of trees within the farmed landscape for different functions, e.g. as windrows, for providing shade, as fodder for cattle (from fallen leaves or prunings).

2 FAO data from 2017, http://www.fao.org/economic/ess/environment/data/emission-shares/en/

3 Greenhouse Gas Protocol, https://www.ghgprotocol.org/sites/default/files/ghgp/Global-Warming-Potential-Values%20%28Feb%2016%202016%29_1.pdf

4 https://www.scientificamerican.com/article/deforestation-and-global-warming/

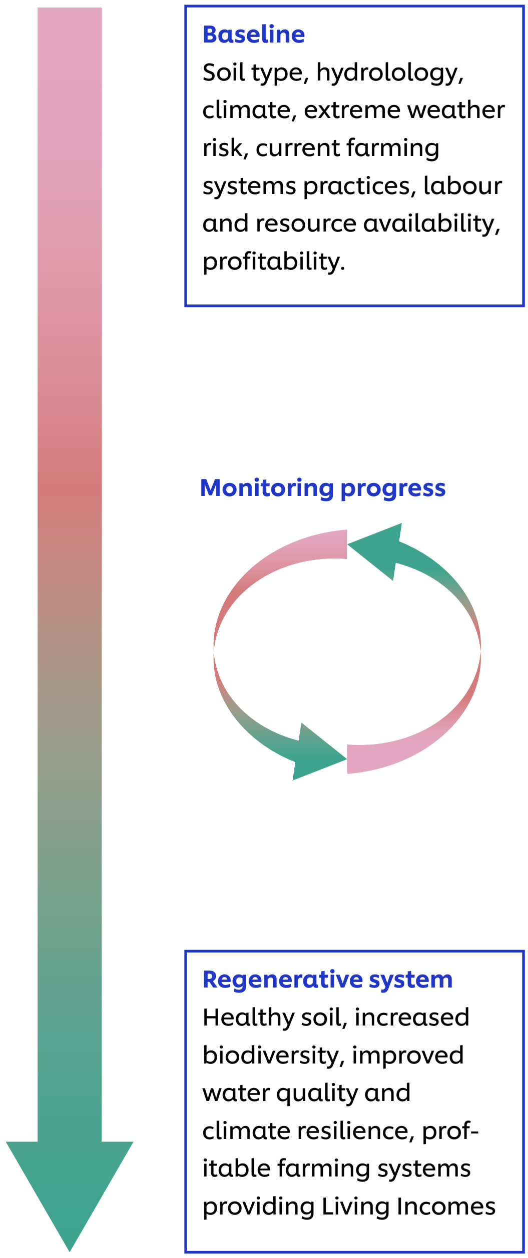
UNILEVER REGENERATIVE AGRICULTURE PRINCIPLES FOR SOIL, WATER and CLIMATE

Putting regenerative agriculture principles into practice for any farming system means knowing your site and system and then selecting the best management options so that the system becomes optimally adapted for the local site

SOIL	WATER	CLIMATE
• Keep living roots in the ground at all times	Protect waterways from nutrient leaching	Keep living roots in the ground at all times
• Apply conservation tillage practices with zero-till where possible	Protect waterways from runoff and erosion	Apply conservation tillage practices with zero-till where possible
• Prevent erosion	Optimizing water use efficiency by matching crop demand to water availability	Optimize use of nitrogen fertilizers -select the right product, rate and timing
• Have a diverse crop mix	Optimize irrigation plans in accordance with water availability in the watershed	Preserve existing high C storage habitats
• Feed the soil and the crops	Select the most efficient irrigation technology and equipment	Plant trees for different purposes, e.g. timber, diversified food crops, animal feed, shade, windrow, bird habitat.

MONITORING CHANGE

The Principles require the implementation of a process of change rather than the one-time adoption of a single set of practices. Implementation of regenerative agriculture is a journey which will need to take place across many aspects of the farming system over several years, and where the benefits may take decades to be fully measurable. The process of change will be different for different farming systems and may vary for different farms with the same farming system, where climate, hydrology, soils or socio-economic conditions are different.



The process of putting regenerative agriculture principles into practice for any farming system begins by having a good baseline understanding of the current site and system. Knowing the condition of the system before the process begins is key to selecting the best management options (route-planning) so that the system can become optimally adapted for the local site.

On-going monitoring is an important part of the journey. Indicators are used to show progress towards the outcomes, the direction or speed of change, and/or changes in environmental or socio/economic conditions

On-going monitoring can allow adjustment to the on-going process of system change, to meet new challenges or address new constraints, but always with the ultimate destination in mind. A balanced approach will be needed so that progress is made towards all the final goals. These indicators include process indicators, as well as tracking the direction and extent of change in some of the baseline indicators

Regenerative metrics (KPIs) show that the system is beginning to achieve its goals. They are not substitutable, and all the goals need to be met if a farm is to deliver a regenerative system. These metrics may include some of the same measures that were used as part of the baseline, but these indicators are used to show that the new targets or thresholds have been reached.

More information on Putting monitoring into practice is given later.

Putting regenerative agriculture principles into practice needs to be underpinned by robust baseline measurement and monitoring
within the farming system and the local environment

SOIL	WATER	CLIMATE
• Soil type and texture • Soil depth • Nutrient status • Soil organic matter content • Soil microbial activity • Erosion risk	• Watershed hydrology • Eutrophication status in local surface water • Sediment issues in local surface water • Water volume used for irrigation each year	• Soil type and texture • Soil organic matter content • Area and condition of high diversity forests, wetlands and basin peats under natural vegetation within the farmed landscape • Nitrogen fertilizer used each year • Fossil fuel used each year
• Documented adoption of soil-improving practices • % of the year with full ground cover • Presence of physical (compaction) or chemical limitations to rooting • Soil organic matter content (every 5 years) • pH and nutrient status adequate for crop growth • Soil microbial activity • Erosion risk	• Documented nitrogen management plan • Full ground cover in high erosion risk periods • Sufficient but never excessive soil nutrient status • Documented irrigation planning at watershed level • Irrigation scheduling • Same or reducing water volume used for irrigation each year gives same or increased yields	• High carbon habitats protected • Nitrogen use efficiency increasing • Carbon footprinting implemented to monitor climate impacts • Reducing fossil fuel use on farm sustained over several seasons • Long-term trend of increasing soil organic matter in mineral soils and tree cover on-farm
Healthy soil • Soil Organic Matter is higher than average for soil type and level is maintained or improving over time • Soil microbial biomass activity and diversity is higher than average for the soil type • pH and soil nutrient status is optimum for crop growth • Soil structural stability is high, especially in the surface soil	**Clean and sufficient water in the watershed** • Nitrate and phosphate levels in drainage or local surface water is less than threshold for eutrophication • Low suspended sediment loads (clear water) in water bodies adjacent to farmland even following high rainfall incidence • Abstracted Water footprint of irrigated crops lower than the average for the crop type grown in the same climate region	**Climate resilient, zero carbon farming system** • Improving condition of high diversity forests, wetlands and basin peats under natural vegetation within the farmed landscape • Nitrogen Use Efficiency higher than average for farming system • Fossil Fuel Use on farm per hectare lower than average for farming system • High % tree cover compared with the levels typical in the region • Crop Carbon Footprint lower than average for crop grown in the same climate region

Making a difference to SOIL HEALTH - implementation opportunities

Putting regenerative agriculture principles into practice means knowing your site and system
and then selecting the best management options so that the system is optimally adapted for the local site

Use local soil knowledge, observation and analysis to understand soil type

Take soil, slope and extreme weather risks into account when you plan your cropping system

Peat soils
Drainage, depth and decomposition status determine the character of the soil together with the permeability of underlying sediments

Mineral soils
Sand and silt content together with clay type and content determine the character of the soil together with local hydrology

CHOOSE SOIL-SMART PRACTICES

	If	Tree / plantation crops Not all these practices will be appropriate in smallholder systems	Arable crops	Pastures
Keep living roots in the ground at all times	Then consider ...	• ... cover crops grown in alleys	• ... catch and cover crops grown between cash crops	• ... managing stocking density carefully to prevent overgrazing; implementing adaptive rotational grazing systems
Apply conservation tillage practices with zero-till where possible		• ... minimising soil disturbance in alleys	• ... zero-till approaches to establish grains, pulses and oilseed crops; minimise tillage for root crops and field vegetables	• ... rejuvenating grassland by overseeding rather than full cultivation whenever possible
Prevent erosion		• ... plantation establishment that minimises bare soil using cover cropping; maintaining soil surface cover with residues; terracing and contour farming	• ... crop residues as a surface mulch; minimising bare soil within the rotation; contour farming	• ... removing stock from wet ground to minimise compaction and pugging/ poaching of the vegetation
Have a diverse crop mix		• ... diverse species mixes in alleys; intercropping a wider variety of tree species in the plantation	• ... rotations with both shallow and deep rooting crops; intercropping approaches including agroforestry	• ... increasing pasture diversity with grasses, legumes and herbs
Feed the soil and the crops		• ... using organic materials as well as mineral fertilizers	• ... using organic materials as well as mineral fertilizers	• ... using legumes within grasslands to supply nitrogen; maintaining pH and soil nutrients at optimal levels
		Use observation and analysis of crops, soil health and local environment to monitor effectiveness		

Making a difference to WATER - implementation opportunities Putting regenerative agriculture principles into practice means knowing your site and system and then selecting the best management options so that the system is optimally adapted for the local site.	**Drought-risk sites** Shedding sites with shallow or very permeable soils especially where local climate has rainfall deficits in some seasons
Use local knowledge, observation and analysis to understand the hydrology within the watershed Take slope, climate (water balance) and extreme weather risks into account when planning the cropping system	**Flood-risk sites** Receiving sites especially where local climate has surplus rainfall in some / all seasons

CHOOSE WATER-SMART PRACTICES

	If	Tree / plantation crops Not all these practices will be appropriate in smallholder systems	Arable crops	Pastures
Protect waterways from nutrient leaching	Then consider ...	... precision application of nitrogen fertilizers (right rate, right place); cover crops grown in alleys	...optimizing rate and timing of nitrogen fertilizers and livestock manures to minimise soil nitrate in leaching risk periods; catch crops grown	... optimizing rate and timing of nitrogen fertilizers and livestock manures to minimise soil nitrate in leaching risk periods
Protect waterways from runoff and erosion		... plantation establishment that minimises bare soil using cover cropping; maintaining soil surface cover with residues; terracing and contour farming; managed sustainable drainage systems	... crop residues as a surface mulch; minimising bare soil within the rotation; contour farming; managed sustainable drainage systems	...preventing livestock access to waterways; removing stock from wet ground to minimise compaction; prevent overgrazing; managed sustainable drainage systems
Optimize water use efficiency		...matching crop water demand for yield and quality; where irrigation is present use irrigation scheduling and careful water management	...matching crop water demand for yield and quality; where irrigation is present use irrigation scheduling and careful water management	.. providing efficient and effective drinking water sources
Optimize irrigation plans in accordance with water availability in the watershed		...assessing irrigation need carefully considering crop demand, net rainfall and the demands of other users for surface and groundwater in the watershed; adopting irrigation only as part of a considered long-term strategy.	...assessing irrigation need carefully considering crop demand, net rainfall and the demands of other users for surface and groundwater in the watershed; adopting irrigation only for key crops and as part of a considered long-term strategy.	...assessing irrigation need carefully considering fodder requirements, net rainfall and the demands of other users for surface and groundwater in the watershed; adopting irrigation only as part of a considered long-term strategy.
Select the most efficient irrigation technology and equipment		...adopting drip irrigation systems where possible	...adopting sprinkler irrigation systems where possible	...wherever possible, designing effective dryland pasture systems
		Use observation and analysis of drains and waterways together with crop water footprints to monitor effectiveness		

Making a difference to CLIMATE - implementation opportunities

Putting regenerative agriculture principles into practice means knowing your site and system
and then selecting the best management options so that the system is optimally adapted for the local site

Use local knowledge, observation and analysis to understand the spatial patterns of profitability across the cropping landscape

Take land use suitability and extreme weather risks into account when you plan your cropping system

Non-cropped and marginal cropping land
(gross margin regularly zero) best suited to enhancement of biodiversity and/or renewable energy

Highly productive cropping land
(gross margin regularly positive) where improvement in resource use through sustainable intensification should be targeted

CHOOSE CLIMATE-SMART PRACTICES

	If	Tree / plantation crops Not all these practices will be appropriate in smallholder systems	Arable crops	Pastures
Keep living roots in the ground at all times	Then consider …	… cover crops grown in alleys	… catch and cover crops grown between cash crops	… managing stocking density carefully to prevent overgrazing; implementing adaptive rotational grazing systems
Apply conservation tillage practices with zero-till where possible		… minimising soil disturbance in alleys	… zero-till approaches to establish grains, pulses and oilseed crops; minimise tillage for root crops and field vegetables	… rejuvenating grassland by overseeding rather than full cultivation whenever possible
Optimize use of nitrogen fertilizers - select the right product, rate and timing		… using organic materials as well as mineral fertilizers to meet crop nitrogen need	… optimizing rate and timing of nitrogen fertilizers and livestock manures to minimise soil nitrate in warm/moist periods; controlled-release or other mitigated fertilizers; including legume crops in the rotation	… … using legumes within grasslands to supply nitrogen; optimizing rate and timing of nitrogen fertilizers and livestock manures to minimise soil nitrate in warm/moist periods
Preserve existing high C storage habitats		… identifying and actively conserving high diversity forests or other natural vegetation, wetlands and basin peats under natural vegetation within the farmed landscape; restoring such habitats where possible e.g. by drain blocking, excluding grazing.		
Plant trees for different purposes, e.g. timber, shade, windrow, animal feed, bird habitat.		… intercropping a wider variety of tree species in the plantation	… introducing hedges, shelter belts; integrated silvoarable agroforestry systems	… integrated silvopastoral agroforestry systems; integrating fodder trees /shrubs, shelter belts and shade trees
		Use observation and analysis of energy and fertilizer use, C storage in trees and soils together with crop carbon footprints to monitor effectiveness		

Technical background

Keep living roots in the ground at all times

SOIL-SMART CLIMATE-SMART

The roots of plants have three functions for plant growth:

- Anchoring the plant and holding the stem upright and steady
- Absorbing water and dissolved minerals from the soil and conducting them to the stem
- Storing reserves of nutrients and water, especially in tuberous crops

Roots are also a dynamic and varied component of the living soil.

Plant roots have a central role in the development and stabilization of soil structure

Roots are ecosystem engineers that change the soil pore space as they grow through it. Root mucilage, exuded at the root tip, and root-produced polysaccharides and glycoproteins act as glues and gums which bind clay, silt, sand grains and soil organic matter together to create soil crumbs and aggregates which improve soil structural stability. As roots grow and develop, they also compress the soil in their vicinity creating a network of continuous channels that remain open for some time after the root decomposes, creating avenues for the movement of water, air, soil organisms and the next season's roots.

Plant roots are an energy pipeline into the soil

Plant roots also serve as an important habitat for a range of soil organisms, including symbiotic and other endophytic bacteria, mycorrhizal fungi, root pathogens and herbivores. Direct damage to plant roots by root feeding and parasitic organisms can be considerable (particularly that caused by some beetle larvae and nematodes). Roots also feed soil organisms through the mucilage and other root exudates released into the soil. Up to 10% of the carbon fixed through photosynthesis is released as sugars and organic acids from the roots and this provides an important energy source for the soil ecosystem. As a result, large increases in the soil bacterial community and changes in its composition are found in the zone around the root (often known as the rhizosphere) and this also stimulates the activity of bacterial grazers such as protozoa and nematodes. Together these interactions tend to increase plant nutrient availability in the rhizosphere. Bacterial and fungal activity also produces polysaccharides and glycoproteins which, with those produced by the roots, help to glue soil particles together and stabilize aggregates. These interactions help to trap carbon in the soil; so deep-rooting plants can have additional benefits for carbon sequestration.

Plant roots and soil micro-organisms communicate with one another

Understanding how roots interact and communicate with soil organisms through the release of exudates and other metabolites is a rapidly emerging area of research that may provide new opportunities for plant protection and growth promotion in the near future.

> The unique long-term bare-fallow site at the Rothamsted Highfield site (UK) has shown that where no living roots were present (and no other organic matter additions made) for over 50 years, organic matter contents and the population size of the soil microbial and mesofaunal communities declined very significantly and soil structure became very unstable.

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Prevent erosion; Protect waterways from runoff and erosion

SOIL-SMART WATER-SMART

Soil particles can be blown away or washed away – both processes are erosion, by wind and water respectively.
Erosion processes occur without human intervention (in fact erosion by water is a dominant geomorphic process that has shaped much of the Earth's land surface over millennia), but erosion is usually accelerated in agricultural systems compared with native vegetation. Wind erosion is a major problem in arid and semi-arid areas. Soil erosion can have impacts over large areas, not just at the site where soil is lost. Dust storms once started can travel large distances affecting air quality, with potential impacts on human health, and water erosion can lead to extensive flooding of valleys, silting up of rivers and have a negative impact upon aquatic ecosystems. On farm, erosion is a major cause of soil degradation, as topsoil is lost preferentially.

For erosion to occur soil particles must be first detached and then moved. Climate, soil, topography and land use factors all combine to determine the erosion risk and knowing how these operate can help to identify opportunities for mitigation.

Climate The more energy present in the wind, raindrop impact or surface run-off, the larger the particles that can be moved. The climatic factors affecting water erosion risk are rainfall amount and intensity; for wind erosion, wind speed and direction are important.

Soil For water erosion, soils that are high in silt have been shown to be most at risk of erosion. For wind erosion, soils at highest risk are fine sandy and peaty soils. However, it is not only the soil texture but also the soil structure that is important, i.e. how the individual soil particles are held together in soil aggregates by chemical bonds and glues (polysaccharides and glycoproteins) produced by roots and biological activity. When aggregates are not stable to raindrop impact then they can become dispersed and can generate a dense layer (cap) at the soil surface, which reduces infiltration and exacerbates run-off. Compaction below the soil surface can also reduce water movement downwards through the soil and increase run-off.

Topography Slope length, steepness and shape are also important in determining the risk of water erosion. Run-off accumulates downslope but can also be channeled by slope shape into rills and streams.

Land use This has more effect on erosion than any other single factor. Climate and soil usually determine the type of vegetation present, but the location and amount of vegetation is determined by management. Erosion risk is significantly higher on bare soil; the presence of a vegetative canopy or other surface cover reduces the energy of wind or water and hence the erosion risk.

It is also important to keep in mind these factors interact. When the rainfall rate exceeds the infiltration capacity of the soil, runoff collects and flows across the land surface generating the hydraulic forces that erode and transport sediment downslope and can form rills and gulleys. For example, early in a wet season, the soil can often absorb moderate intensity rainfall events through infiltration and storage. However, as the soil wets up, additional soil storage capacity for new rainfall is reduced and more run-off will result from a rain event of the same intensity.

Interventions to prevent erosion and to restrict its impact target a number of different processes.

- Reduce rainfall impact, run-off and/or wind speed at the soil surface.
  e.g. windbreaks, cover/nurse crops, mulches (often of crop residues), contour cultivation, terracing
- Stabilize the soil surface.
  e.g. improve aggregate stability by increasing soil organic matter and biological cycling; reduce overgrazing risks; use chemical binders or matting in high risk areas
- Trap soil particles already in motion.
  e.g. use vegetated buffer strips and bunds along waterways, include temporary ponds in flow pathways, use living fences/ hedgerows

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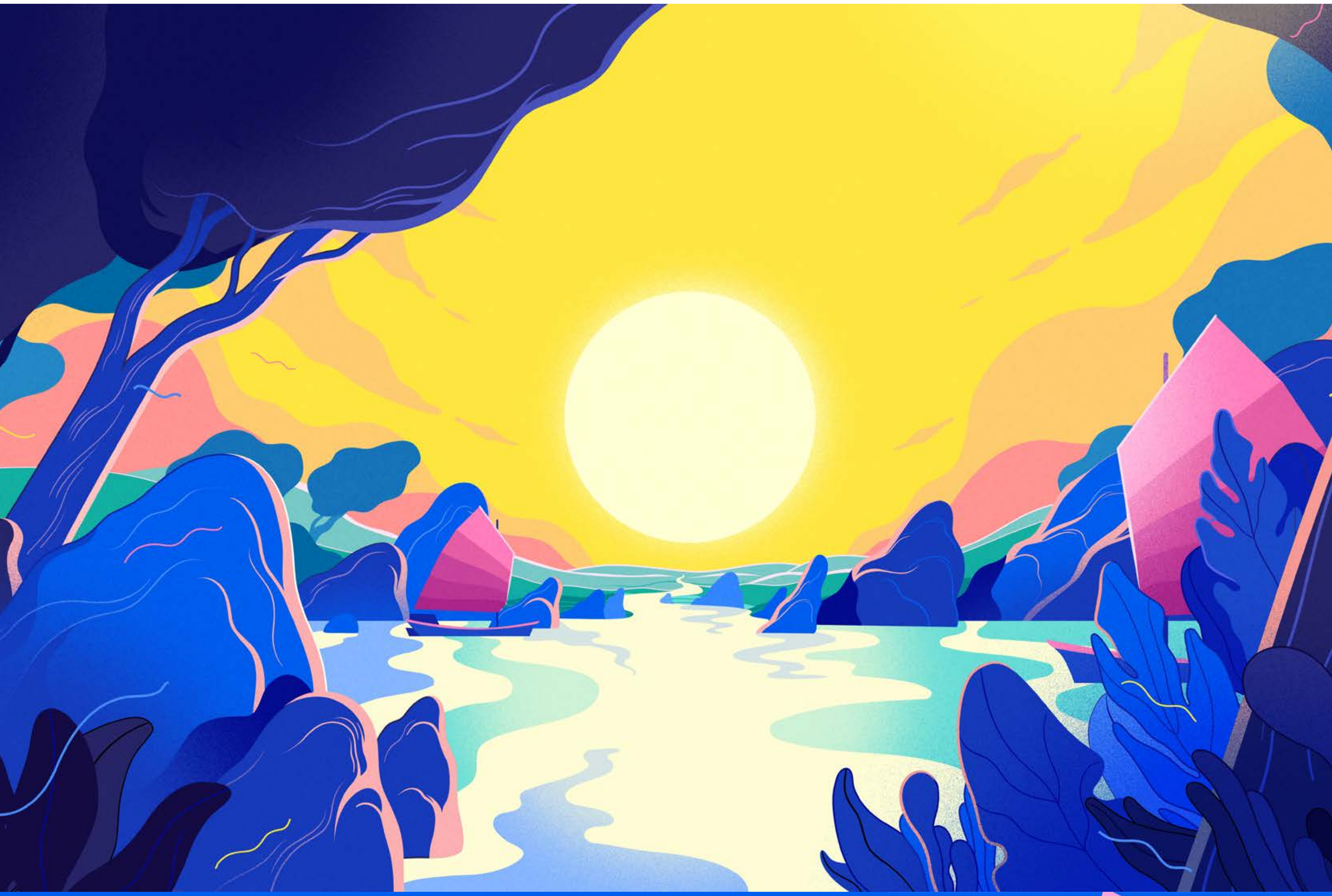

Apply conservation tillage practices with zero-till where possible

SOIL-SMART CLIMATE-SMART

Tillage is the manipulation, usually mechanical, of soil to modify conditions for crop production. Most tillage operations reduce soil density in the disturbed zone and a range of different implements are used to loosen, mix or crush the soil. Tillage is used for:

- seedbed preparation,
- remediating compaction or breaking hard-pans,
- incorporating crop residues, fertilizers or other amendments and
- weed management, (about half of tillage operations are used for this).

Tillage operations are usually time intensive, often costly and energy intensive, and have high capital requirements in mechanised systems.

Tillage significantly affects certain soil characteristics such as infiltration, evapotranspiration processes and soil temperature. However, the change in soil properties following any tillage operation, even where the same implement is used, depend on a combination of equipment factors (including depth, energy input, speed) and soil factors (including water content, texture, residue cover). Therefore, careful timing of tillage (with awareness of soil type and water content) is important to optimize tillage effectiveness and minimise negative impacts, such as compaction. Research studies have shown that tillage disrupts soil aggregates in surface layers, freshly exposing soil organic matter, stimulating decomposition and the release of carbon dioxide to the atmosphere. Increased tillage intensity and/or repeated tillage operations tend to reduce the amount and stabilisation of soil organic matter, which then has negative effects on soil structure and soil organisms, with bigger impacts on the larger soil organisms, such as earthworms. Changes in tillage also leads to changes in:

- the proportion of time where there are active roots in the soil, affecting soil structural development
- the amount of cover on the soil surface by plants or residues, affecting run-off and erosion.
- stratification of organic matter inputs within the soil, affecting biological activity.

Conservation tillage seeks to:

- reduce tillage intensity,
- reduce the costs and time associated with crop establishment
- improve soil health.

A well-accepted operational definition of conservation tillage is cultivation or cultivation and planting combination that retains more than 30% cover of crop residue on the soil surface. Generally, there are four main types of conservation tillage:

- mulch tillage,
- ridge tillage,
- zone tillage,
- zero-till (also known as direct drilling).

An important aspect of all these approaches to conservation tillage is the use of surface residues to maintain soil cover, avoiding evaporative soil water losses, and improving water infiltration. Conservation tillage can also provide several benefits for agricultural systems including economic advantages (by reducing crop establishment time and energy use) and a reduction in run-off and water erosion. In semi-arid climates the benefits of water conservation for subsequent crop germination and establishment are very important. Conservation tillage also increases the retention of crop residues at the soil surface, which helps support biological activity and increased stabilisation of soil organic matter in the surface soil. In mechanised systems, reductions in fuel use through reduced tillage intensity have a larger impact than changes in the total soil organic matter in terms of the net carbon footprint of agricultural systems.

For large-scale farms on appropriate soils, the adoption of controlled traffic farming should reduce the level of overall compaction.

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Have a diverse crop mix

SOIL-SMART BIODIVERSITY-SMART

The use of monocultures or simplified rotations leads to practical simplification of soil management but also reduces diversity in the inputs to systems and cultivation approaches and has also been shown to lead to reduced diversity in the soil food web. In most tillage crop systems, mono-cropping is the exception and most cropping systems include a distinct break crop to:

- interrupt host/pathogen interactions
- impact on soil structure
- reduce the need for N fertilizer (usually alternating legumes and nitrogen demanding crops).

Crops differ in the mass of roots produced, as well as in the depth and pattern of rooting. Increases in plant diversity, whether in space or time, therefore leads to increased diversity in litter, exudates, rooting patterns, and plant associations. Changes in crops and/or the introduction of intercrops or mixtures also lead to changes in crop cover and organic matter inputs, together with changes in timing and type of tillage. These differences between crops may have short-term and/or long-term effects on:

- soil structure,
- soil biological community,
- nutrient use and distribution within the soil.

The presence of host crops is well known to be critical for the survival of certain root-associated species e.g. for rhizobia, mycorrhizal fungi and pathogenic species. Knowledge of the survival strategy of the particular organism in the absence of a host plant is important for rotation planning either to maintain beneficial populations (N fixers, mycorrhizal fungi) or to break the pathogen/host cycle. For soil biota that are strongly root associated (e.g. plant parasitic nematodes), extended periods where key host plants are absent are already used to reduce populations of pathogens. Productivity and efficiency gains are likely to result where root and rhizosphere phenotypes can be matched with the soil, climate and regional management practices.

Increasing the diversity of crops, or of sown pasture species, is likely to increase the variety of pollen and nectar sources and may extend the season over which these are available. This may help sustain pollinating insects and support better pollination of other agricultural crops. Monocultures of single variety crops have often been blamed for the increasing reliance on pesticides to prevent rapid spread and impact of crop pests. Developing a more diverse approach to cropping could reduce pesticide requirements or prevent catastrophic loss of entire crops to disease or pests. Management of the farmed landscape rather than just the fields is also important as field margins, hedges etc. provide a diversity of niches for a wider range of soil (as well as above-ground) organisms.

Market access is critical to determine whether crops are viable. Therefore, increasing the diversity of crops within an agricultural system is often an economic rather than agronomic decision. However, there are a range of opportunities within current tillage systems to better optimize rotations to benefit soil and crop health. In grasslands, use of legumes within pastures is a long-established practice which reduces the need for nitrogen fertilizer; new opportunities are emerging to integrate herbs in pastures to the benefits of livestock productivity and health. In tree/ plantation crops, approaches taken for pasture/ forage diversification can often be integrated into the management of vegetated alleys. Integration of trees and crops in agroforestry systems is also possible but may require careful planning, especially in mechanized systems.

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Plant trees for different purposes, e.g. timber, shade, windrow, animal feed, bird habitat

CLIMATE-SMART BIODIVERSITY-SMART

Cultivation of a range of crops together with trees (polyculture) is a common traditional smallholder production system in many regions and climates. Intensification of production for a range of crops has seen many farms increase in size and transition towards simpler monoculture systems, which allowed for easier mechanization. Even where the main crop can tolerate (and sometimes even prefers shade) e.g. coffee and cocoa, full sun production systems have been developed to allow higher density planting. However, it has been recognised that intensive monocultures and understorey trees grown in full sun can have lower quality and are more susceptible to pest outbreaks.

The valuable contribution of trees where ecological intensification is the focus, rather than increased crop productivity, has been highlighted by many studies in many different farming systems and regions. Benefits to crop yield, water balance, the presence of natural pollinators and reduction in pests have been seen, but it is important to recognise that in some contexts the integration of trees can also have negative impacts on crop productivity and local ecosystems[5]. Trees have an important role in carbon storage when considered at the landscape scale, but at local scale they can also bring a range of benefits producing fruits/nuts/leaves for consumption or trade, fodder for livestock, timber, firewood, as well as medicinal ingredients. This increased diversity within the agricultural system can also support increased plant and animal biodiversity and help provide corridors between native habitats. However, managing trees within agricultural systems requires understanding which tree species to include and how to manage them appropriately for different socio-ecological contexts.

The effective integration of trees in agricultural systems can take a range of forms. The simplest approach, and the least disruptive where cropping intensification has already occurred, is the establishment of trees in lines along drainage ditches, in other riparian buffer zones or in marginal land (e.g. wet field corners, shallow stony areas). This increases the proportion of trees within the farmed landscape but does not truly integrate trees into the agricultural system.

Agroforestry is an efficient and integrated land use management system that involves raising of certain agricultural crops, forest tree species and or animals simultaneously or sequentially on the same land unit with appropriate management practices which result in overall increase in production. Different approaches to agroforestry design are needed where the trees are integrated with arable crops (silvoarable), with pasture (silvopastoral) or with other tree crops. The introduction of nitrogen fixing plants or weakly competitive trees such as *Grevilla Robusta* into timber and tea plantations has been shown to have a range of benefits for productivity driven by interactions between plant roots and the soil ecosystem that increase nutrient cycling and crop disease resistance. Coffee and cocoa agroforestry systems use tree companions that provide moderate shade, protection for younger plants from radiation and extreme heat, reduce evapotranspiration rates, and increase organic matter in the soil over time. For example, many cocoa farmers use bananas and plantains as shade crops in plantation establishment, the local market for the shade crops brings an earlier profit return to the farm.

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5 Barrios et al. 2016 https://doi.org/10.1080/21513732.2017.1399167

Optimize use of nitrogen fertilizers - select the right product, rate and timing; protect waterways from nutrient leaching

CLIMATE-SMART WATER-SMART

Feed the soil and the crops

SOIL-SMART CLIMATE-SMART

Crops and pasture need nutrients – Nitrogen (N), Phosphate (P), Potassium (K) and micronutrients – as we are continually removing them in harvested products, as well as there being losses to both air and water. Crop yields are often limited by nutrient availability and supplying nutrients using the right product, rate and timing is an important part of managing crop production effectively.

Plant nutrient availability is affected by soil type and local knowledge of soils is important to optimize nutrient use efficiency. Nitrogen supplies are particularly problematical as the manufacture of N fertilizers uses a great deal of energy. The over-application of fertilizers leads to the production of the potent greenhouse gas (N_2O) and the leaching of nitrates can pollute waterways and groundwater aquifers. Avoiding N excess by optimizing N addition to match the amount and timing of plant need in fertilizers and manures reduces losses compared to cropping systems where N available is significantly greater than the crop N demand.

A diverse range of materials produced on and off-farm are used as organic amendments to soil, including microbial, plant, and animal wastes, and by-products of the food processing industry. The most common wastes used on agricultural land are livestock manures; but there is an increasing production of composts during waste management. A wider range of organic amendments can be used on agricultural land partly to facilitate their disposal, but also to help meet plant nutrient demand and/or as soil conditioner.

Application of organic amendments to soil generally leads to an increase in the population of soil organisms. The duration of this effect depends on the amount and quality of the material added; sustained changes are most likely where organic amendment is regular. Some inputs have been shown to suppress pathogenic organisms either due to stimulation of competition or predation within the soil food-web or as a result of direct suppressive effects. Decomposition of organic amendments stimulates structure development and improves structural stability in soils. Soils with regular inputs of organic amendments therefore have improved structural characteristics with positive benefits for aeration (in clay soils) and water holding capacity (in sandy soils). Therefore, targeted used of organic amendments can help reduce runoff and soil loss via water erosion.

However, use of organic amendments alone does not often allow balanced nutrient supply for crops and crop deficiency and the risk of environmental pollution are increased where organic amendments are used alone. In many locations, access to mineral fertilizers is difficult or costly and hence crop productivity is restricted by low nutrient availability. To meet crop requirements, integrated use of mineral fertilizers with organic amendments allows better targeting of nutrient supply to achieve optimum crop growth and productivity. The local availability of nutrient resources (organic and mineral sources) needs to be assessed and the development of a targeted nutrient management plan for the cropping system may require local on-farm trials. Farmers also need to know which form of plant nutrients can be combined with each other to achieve maximum nutrient-use efficiency and also how these supplies can be integrated to obtain highest productivity levels within acceptable economic returns and satisfactory environmental impacts.

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Optimize water use efficiency

Optimize irrigation plans in accordance with water availability in the watershed

Select the most efficient irrigation technology and equipment

WATER-SMART

The soil serves as a reservoir for rainfall (and groundwater inputs) from which a plant extracts water to meet its demands for photosynthesis and growth (evapo-transpiration, ET). The water storage capacity in the soil depends on both the type of soil and the rooting depth of the crop plants. Soil texture and structure which result in large pore sizes, e.g. sandy soils, have lower water storage capacity than soils with smaller pore sizes. More deeply rooted crops can access more of the soil storage than shallow rooted crops. Where rainfall is not sufficient to meet ET demands then crops reduce water loss but also photosynthesis, this allows the plant to survive but may reduce productivity. Actions that improve soil health are also likely to improve both the soil's water storage and infiltration capacity hence water use efficiency by crops.

Irrigation is the practice of recharging the water storage in the soil that has been depleted by ET when natural precipitation is not adequate to meet the ET demands. A canal, well, or pond may serve as the irrigation water supply and this may divert water from other uses in the watershed, or slow recharge of ground and surface-waters. Re-use of waste waters for irrigation can increase efficiency of use at watershed level, although care must be taken to ensure water quality is compliant with crop water and soil requirements to avoid crop or soil damage.

The irrigation system then also includes the method of transferring the water from the source and applying it to the root zone. In the simplest systems, water is delivered and allowed to flow across the field e.g. via ditches. Pressurized irrigation systems deliver water through a pipe under pressure and then discharge it by one of a variety of different outlet designs including sprinkler heads and drip emitters. Irrigation systems usually deliver water to the soil surface from which it must infiltrate into the soil to recharge the soil water storage. A well-designed system fits well into the cropping system and does not deliver the water to the soil surface more rapidly than it can infiltrate. Pressurized systems give much more control over irrigation rates and increase uniformity of application; they also have lower water losses by evaporation during application. Drip irrigation has the potential to give the highest uniformity, but the costs of the system are also the highest compared with sprinkler systems. It is important to consider not only the capital costs of a new system, but also the requirements for skilled maintenance.

Irrigation scheduling refers to the approaches taken to determine the timing, duration and quantity of irrigation. The time to irrigate is usually before the soil is too dry for water to be extracted by the plant at a rate to meet the transpiration rate. This can be determined by experienced field observation, measurement of soil water content or by using local weather data so that ET and rainfall can be estimated. The combination of a soil and crop rooting system that has a low storage capacity dictates the use of smaller quantity of water and more frequent irrigations; whereas a larger storage capacity allows less frequent, higher quantity irrigations.

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Preserve existing high C storage habitats

CLIMATE-SMART BIODIVERSITY-SMART

Unmanaged forests and grasslands typically allocate a large fraction of their biomass production below-ground into their root systems and their soils are relatively undisturbed. The trees themselves are also a significant carbon store. As a result, native ecosystems usually support much higher soil carbon stocks than adjacent agricultural systems. Rapid losses of soil carbon (typically 0.5 to >2 tonnes of C per hectare per year) occurring where such systems are converted to cropland have been extensively documented. Hence, avoiding conversion and degradation of high diversity forest and grassland ecosystems is an important strategy to reduce GHG. This is in line with Unilever's commitment to protect natural ecosystems, with a cut off point for conversion of natural ecosystems of December 31st, 2015. Converting marginal or degraded lands to perennial forest or grassland increases soil C storage, although usually at a slower rate than the original losses.

Long-term carbon storage in soils happens when inputs of organic materials, via roots, plant residues and other inputs of organic materials exceed losses via decomposition. Decomposition in wetlands is slowed or halted as a result of near-permanent wetness and hence peat soils form over any underlying mineral soils initially present. The wet conditions also often reduce the number and range of plants that can grow reducing the inputs of organic materials and hence peat soil formation is slow. Some farmed landscapes are dominated by peat soils e.g. tropical woody peat swamps of Malaysia, fen peats of Eastern England and the Netherlands. However, wetlands and pockets of peats occur in small patches within the farmed landscape in many regions and climates. If wetlands are drained for agricultural use, the subsequent decomposition losses, stimulated by increased aeration, can be as high as 5–20 tonnes C per hectare per year. Therefore, all farms should identify and actively conserve such habitats within the farmed landscape. Restoring wetlands that have been drained reduces on-going decomposition losses and can also restore the peat-building processes though methane emissions may increase.

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Putting monitoring into practice

Understanding the farm baseline to select SOIL-SMART practices

Some soil properties are inherent (i.e. the result of soil formation) and fixed e.g. soil depth, texture and mineralogy. These properties are used to classify and group soils by combining field description with laboratory analysis of typical soil profiles so that this natural variation can be mapped and then used to guide land use decisions at farm and wider scales. Where detailed soil maps are not available then local soil knowledge, observation and analysis can be used to create simple farmer maps that distinguish key groups of mineral and peat soils. These soil-type-defining properties only need to be measured once. All farms require a simple soil map that they use to develop a soil management plan. Other potentially limiting features of land e.g. climate and gradient can be used alongside inherent soil properties to define a wider range of characteristics, such as erosion risk or wetness (risk of flooding and/or waterlogging). Land suitability for key crops or new practices e.g. reduced tillage can be assessed by combining knowledge of the soils' inherent properties with wider environmental factors.

Tracking change in SOIL health

Some soil properties are dynamic (i.e. the result of interacting human and environmental control) and hence they are manageable. For example, measurement of soil nutrient content has been a cornerstone of soil fertility and consequently fertiliser management for at least 50 years. It is now widely recognised that integrated chemical, physical and biological processes are important for sustained productivity and environmental quality and hence a wider range of soil properties are used to characterise the state of soil health, which may be compared with benchmarks for that soil type or with previous measurements at that site.

There are many indicators available that provide clues about how well the soil can function. The indicators can be physical, chemical and biological properties or indicators of overall function such as crop yield or amounts of soil erosion. As a minimum, it is recommended that a combination of in-field measures and samples sent for laboratory analysis are used as part of on-going soil monitoring (at least every 5 years) including measures of:

- pH and nutrient status
- Soil organic matter content
- Soil microbial activity, and
- Soil structure or aggregate stability at the soil surface

Where data are compared, it is important to check which method of sampling and analysis has been used; ideally these should be the same each time. Representative soil sampling sites should be chosen across the farm with the location recorded carefully so they can be reliably revisited at the next sampling. Changing sampling sites can hide changes in soil health as a result of management. It is also important to choose sites where the data will best inform farm practice in soil management.

Changes in soil properties can be very slow and hence it may take several sampling cycles (up to a decade) to detect differences. It is therefore also important to record site management and its impact on other properties of the soil-plant system for example:

- adoption of soil-improving practices
- % of the year with full ground cover
- presence of physical (compaction) or chemical limitations to rooting
- signs of erosion, run-off or sediment deposition

The aim of regenerative agriculture is to ensure that the soil KPIs are met and maintained.

SOIL KPIs

Healthy soil
- Soil Organic Matter is higher than average for soil type and level is maintained or improving over time
- Soil microbial biomass activity and diversity is higher than average for the soil type
- pH and soil nutrient status is optimum for crop growth
- Soil structural stability is high, especially in the surface soil

SOIL-SMART implementation

Understanding the watershed baseline to select WATER-SMART practices

At its simplest, the water balance of a watershed is the difference between the inflows (dominantly precipitation) and outflows, mainly evapotranspiration by vegetation and stream/river flows; there may also be some groundwater recharge. The time delay between precipitation events and changes in river flows depends on the potential storage within the watershed (in soils, ponds, reservoirs etc) which may also vary through the year. The long-term average values of precipitation and evapotranspiration, reported as climate, may bear little resemblance to the actual weather patterns experienced and while long-term climate records can provide some insight into the size and likelihood of extreme events – there should be a basic weather station recording temperature and precipitation within each watershed. Proper siting is essential if the weather station is to provide data in a consistent and reliable manner.

The ideal situation would be to centrally locate the station in a large, flat, well-watered vegetated area that is a considerable distance from objects that might disrupt wind flow or cause shade. Regular cleaning and maintenance are important. Another important aspect of local validation is to compare the solar radiation, temperature and humidity data collected by your weather station with data collected from another nearby station. Note that wind speed and rainfall data can vary markedly over short distances.

The location and flow characteristics of waterways within the water shed are the consequence of the interactions of land-form (topography), geology (determining the location of aquifers and spring lines) and, of course, climate. Waterways may be natural, modified or completely man-made and their flow patterns may be:

- Permanent – permanently or near permanently flowing.
- Intermittent – flowing predictably for weeks and months, but also drying for similar periods
- Ephemeral – only flowing occasionally in response to rain.

Where detailed maps of the watershed are not available then local knowledge and observation, best done in the wet season, can be used to create simple farmer maps that identify the permanent and intermittent waterways, drains and distinguish shedding and receiving sites within the farm landscape. These watershed properties will only need to be measured once. All farms require a simple watershed map that they use as they develop their water management plan to minimise the risks of contamination of surface water. Other defining features of the climate, especially water balance, and extreme weather risks can be used together with the understanding of the watershed hydrology to define a wider range of characteristics, such as flood risk and run-off / erosion risk at a local scale.

Tracking change in WATER quality

Agricultural practices may have negative impacts on water quality. Poor agricultural management may elevate concentrations of nutrients and sediment loads and care is also needed to restrict livestock access to waterways. Poorly targeted (wrong rate, wrong place, wrong time) applications of fertiliser or animal manures can increase nutrient concentrations and lead to eutrophication of water bodies which may eventually damage aquatic ecosystems. Poor vegetation management leading to low groundcover when rainfall is intense can accelerate erosion increasing sediment input to nearby water sources which affects fish and macroinvertebrates. As part of an irrigation management plan farmers should keep accurate records of extraction and distribution patterns for irrigation each year. It is also important to monitor the water quality. There are many indicators available that provide clues about water quality and the aquatic ecosystem health. As a minimum, it is recommended that regular waterway observation is used, together with samples sent for laboratory analysis where appropriate. As part of on-going water quality monitoring include annual measures of:

- Eutrophication status in local surface water
- Sediment issues in local surface water

Changes in water properties can fluctuate and hence it may take several sampling cycles (several years) to detect a clear trend. It is therefore also important to record site management and its impact on other properties of the farm and the watershed, for example:

- Documented nitrogen management plan
- Full ground cover in high erosion risk periods
- Sufficient but never excessive soil nutrient status
- Documented irrigation planning at watershed level
- Irrigation scheduling
- Same or reducing water volume used for irrigation each year gives same or increased yields

The aim of regenerative agriculture is to ensure that the water KPIs are met and maintained.

WATER KPIs

Clean and sufficient water in the watershed

- Nitrate and phosphate levels in drainage or local surface water less than threshold for eutrophication
- Low suspended sediment loads (clear water) in water bodies adjacent to farmland even following high rainfall incidence
- Water footprint of irrigated crops lower than the average for the crop type

WATER-SMART implementation

Understanding the cropping landscape baseline to select CLIMATE-SMART practices

In most situations, the GHG emissions of a farming system can be monitored indirectly because of the strong link between GHG emissions and farm inputs. However, reducing agricultural inputs may not reduce overall GHG emissions at a regional or national scale if the crop production levels fall as a consequence. This only serves to move the production (and associated inputs) elsewhere to achieve the market demand for the product. Therefore, to understand local GHG emissions, it is important to link agricultural productivity to inputs and optimize the efficiency of fertilizer and fossil fuel use wherever possible.

Spatial variation in yield and input use efficiency is very common because of the variability of soils, topography and microclimates across the farmed landscape. Not all parts of the cropping system give the same level of productivity and profitability for the farm. It is therefore important to use local knowledge, observation and analysis to understand the spatial patterns of profitability across the cropping landscape. In intensive cropping systems, automated yield mapping at harvest together with input records can allow annual and rotational maps of profitability to be derived. Maps of the farm that clearly show the non-cropped land (together with the associated habitat and its condition), and identify marginal areas within the cropping area where profitability is regularly low or negative, can help target climate-smart management within the farming system. On the non-cropped and marginal land, climate-smart management should focus on increasing carbon storage in trees, reducing losses of peat, enhancement of biodiversity and, where appropriate, generation of renewable energy.

For highly productive cropping land, climate-smart management should focus on continuous improvement in resource use through sustainable intensification of the cropping system. It is important to build on the farm's soil and watershed maps so that the cropping system design and management takes land use suitability and the additional risks associated with extreme weather events into account.

Tracking change in CLIMATE impacts

A carbon footprint measures the total GHG emissions caused directly and indirectly by a farm or associated with a final product. Different approaches may be taken when compiling a carbon footprint at farm-scale than across the whole supply chain, but the basic principles are the same. Through carbon footprint analyses, important sources of emissions can be identified, and emission reductions targets can be prioritized.

Farm-scale carbon footprints take account of the direct emissions taking place on-site that largely result from the nitrogen fertilizer and fossil fuel used. The additional indirect emissions are GHG emissions from the production and transport of all the inputs used on farm (e.g. lime, fertilizers, pesticides); production of nitrogen fertilizer is very energy intensive and hence the indirect emissions associated with nitrogen fertilizer are also high.

Farm-scale carbon footprints should also take account of the capacity of the soil and farmed landscape to act as a sink for GHG emissions through increased carbon storage in trees and soils. Calculation of the carbon stocks in trees requires regular monitoring of tree growth (height, trunk diameter). The carbon stock in hedges is usually estimated from the width and height of the hedge as a whole. Quantification of the carbon stock in soils requires more detailed monitoring than measurement of soil organic matter alone. Volumetric soil samples are needed so that bulk density can be estimated; these samples are much more laborious to collect than soil samples collected for routine nutrient analyses. Ideally, sample preparation is followed by analysis via automated dry combustion in the laboratory. For soils that contain inorganic forms of carbon, acidification may be required to determine organic carbon concentration. However, the main challenges to measuring soil carbon stocks at field-scales are the high spatial variability of soils and the fact that changes are often small relative to the initial background soil carbon stock. Therefore, representative soil sampling sites should be chosen across the farm with the location recorded carefully so they can be reliably revisited the next time samples need to be collected.

To track climate impacts, even where a farm is not able to carry out a full carbon footprint, a farm is required to keep accurate records of:

- Nitrogen fertilizer used each year, ideally with the rate, timing and product use also recorded;
- Fossil fuel used each year, ideally with allocation to operations e.g. tillage, irrigation, storage etc.

Measurement of soil organic matter content is an important part of monitoring soil health on-farm; where possible, the sampling programme should be enhanced so that the carbon stock can also be estimated.

Changes in the properties of the site and cropping system that impact GHG emissions and carbon storage in soils and trees can fluctuate from year to year, hence it may take several sampling cycles (up to a decade) to detect a clear trend. For example, simply planting trees does not guarantee that all of them will thrive and deliver the expected benefits whether shade, support for beneficial insects or carbon storage. It is therefore also important to record site management and its impact on other properties of the farm landscape, for example:

- High carbon habitats protected
- Nitrogen use efficiency increasing
- Carbon foot printing implemented to monitor climate impacts
- Reducing fossil fuel use on farm sustained over several seasons
- Long-term trend of increasing tree cover and soil organic matter in mineral soils

The aim of regenerative agriculture is to ensure that the climate KPIs are met and maintained.

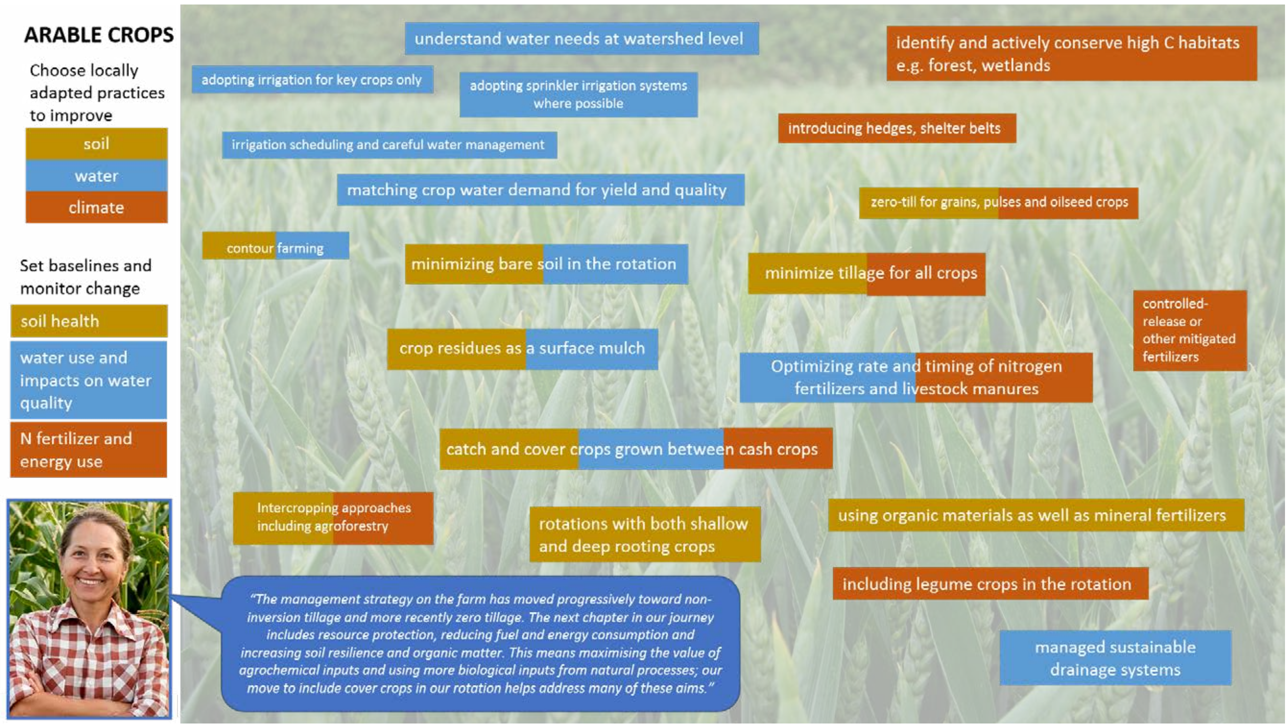
CLIMATE KPIs

Climate resilient, zero carbon farming system

- Improving condition of high diversity forests, wetlands and basin peats under natural vegetation within the farmed landscape
- High % tree cover compared with the levels typical in the region
- Nitrogen Use Efficiency higher than average for farming system
- Fossil Fuel Use on farm lower than average for farming system
- Crop Carbon Footprint lower than average for crop grown in the same climate region

CLIMATE-SMART implementation

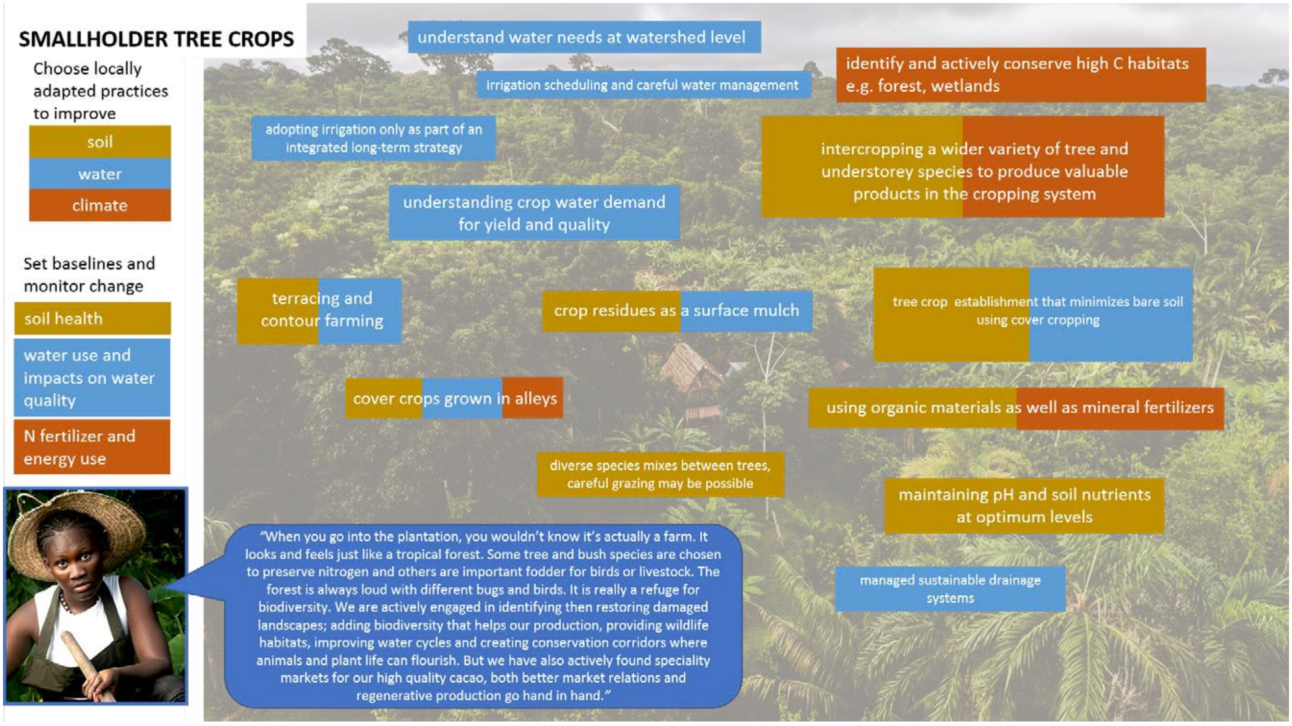
Exploring management options for arable systems



Exploring management options for pasture systems

Exploring management options for tree/plantation crops

Exploring management options for smallholder tree crops



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Implementation guide for Biodiversity

1 Regenerative Agriculture Principles

1.1 Definition

There is no clear definition of "Regenerative Agriculture"; different experts advocate their own interpretation. However, the overarching goal of regenerative agriculture is to go further than the 'do no harm' principle and actively improve the local environment. This is done through holistic management measures to improve and restore soil health, water quality and biodiversity.

In this guide we focus on the biodiversity side of regenerative agriculture. By creating space and food sources, a farmer can create an ideal environment for local insects, birds, and other animals. Measures that improve biodiversity often also have a positive effect on water quality and soil health.

1.2 Implementation

In recent years, biodiversity has had a special interest in the media and its decline raises public alarm. However, farmers don't always have biodiversity as a first priority. Biodiversity can even be seen as a source of pests, weeds or other forms of hindrance. When suppliers or brands want to work on biodiversity, there are a few factors that are key to ensure implementation of biodiversity enhancing measures.

1.2.1 Engagement

Suppliers have an authority that enables them to promote biodiversity conservation on a higher level. However, to get farmers interested in implementing measures, the engagement process is very important. Field agents and local advisors can play a key role in this, making the farmer aware of the importance of biodiversity and the potential benefits for the farmer. They can connect efforts of individual farmers and create partnerships in order to reach a regional goal.

The Unilever lemon supply chain developed a biodiversity manual with the WWF. They worked with the farmers to determine which measures work for both the farm and local biodiversity. The farmers could easily select measures from the guidelines to implement on their farm. [See example lemons in Sicily, section 2.5]

1.2.2 Profitability

Both supplier and farmer have a business to run. The concept of 'sustainable farming' also includes a good income for the farmer, now and in the long term. By linking practices to profitability, it is clear that some measures create a win-win situation. Several measures that enhance biodiversity can be beneficial for farmers, when it comes to so-called 'functional biodiversity'. Examples of this component of biodiversity are natural enemies and soil life, which play a key role in agricultural ecosystems. [see example strip cultivation marigold-tomato, section 2.3.2].

1.2.3 Biodiversity Action Plans and partnerships

A Biodiversity Action Plan (BAP) identifies objectives, conservation activities, key actors and their responsibility, and milestones. For a good BAP, suppliers should attract local NGO's or research institutes. Their input should help you identify priority species for conservation.
Teaming up with public initiatives and existing biodiversity programs, amplifies your impact. Restoration efforts will be more widely supported, if you involve local communities from the start.

Landscape approach in palm oil areas of Indonesia
In a landscape approach, parties join forces to balance competing demands for resources in a way that is best for human wellbeing and the environment. In the Indonesian provinces of North Sumatra and Aceh, the NGO Conservation International is working together with Unilever (2019) to enhance forest governance, by strengthening local government. As a result, the area of legally protected forest has grown, smallholder plantations are mapped, and tenure rights are secured. At the same time, smallholder palm oil suppliers, who often don't have the knowledge nor capacity to sustain remaining natural forest, are supported. Through piloting agroforestry, the needs of community livelihood are addressed while the integrity of the ecosystem is sustained. At the same time, smallholders are trained in good agricultural practices to attain RSPO certification.

1.3 Measuring the results

Finding ways to demonstrate the effect of biodiversity enhancing practices, will motivate those who are involved in a project, but is also important to substantiate marketing claims. Measuring can be based on input:

- the area of the project (based on satellite imaging or farmers data);
- the number of farmers who join;
- the number of measures taken (efforts).

Or on output:

- the effect of measures by monitoring number of species or individual animals/plants.

Deciding on the best monitoring strategy depends on the available resources and your specific goals. Efforts are usually easier – and therefor cheaper – to measure, e.g. using satellite or management data than monitoring species. For monitoring remaining forest size, open-source available maps from Global Forest Watch can be used. The biodiversity module of the Cool Farm Tool can give an idea about the biodiversity potential of a farm.
However, the Regenerative Agriculture Principles of Unilever focus on net positive impact on biodiversity, hence biodiversity improvement should be tracked by measuring output.

Monitoring of species can be very inspiring to farmers, creating awareness and enthusiasm for the species and nature in general. Farmers will be proud to share positive results with their costumers/neighborhood. Local experts can help choose indicator species with high conservation value, either because they are severely threatened (IUCN species Red Lists) or are an indicator for other species (e.g. predators on top of the food chain). Cultural or PR value can also be a reason to choose for certain iconic species like tigers, elephants or a local mascot species.

1.3.1 Monitoring method

Through observation and counting of species, the abundance and number of species can be measured. Monitoring can be done through direct observation, sound (birds, monkeys, frogs) or with tracks (e.g footprints, droppings, or nests). Nowadays also automated systems are being developed. The pro's and cons of different methods are discussed below:

1. Field inventory: depending on the knowledge level needed, direct monitoring can be carried out by field biologists, trained farm workers or volunteers from local communities. Most terrestrial species can be monitored, but this can be very cost intensive. Depending on the (number of) species, only small areas can be inventoried.
2. Camera traps: for mammals, large birds or reptiles. The advantage of camera traps is that they function remotely and do not disturb species. Nowadays there are also camera traps available that can identify insect species through Artificial Intelligence.
3. Sound/echo recording: birds can be monitored remotely using low-tech equipment with sound recording options, for example using a mobile phone. For recording and analyzing echo of bats a batlogger can be used, which does not only record but also identifies the species of bat.
4. Drone imaging: for example to count bird or primate nests. Good to monitor large areas.
5. Lab testing: Used to measure microfauna biomass or diversity in soil.
6. Environmental DNA: this technique uses DNA in the environment (e.g. soil or water sample) to show that a species is present or not. Species leave DNA samples through natural shedding of skin or hair, or through droppings.

1.3.2 Monitoring protocol

To monitor biodiversity over time or to compare it with other areas, a standardized method is needed. Species are counted along transects of a certain length and width (e.g. for insects, birds), in plots of a certain size (e.g. for plants) or at specific viewpoints like with camera traps. A good spread over the different crops and habitats of the farm is important and inventoried areas should be placed randomly. If monitoring takes place over a longer period of time, the same areas should be used over the years and differences in external conditions and knowledge/effort of the person executing the monitoring should be kept minimal. This requires development of protocols stipulating the method and number of counts per year, taking into account certain types of external variables, like weather conditions, and describing the knowledge level required. For example, insects are susceptible to temperature, sunlight and windspeed and reptiles require a certain temperature to become active.

1.3.3 Sustainability reporting

Ideally, monitoring data becomes part of sustainability reporting. Natural assets should become part of the financial balance sheet, when they deliver financial benefit to the farm. For example, on- farm peat forest patches offer water buffering capacity that helps to prevent drought during dry spells and flooding during the rainy season, thereby increasing farm-productivity.

2 Arable crops

2.1 Introduction

Arable crops are cultivated all over the world, often on large areas in a monoculture. As a result, there is a lot of potential to increase biodiversity in these crops. There are several measures a farmer can take to enhance the biodiversity while growing arable crops. The most important measure is to prevent further habitat loss, by preserving areas with a high conservation value and by not enlarging cultivated areas. Besides that, measures can be taken to improve the habitat on arable land for many species. Insect, bird and mammal species have key functions in good agricultural practice, which is known as 'functional biodiversity'.

As arable crops are grown worldwide, cropping systems and climate conditions vary widely. In this chapter, we will give an overview of measures that promote biodiversity in the following crops and regions:

- Grains (including rice) in temperate zones;
- Vegetables (in particular onion, carrot and parsley) and tomatoes from open-field cultivation in temperate zones;
- Soybean in Brazil (tropical) and USA (temperate).

2.2 Management measures

Wildlife can be disturbed by agricultural activities. Some of these activities have alternatives that are less disruptive. Furthermore, separation of activities can enable animals to escape from one field to another for the duration of these actions.

2.2.1 Fertilizing

By applying rough straw-rich manure instead of chemical fertilizers, many species benefit. Dung beetles and flies thrive, then serving as food for species higher up in the food chain. It also promotes good soil structure, which is good for soil biodiversity and crop growth.

2.2.2 Cover crops

Cover crops can keep harmful weeds, that affect the farms productivity, under control. Moreover, nitrogen fixing plants can boost productivity by making nitrogen available to the crop. The associated soil biodiversity is key to nutrient cycling and enhances organic matter content (see the soil section of the guideline for more information).

2.2.3 Housing facilities

Introducing nesting facilities for birds can increase the predation of rodents by owls and other birds of prey. Leaving behind fallen trees and other plant material can provide housing for beneficial insects, such as earwigs. A farmer can also place a so-called 'bee hotel' to attract pollinators.

2.3 Crop diversification

When more crops of different species are grown, often a more diverse environment is created, augmenting biodiversity and reducing pest and disease risk. Net productivity is usually higher while the added diversity can host more biodiversity. Local research institutions or advisors can help plan the most beneficial system for a specific situation. Crop diversification in arable fields can be achieved through several methods:

2.3.1 Crop rotation

By increasing the number of crops grown on a farm and rotating them between the fields, a more diverse system is created. This reduces exponential growth of certain pests and diseases, while giving opportunities to more beneficial species. Rest crops and cover crops also allow for an increased soil biodiversity (AGEITEC, n.d.).

Crop rotation within a season

In some areas in Brazil, the growing season is long enough to harvest several crops in a year. When doing this, it is important that the crops in rotation don't increase each other's pests and diseases. Well known rotations are the combination of soy and wheat or barley in winter and maize or sunflower in summer.

2.3.2 Intercropping

Some crop and species have beneficial effects on each other (synergy). By combining them, pest and disease incidence is lower. This reduces losses and pesticide costs, while potentially increasing yields (Zavvaleta-Mejía & Gómez, 1995; Gómez-Rodríguez et al., 2007).

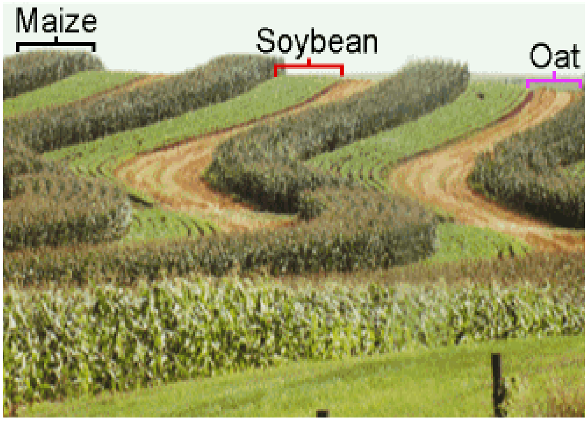
Intercropping

Intercropping in tomato

Tagetes, or Marigold, is a flowering species with positive impact on crops like tomato. By intercropping tomato and Tagetes erecta, nematode, pest and disease damage can be reduced. This increases overall yields (Zavaleta-Mejía and Gómez, 1995; Gómez-Rodríguez et al., 2007).

Intercropping in soy

Intercropping of soy with maize and oat can have advantages in terms of soil health, avoiding diseases and enhancing production. It can also have a positive effect on biodiversity by providing a more varied environment. Beneficial insects and birds can find food and shelter (picture from Department of Agronomy, Iowa State University).



Strip cultivation in soy

At the end of the first year of growing eucalyptus, soy (Glycine max (L), Merril, cultivar Conquista), at a spacing of 0.45m, was introduced (De Souza et al, 2012).

Strip cultivation in grains

Strip cultivation in grains can be achieved by combining grains with strips of native trees species. The trees provide habitat for birds and some specific insects. They also provide corridors for species between different habitats

2.3.3 Strip cultivation

Trees and shrubs provide a habitat for serval birds, mammals and insects. They also improve the soil quality and health, promoting underground biodiversity. With help from local experts, a system can be designed that fits with existing mechanical practices.

2.4 Landscape elements

Since arable crops grow only temporarily and fields are regularly disturbed by agricultural activities, adding landscape elements to the farmland will provide a more robust habitat for wildlife. Elements can vary from hedges, trees or flowering field edges, to waterbodies and microrelief (small irregularities on the land surface).

2.4.1 Creating diverse field edges

Sowing field edges with flowering herbs, helps in attracting all kinds of pollinators and insects that aid in natural pest control. It is important to use endemic species as much as possible, as local insect species are well adapted to live on these plants. Planting perennial strips can also be interesting, especially in countries with colder winters. By leaving the strips untouched during the winter season, natural enemies or their offspring have a place to shelter. Combined with different grains and sunflowers, these field edges provide food for seed eating bird species. Covered field edges reduce drift of plant protection products to neighboring fields and prevent the runoff of nutrients and agrochemicals to a ditch, thus improving water quality.

2.4.2 Mowing vegetation around farm

By removing the material after mowing the vegetation around the farm, the nutrient density goes down, increasing chances for herbs over grassy species. Mowing in patches, always leaving a part of the vegetation, leaves space for animals and insects to shelter and reproduce.

Grain field edges can be sown with flowering herb-rich seed mixtures to attract pollinators and natural enemies of grain pest insects. For example, in grains in temperate zones farmers experience problems with aphids. By sowing herb rich field edges that attract natural enemies of the aphids, like hoverflies and ladybugs, these farmers can apply less agrochemicals (figure 1). Depending on the species, natural enemies roam between 50 and 300 meters from the field edges, with 100 meters being a good rule of thumb.

Field edges sown with a herb rich mixture that attracts natural enemies like hoverflies, ladybugs and lacewings. On the right a picture of grains that are exposed to aphids.

2.5 Nature conservation

The registration of species present on arable land can help in preserving them. This can be done with help of local NGO’s or wildlife protection groups. Protection is especially important with more vulnerable species, like nesting birds and insects (pollinators and natural enemies). When a farmer is aware of the presence of certain animals, he can take this into account while performing agricultural activities. Drone imaging and GPS-mapping can be used to avoid the nests, as well as monitoring by local wildlife protection groups. Local advisors and biological control agencies are often able to help with insect monitoring (both pest and natural enemy counts), to determine if a plant protection product application can be delayed.

Registration of species

Grains in the Netherlands

The montagu's harrier is a raptor that breeds in the Netherlands, mainly in fields of grains. Volunteers of bird protection workgroup Grauwe Kiekendief search the nests of these birds and mark them. By doing this, the farmers know the locations of the nest and avoid them while doing their fieldwork.

Lemons in Sicily

To increase biodiversity on fruit farms in Sicily, Unilever has joined forces with WWF Italy. Birds and landscape elements were monitored on 20 farms. With this information, they analysed which landscape elements can be considered areas of ecological interest.

The results were used for a format and guidelines that agronomists can use to prepare better biodiversity action plans that suit their unique conditions. Examples of measures are reduced mowing of rows between the trees, addition of landscape elements, such as stone walls, hedges and trees, construction of ponds or small wetlands, and increase of housing, like artificial nests.

2.6 Post-harvest flooding of rice fields

Irrigated rice fields represent 15% of the world's wetlands. Rice production can provide most of the total flooded area, like in the Sacramento Valley, where rice fields provide 80% of the total wetland habitat. Flooded and irrigated rice fields are a hotspot for waterbirds and aquatic animals. In some areas, rice is rotated with other crops or combined with fish or poultry farming. In the Rhone and Ebro deltas, as well as in the USA, farm management has changed; some rice fields are also flooded in autumn, after harvest. Originally introduced to attract waterfowl for hunting, other wildlife benefits from this as well. Nevertheless, flooding rice fields contributes to greenhouse gas emissions and often rice production has to compete with cities for water supply. In Italy, an intermediate solution might be found, by creating a small pond or ditch in the fields as a refuge for aquatic animals (Sesser et al., 2016).

Post-harvest flooding became part of California's clean air policy. After harvest, straw and stubble are left on the field. In 1991, the Government of California restricted rice-straw burning, to limit air pollution. Farmers then found out, that when fields were flooded in autumn, the presence of numerous waterbirds increased the rate of straw decomposition up to 80% (van der Weijden et al., 2010). This measure thus proved to be good for bird, farmer and civilian.

Wildlife corridors in Brazil

In Brazil, the NGO Aliança da Terra and related company Produzindo Certo help farmers protect and, when necessary, increase biodiversity on their farm. The Forest Code (Código Florestal) establishes norms for areas of the farm that need to remain in its natural state, ranging from 20% in the South to 80% in the Amazonian region. Also, areas around rivers are to be kept in their natural state. As rivers are often well connected, this means that natural wildlife corridors are formed.

When this value isn't met, the farmer needs to rehabilitate the area with native species. To do this, Produzindo Certo provides guidance on which areas should be recovered, recovery techniques, and also connects the producer with indigenous populations, who source seeds of native species to be planted.

Images provided by Produzindo Certo

2.7 Creating wildlife corridors

Wildlife corridors are strips of connected habitats that allow animals to move between patches of nature. The strips can be rivers, untreated field margins, strips of forest and any other form of habitat. Tunnels or bridges can be used to help land animals cross roads.

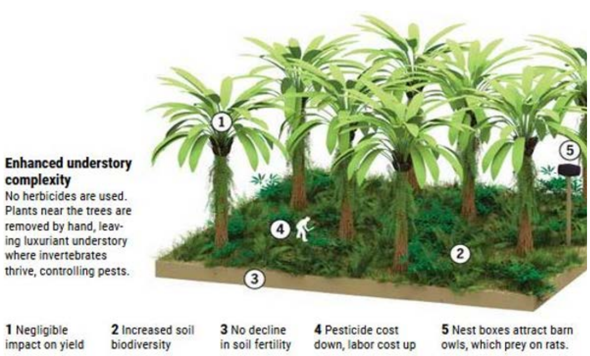
3 Perennials

3.1 Introduction

Farming perennials provides many opportunities for enhancing biodiversity. Because of the permanent nature of perennial plants, species (both plants and animals) have the opportunity to establish and thrive. In many cases, current perennial farming systems can be adapted better to species needs, without compromising productivity. Functional biodiversity will make the farm more resilient to pests, droughts, high temperatures and storms, favouring crop productivity. Moreover, farmers often manage non-cultivated land that is still covered with natural vegetation. If these are of High Conservation Value (HCV), they should be conserved (see 3.5).

Under sowing in oil palm

In oil palm plantations, keeping an understory (see figure; RSPO, 2007) will increase soil biodiversity and favour natural enemies of pests, which may lower the need for pesticide input. Depending on maintenance needs, it could increase labor costs. There does not seem to be any significant nutrient competition between crop and understory (Ashton-Butt et al., 2018). Because of the different habitats in a plantation (core, edge, palm tree trunk), high variety of plant species are found. Plants are food and hosts for many other organisms meaning that a high variety of plants supports a high biodiversity in general (Luke et al., 2019).



As perennials are grown worldwide, cropping systems and climate conditions vary widely. In this chapter, we will give an overview of measures that promote biodiversity in the following crops and regions:

- Oil palm from Southeast Asia;
- Cocoa from West-Africa;
- Tea from India;
- Coconut.

3.2 Management measures

There are many management practices a farmer can take to increase biodiversity on his farm. Some measures specific to perennial crops are listed below.

3.2.1 Undersow with flowering herbs

Sowing flowering herbs between the productive crop as well as along roads can boost beneficial insect populations. Insects are the main pollinators of many agricultural crops and are food for other fauna, like birds or small mammals. In many agricultural systems with perennials, it is possible to keep an understory of herbs or bushes without affecting, sometimes even boosting, productivity of your crop. It is important to only sow indigenous plant species, as these are adapted to the local insect population. By selecting the right plant species, you can attract natural enemies that help reduce damage by insect plagues.

3.2.2 Cover crops

Cover crops can keep harmful weeds under control and nitrogen fixing plants can boost productivity (see 2.2.2.). For smallholders, these wild plants provide a source of food, medicine and materials for construction.

Improved cocoa yield by taking care of pollinators

While many of the world's flowers are pollinated by bees or butterflies/moths, cocoa flowers are pollinated by tiny flies, *Forcipomyia* midges in the family *Ceratopogonidae*. There is increasing evidence that low yields in cocoa are partly due to inadequate pollination. This leads to hand pollination being recommended in various parts of the world. In an experiment in Ghana, banana stems, cocoa pod husks and leaf litter were added under and in between the cocoa trees as pollinator breeding substrate. The researchers found that the midge population was five times higher and fruit set was four times higher than in trees with no substrate. While Cherelle wilt (natural fruit-thinning process) increased due to the substrate, the much higher fruit set resulted in double the number of mature fruits compared to no substrate. Research in Sulawesi (Indonesia) and North Queensland (Australia) shows similar effects. By adding cocoa husks, in North Queensland hand pollination was no longer necessary (Toledo-Hernández et al. 2020 and Claus et al. 2017).

3.2.3 Introducing housing

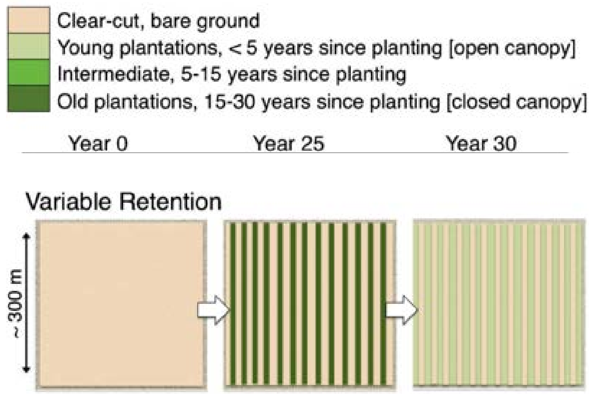
Introducing nesting facilities for birds can increase the predation of rodents by owls and other birds of prey. Some birds keep populations of caterpillars and other arthropods down and reduce damage to harvest. Providing nesting facility (old standing tree(s) trunks or artificial) can also boost the presence of bats on the farm. They keep mosquito populations down, which benefits your farmworkers. Some bats have a pollination function, boosting productivity.

Barn owls

Introduction of nest boxes for barn owls in oil palm plantations will help to control rats. Asian Agri (2019) found barn owls more effective than rodenticides in keeping down rat populations. They place one nest box for every 25 ha of plantation. Akvopedia provides more practical information on rat biological control.

Variable retention model

While clear-felling (removing all trees) is the most attractive model for large estates, smallholders and biodiversity could benefit from income of retained palm trees. The variable retention model is a system in which every other row is replanted with young palms in year 25 and after 5 years the remaining rows are planted (Luskin & Potts, 2011). Windrowing the old tree trunks can provide for some biodiversity, but also enhances Rhinoceros beetle infestation and Ganoderma infections of the young, replanted palms. To suppress pests like Rhinoceros beetle, it is important to pulverize the palm tree trunks and sow a leguminous cover crop (Akvopedia, 2018). Also, Ganoderma infections can be reduced by pulverization and spreading over a large area of soil (Ooi and Heriansyah, 2005).



Variable rotation (Luskin & Potts, 2011)

3.2.4 Replanting

Many oil palm plantations are currently in the process of replanting. During that process, it is important to consider biodiversity. Luskin & Potts (2011) found that retention of old palm trees can keep more of the plantation's microclimate, hence provide a better habitat for resident species

3.3 Crop diversification

By adding more species to the fields, farmers create more diverse environments (see 2.3). Net productivity is usually higher while the added diversity can host more biodiversity. Local research institutions or advisors can help plan the most beneficial system for your situation. Some examples specific to perennials are listed below.

3.3.1 Intercropping

Systems with multiple perennials or with both perennial and arable crops are more efficient in using nutrients, light and water. By choosing crops that help each other, for example by hosting beneficial insects or repelling pest species, both productivity and biodiversity can be enhanced.

Intercropping and integrating dairy farming in coconut

In coconut plantations many different systems of intercropping have been applied with e.g. pineapple, banana, pepper and cacao. It is known that coconut sources moisture and nutrients from deeper soil layers than cacao, which has relatively shallow roots. Also, cattle farming for dairy or meat are common in coconut plantations.

Looking for new opportunities to diversify?

- Investigate the feasibility of cultivating one of the 50 Future Foods. These are 50 plant-based ingredients selected by Knorr and WWF based on their nutritional value and relative impact on the environment (2019). Through its products, promotions and programs, Knorr plans to make these foods more accessible for audiences all over the world.
- Farmer-led experimental plots with different type of intercropping in your community will help see the effect of different intercropping systems. Refer farmers to seedbanks for inputs (if such are well functioning in your region).
- As a Unilever supplier, help develop local markets: e.g. source fresh tomato or spices locally to produce sauces (ketchup etc.) for the domestic market. A trusted brand like Unilever gives consumers in the urban middle class the guarantee of value for money.

3.3.2 Agroforestry systems

In an agroforestry system, several crops and sometimes animals are grown within the same field. When well designed, the crops benefit each other with shade and nitrogen fixation. Mixed systems can also help with spreading financial risk between multiple commodities.

Rewarding survival

Remember: it's not about planting the most trees, but about how many trees actually survive the coming years. Ideally, this is because they are well taken care of by the farmer for the benefits they provide to the farmer (e.g. fruits, timber). But suppliers or farm cooperatives may consider rewarding farmers for tree caring. That is exactly what the Karnataka Forest Department (India) does. The farmers are paid an amount of Rs 30 as incentive for every surviving seedling at the end of the first and second year and Rs 40 after completion third year. The total amount of money provided more than compensates the cost incurred by the farmer in procuring and planting the seedling.

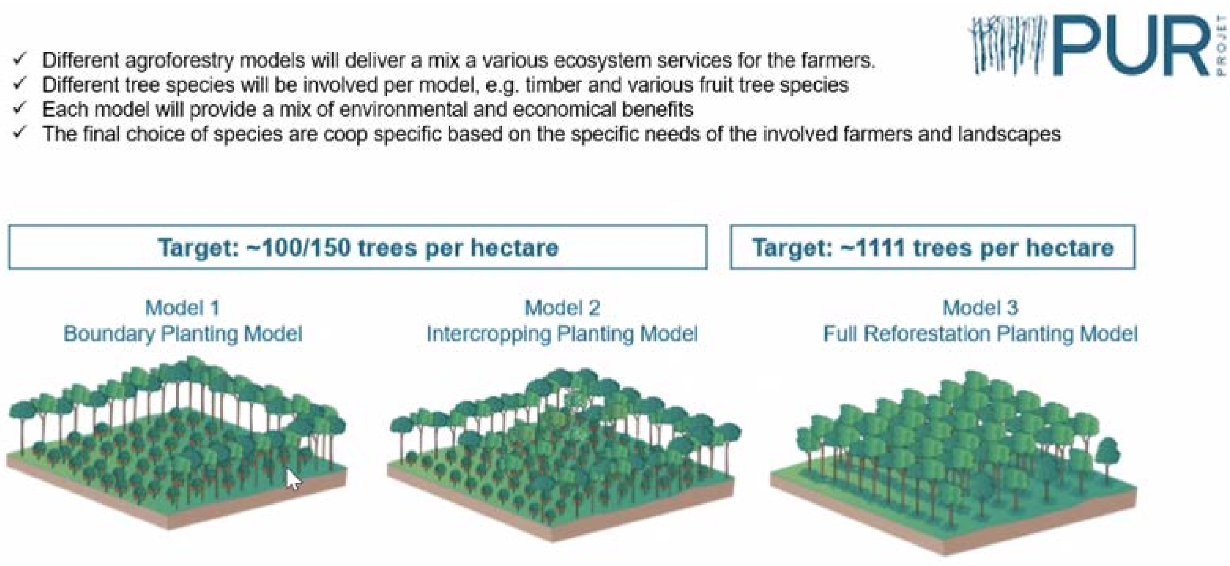
Agroforestry in cacao

In West Africa, monoculture cacao is currently the norm and farmers perceptions towards agroforestry are generally negative. Ghanaian cocoa farmers abandoned agroforestry for a variety of reasons, of which the introduction of sun-tolerant hybrids in the 1980's is most important. In combination with increased use of inputs like fertilizer and pesticides, these vigorous hybrids gave quicker, higher yields as compared to the former shaded cocoa plots. Forest trees are now seen as bad, lowering yields through competition for light and increased damage by squirrels, insects and fungi. (Ruf, 2011)

On the contrary, in a 11-year study with hybrid cacao in Central America, 'light' agroforestry with leguminous or timber species did not result in reduced cacao yields. Pur Project (2020) found that in Cote d'Ivoire agroforestry has the potential for an increased household income of 9-50% over 30 years. Leguminous species like groundnut or peas can be intercropped for a better nutrient status (Dohmen et al., 2018).

Another factor affecting farmers readiness to maintain forest trees has been tenure right. In Ghana and Cote d'Ivoire all forest trees were owned by timber concession holders, who could come into farm plots to harvest. A farmer would run the risk that his cocoa trees were damaged in the process (Ruf, 2011). In Cote d'Ivoire the 2019 Forest Code stipulates that trees are owned by the farmer but implementation of the code and changing the farmer's mind about agroforestry takes time.

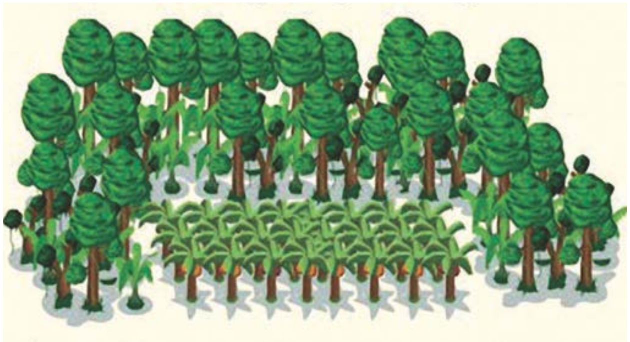
In collaboration with PUR Project, Cargill has developed an agroforestry program. They work on enabling conditions like tenure rights to trees and access to domestic markets for timber and fruits. Key is to challenge farmers believes and attitudes through community-led experimental plots and training in agroforestry management. Farmers are given access to seedlings and other inputs. They can choose from various planting models (see figure.) Cargill worked with 8000 farmers in Ghana and Cote d'Ivoire on agroforestry and reforestation in 2018 and 2019 (Cargill, 2020).



Agroforestry models (PUR project, 2020)

3.4 Landscape elements

Landscape elements on the farm are important for many farm dwelling fauna (see 2.4). Their conservation is therefore key to conserve this fauna. Elements vary from remaining patches with trees or other natural vegetation, marshland or other waterbodies and microrelief (small irregularities on the land surface). These elements boost plant and animal populations, while not interfering with production. Remaining large trees are also key in the recolonization of areas for nature restoration purposes (see 4.5). With large trees remaining, efforts to bring back forest through planting can be minimal.



Nature conservation in Palm plantations (The International Palm Society (n.d.))

The ongoing threat of deforestation

The expansion in cocoa production in West-Africa contributes to deforestation. In Ghana and Côte d'Ivoire, most cocoa expansion was done by clearing bush or a natural area, rather than by converting land under other crops (Bymolt, 2018). As a supplier it is vital to contribute to the zero-deforestation policy by:

- Increasing the share of your sourcing from certified farmers,
- Mapping certified and non-certified farms
- Letting non-certified farmers participate in projects you finance to increase yield per hectare or lengthening productive lifetime of a current cocoa plots, by sharing training and inputs.
- Using your influence on governments to make the right policy changes in order to protect natural areas and stop unsustainable practices.

3.5.1 Net positive impact: nature restoration

Many HCV areas in agricultural landscapes are degraded. To restore the function of the ecosystem, maintain habitat quality and stop biodiversity decline, active restoration of degraded areas with HCV is needed. Restoration activities can both influence abiotic and biotic conditions:

- abiotic conditions: restoration of hydrology (waterways and drainage) and preventing the leaching of farm effluents (fertilizers and pesticides).
- biotic conditions: enrichment by planting secondary forests with shade-loving trees, eradication of invasive species, or introduction of 'ecosystem engineers' like seed dispersers (fruit eating birds and monkeys).

Keeping or enhancing the size of the HCV area is very important to ensure sufficient habitat of high quality. This can be done by developing a buffer zone with a less managed system like agroforestry, or a strip of managed natural vegetation. Riparian vegetation is an important buffer around waterbodies. These protect the farm from erosion and flooding and provide key habitats to many (aquatic) species. It is also important to keep HVC areas connected, both on and off the farm. This can be done though development of corridors or patches (stepping-stones) of natural vegetation. By working with neighbours, farmer cooperatives or supplier, functional conservation can be done via a landscape approach.

Wildlife Friendly Tea gardens (India)

Tea gardens form crucial stepstones for wildlife, such as elephants, leopards, rhinoceros and potentially tigers, between the remaining parts of (rain)forest. Natural reserves – although important – are usually too small to sustain their populations. Animals need to migrate between these reserves in order to find food, water sources and mates, otherwise their genetic diversity and viability is jeopardized.
As a tea grower this is what you can do to preserve these iconic animals and at the same time reduce the risk of damage to workers and villagers:

- Be aware that elephants keep to old migration paths. Team up with wildlife NGO's to map these roadways through sign- and camera-trap surveys and use this knowledge for smart spatial planning.
- Educate tea workers and nearby villages: dangerous encounters with wildlife can be reduced by simple measures e.g. making noise before entering the gardens and avoiding the gardens in darkness.
- Preserve shade trees and small patches of wild vegetation, as they offer food and shelter. Buffer zones between the tea gardens and the natural forest can be planted with bamboo and star fruit as an additional food source for wild animals.
- In more open-grown tea plantations with smallholders or in hilly areas (Sri Lanka), weeding is an important part of the management. Selective weeding in which you only remove unwanted plants (instead of full field herbicide spraying) will enhance soil health and prevent erosion and landslides.
- The presence of swamps and natural vegetation along the stream banks form natural corridors for amphibians, reptiles, mammals and birds. Planting fruit trees will aid the movement of arboreal mammals.
- Consider not using pesticides within five meters of a permanent water source and reducing drainage ditches and other water channels to prevent risk of injury to elephants that wish to cross or access water.

As a supplier:

- Support NGO's that are in close contact with farmers, offering them practical on-the-ground support with knowledge and materials. In India, Wildlife Conservation Society and Nature Conservation Foundation are trustworthy examples of these.
- Integrate this guideline in farm field school syllabus and practical learning on the farm.

Elephants in tea gardens (National Geographic, 2020)

Management of set-asides in palm oil plantation concessions

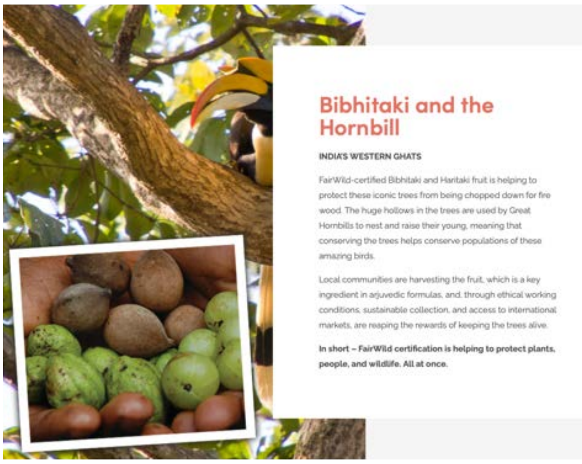
28% of Indonesia's landbank for oil palm cannot be developed by their owners as it is non-compliant, stated in the No Deforestation, No Peatland, No Exploitation (NPDE) policies (Levicharova et al., 2019). Natural forests in oil palm plantations are key for biodiversity protection and active restoration is needed as significantly less seedlings were found in comparison to primary rainforest (Fleiss et al. 2020). For example, Olam in Gabon has planted 202.000 ha with palm oil and conserving 99.000 ha of forests that are set aside under NDPE commitment and RSPO certification. In Indonesia, companies, NGOs and local communities are working together to protect orangutans in the PONGO Alliance. Recognizing that 80% of orangutan live outside of protected areas, this initiative tries to achieve:

- Collaborative engagement between oil palm growers and all interested parties for orangutan conservation;
- To develop guidance on how social and environmental actors contribute to orangutan conservation in oil palm plantations;
- To promote innovative plantation practices and leadership that deliver the best conservation outcomes for orangutans.

Be aware that areas on your premises could be used historically by local communities. To create sufficient buy-in, it is important to involve local communities from the start. This means that setting conservation objectives, identifying activities as well as discussing the terms of use of the area should be done together with local communities. Evaluate the options for value creation through sustainable harvesting of non-timber forest products (see example FairWild) or through community-based eco-tourism.

FairWild

As a supplier you can introduce the communities that you source from to the Fair Wild concept. This is a certificate for the sustainable harvest of non-timber forest products. A 10% premium is used for community development.



4 Dairy farming

4.1 Introduction

Grasslands (areas covered by grasses, with little shrubs or trees) are one of the largest ecosystems on earth. They are estimated to cover around 40% of the world's terrestrial area (Suttie et al., 2005). Temperate grasslands can be found in Europe (steppes), North America (prairies), Argentina (pampas) and New Zealand. Temperate grasslands have a rich soil, which enables extensive grass growth. Two-thirds of the grasslands are farmed. Grazing often takes place on ground that is considered unsuitable for cropping. Permanent pastures and meadows make up 68,5% of the world's farmland and generate more than 90% of the world's milk, 70% of its mutton and 35% of its beef (van der Weijden, 2010). Furthermore, grasslands provide several ecosystems services, including carbon storage, soil conservation, prevention of erosion and water retention. Grasslands support a variety of species, ranging from meadow birds, to insects and larger herbivores. Globally grasslands are declining because of urbanization, conversion to arable land and desertification due to overgrazing and climate change.

Around the world, different grassland farming systems are used. In several Northwest European countries, grasslands are very productive, based upon sown perennial ryegrass and high inputs of nitrogen and phosphate fertilizers. On these cultivated grasslands, cattle often graze a significant part of the time. In eastern Europe, cattle are housed year-round and grass is mown to feed the animals. In North America, there is extensive ranching ('free grazing') or rotational grazing (see text box). Focusing on dairy farming, the cows have to stay close to the farm, in order to be able to milk them daily. Depending on the grazing system, there are several opportunities to enhance biodiversity, as described in the paragraphs below.

In a rotational grazing system, livestock are moved from one portion of the pasture, a 'paddock', to another3. The idea is that the vegetation and soil in the 'rested' paddock have time to recover from grazing. In continuously grazed pastures, there are always patches that are grazed too closely and patches that are overgrown with plants that will not be consumed. By frequently rotating to a new pasture, cows can eat fresh and more digestible grass. Intensive rotation therefore results in better forage utilization and higher nutrient quality. Since this system prevents overgrazing, it reduces the risk of soil erosion. A challenge of the rotational grazing system is to provide shade and water to each paddock. While different grazing systems don't seem to alter overall species richness, they can alter the composition of a grassland; species from early successional stages benefit from grazing, but species from late successional stages might suffer (Conna et al., 1997; Pavlu et al., 2003; WallisdeVries et al., 2016).

4.2 Management measures

Wildlife can be disturbed by agricultural activities. Below some of the more damaging activities and their alternatives are listed for dairy farming.

4.2.1 Mowing

The most important activity on grassland is mowing. Birds or mammals can be frightened away when a farmer starts mowing. Some management practices reduce harm:

- Phased or strip mowing: by not mowing the complete field at once, birds and mammals have a chance to escape to the higher parts of.
- Extensive grazing: when the cattle feeds on grass, no mowing is required. However, without

Escape options during mowing, image: https://weidevogelsoverbetuwe.weebly.com/maaien.html

mowing, grass will then remain in the same growth stage because of this constant grazing.

- Delayed mowing from spring to summer: by delaying the mowing moment, herbs present in the field have a change to flower, and various insects will profit from this (Humbert et al., 2012).
- No hay conditioner on the mower: a hay conditioner crimps and crushes the grass so that it dries faster and is easier to preserve, but also crushes insects. More than 60% of the insects in a grassland die during mowing with this technique.

4.2.2 Fertilization

In temperate zones, applying manure (including chemical fertilizers) is only effective during a few months of the year. Applying straw-rich animal manure improves the organic matter of the soil and promotes soil life and thereby the biodiversity underneath grassland. Moreover, solid dung can generate food for meadow birds (see 2.2.1). Nitrate leaching is a problem, in arable lands as well as grasslands, and effects water quality and the biodiversity in and around surface water. Applying manure and letting cattle graze only during the growing season are important measures to prevent nitrate leaching.

4.2.3 Herb-rich grasslands

A third beneficial measure for biodiversity is sowing herbs, such as clover, vetch, narrow plantain and chicory, in grassland. In some countries, like New Zealand, the grasslands already consist of a variety of grasses and herbs. The intensively grazed fields of Northern Europe often consist of the grass variety perennial ryegrass. Sowing clovers and other herbs into these fields will not only promote biodiversity, but also captures CO_2, increases soil organic matter and soil life, and improves water retention. This last benefit becomes more and more important considering climate change. Moreover, plant species like clover and alfalfa can fixate nitrogen, and some herbs, like plantain, are thought to improve livestock health. Contact local advisors or universities to select the best options for your local situation and targets.

4.2.4 Sourcing farm inputs

An increasingly important theme in dairy farming is the source of concentrated cattle feed. Last decades the international demand for feed increased, but recently there has been a debate about the origin of these feed ingredients, amongst others soy and oil palm. Although some soy and oil palm are produced responsibly, cultivation of these crops is seen as the major driver of deforestation in the rainforests in Asia and Latin America, especially the Amazon rainforest. More and more farmers want to grow their own feed or want to buy it locally. Rest products from the local food industry (other than the rest streams of soy and palm oil production) might be used for cattle feed.

4.3 Crop diversification

Adding trees to grasslands, either as natural elements or for commercial purposes (see 2.3.1.), can have several benefits. Due to climate change, it has become harder to continue grazing during summer. Trees can improve the situation, by providing shade for cattle. Grass can also benefit from the trees, as their shade limits evaporation. Furthermore, trees counter soil erosion and provide habitat for birds and insects.

4.4 Landscape elements

Adding trees, shrubs or water elements and maintaining a natural microrelief in the landscape (little differences in height) will provide shelter for insects, birds, mammals and amphibians (see 2.4 or 3.4). A variety of elements will create gradients of temperature and light within a field.

4.5 Nature conservation

Some species have evolved with the land use of increased grazing. Species known to native grassland are in decline, but the ones feeding on protein-rich grass are thriving (for example the geese in Northern Europe). In cooperation with a nature conservation organization, farmers can survey the presence of wildlife and find ways to conserve endangered species (Nature Saskatchewan, n.d.).

Operation Burrowing Owl

In the Canadian province Saskatchewan, Operation Burrowing Owl has effectively protected grassland habitat of the burrowing owl (listed endangered since 1995). The operation was launched in 1987 by several organizations and served as an example for following programmes across Canada. In 2018, in total 68,605 ha of grassland was conserved, with help of 350 landowners. The landowners conserved habitat and annually reported the number of owls on their land. The owl has become an ambassador for prairie conservation.

Burrowing owl (Nature Saskatchewan, n.d.).

4.6 Pest control

Flies often form a nuisance in stables for both the farmer and the cows. Flies can cause agitation, which can lead to reduced milk production. Furthermore, they can transmit diseases (for instance inflammation of eyes or the Schmallenberg virus). Prevention starts with keeping the stables clean. Pest control can be done with help of natural enemies. Parasitic wasps and other insects are commercially available. The farmer can also facilitate the presence of bats, by placing nest boxes. This leads to increased wildlife and reduces the need to use insecticides.

In the Netherlands, the presence of bats has been promoted in the project *'Boer zoekt vleermuis' ('Farmer searches bat')*. On 25 farms in total 200 nest boxes were placed, in consultation with the Dutch association for mammals (Zoogdierenvereniging). Furthermore, the lighting in the farmyard and stable were adapted and shrubs or trees were planted. Eight different bat species were spotted on the participating farms.

Bat, photograph by Paul van Hoof

4.7 Genetic diversity

Dairy cows have mainly been bred with a focus on high milk production. Focusing on sustainability however, robust livestock breeds became more important. When diets are altered (grazing on more herbaceous fields and making concentrated cattle feed of rest streams of food production), cows should be able to digest these altered diets. Within one of the world's highest-production dairy animals, the Holstein cow, there has been considerable inbreeding. Crossing with other cattle breeds contributes to the health and robustness of cows, and the overall diversity of the herd.

Genetic diversity and biodiverse grasslands

In the Netherlands, a group of organic dairy farmers created a working group around the integration of herbs and flowering plants in their fields. They have cattle that are a cross of various breeds (Fleckvieh, Zweeds, Montbeliarde and VRIJ; with at least three of the breeds being present). These animals have lower milk production, but also have lower protein needs. Being less optimized for production, they thrive on a more varied diet, including different herbs and shrubs. The farmers feel that their cows know instinctively which plant species benefit their health status when allowed to graze freely. An additional benefit of the herb-rich field was the resilience of the fields during the very dry summer of 2018 (CLM project).

Appendix

Appendix 1 Consulted experts

- Gail Smith - DFTM Sustainability, Environment, Supply Chain & Machinery Safety Consultancy - Tea, Oil Palm, Coconut and cocoa
- Erwin Vroom – Unilever – Tea
- Mallika Sardeshpande – ATREE – Tea
- Klaas Jan van Calker, Unilever
- Andrea Granier, Unilever
- Peter van Elzakker
- Sophie Snaas
- Aline Maldonado Locks – Produzindo Certo – Soy
- Charton Locks – Produzindo Certo – Soy
- Adriaan Guldemond – CLM, retired – Grains
- Wouter van der Weijden – Stichting CLM – Rice

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Implementation for livelihoods

Introduction

Implementation guidelines: aim and structure

This document intends to support those companies, agencies and partners seeking to improve the livelihoods of smallholder farmers by applying Unilever's regenerative agriculture principles.
The guidelines provide an overview of Unilever's six well recognised and established principles. We cover their importance, as well as current understanding of the challenges to and opportunities for implementation, drawing from recent evidence.
Illustrations are provided in the form of case studies of smallholder production. These examples – from Africa, Asia and Latin America – show how taking part in commodity value chains can improve smallholder livelihoods. Each case study focuses on a different crop and demonstrates how one or several of the six principles can work together in a positive way.

The six principles and how they relate to smallholders

The six principles designed to improve smallholder livelihoods in the context of regenerative agriculture are:

1. Provide smallholder farmers with access to training in regenerative agricultural practices, farm inputs, finance, land tenure and technology
2. provide smallholder farmers with access to markets
3. support smallholder farmers in income diversification
4. support women's economic empowerment
5. provide men and women with training in business skills, and
6. support farmer cooperatives to professionalise.

These principles are interrelated and mutually supportive; to achieve progress in one area, it is often necessary to make positive gains in others. For example, supporting cooperatives and other collective action (Principle 6) is fundamental to achieving the other five principles. Cooperatives are a tool for delivering training in agricultural practices and business skills. They also provide a platform to engage buyers and improve market access, support farmers in diversifying income and – in the best examples – they enable the economic empowerment of women.

Training (Principle 1) is also a crucial enabler of all the other principles. Building capacity is at the heart of improving smallholder livelihoods, although training alone is by no means sufficient.
Women's economic empowerment (Principle 4) can be seen as both resulting from and driving progress in other areas. More financially independent women are better able to seize new market opportunities, diversify crops, and develop financial literacy and business skills – progress often supported by collective action. At the same time, better markets and improved skills can result in better household decision-making and higher incomes for women, if certain conditions are met.

Greater access to high-value markets (Principle 2) is an important route to increasing smallholder incomes. But it comes with risk, potentially encouraging farmers to depend heavily on one cash crop. Intensive cash cropping can lead farmers to overwork the soil, mine nutrients, increase water use and agri-inputs, and encourage deforestation. In a regenerative agriculture framework, the benefits of market access must be weighed against the possible drawbacks.

Principle 1: Provide smallholder farmers with access to training in regenerative agricultural practices, farm inputs, finance, land tenure and technology

Limited access to training is a key constraint for smallholders in low-income countries

- **Smallholders in low-income countries typically do not earn enough to invest in their farms**. This limits farmers' ability to improve productivity and environmental sustainability. Agricultural sectors dominated by smallholder production are likely to require additional support in order to effectively manage natural resources, improve their livelihoods and increase the quality of their products.
- **Access to and application of training is closely linked to other factors, including credit and inputs.** Smallholders are often already aware of farming techniques that help conserve natural resources but are unable or unwilling to adopt them for a range of reasons.

Traditional training models for agricultural practices are in crisis

- **Farmers have traditionally been supported by publicly-funded extension service providers.** However, these trainings tend to be 'top-down' in style, failing to respond to smallholders' needs and local priorities. They also benefit the smallest farmers the least, and often do not reach the most marginalised groups, such as those working on hard-to-reach lands and women farmers. Over the past three decades, a decline in public and donor funding has led to a more decentralised and pluralistic extension system, as well as greater reliance on private actors.
- **Training in sustainable agricultural practices has increasingly become tied to market standards and certification.** A number of voluntary, mostly private, good agricultural practice (GAP) schemes emerged in the 1990s in response to perceived consumer demand for greater assurances of quality, safety and welfare. However, such schemes require significant investment from farmers. Usually, only smallholders at the 'top of the pyramid' – starting from a place of relative advantage in terms of human and financial capital – benefit from such schemes.

Successful training programmes will be context-specific and provide farmers with a financial incentive

- **Farmer organisations may improve the effectiveness of training in agricultural practices.** Groups which bring together farmers cultivating the same crop can provide members with tailored training on a specific product.
- **Emphasising the financial rewards of good agricultural practices (over environmental benefits) can help secure farmer buy-in.** Global brands increasingly strive to show consumers that environmentally sound agricultural practices are being adopted in their supply chains. However, adopting these practices often requires farmers to take risks; as a result, training programmes aimed at smallholders tend to emphasise productivity and profitability.
- **To be effective, extension services should be combined with other farm inputs.** After receiving training, a farmer's decision to adopt new practices often depends on several interrelated factors. Providing integrated services – combining inputs, credit and training – is increasingly regarded as a more effective way of supporting farmers to improve quality and sustainability.
- **'Farmer field schools' are an intelligent approach to building capacity in sustainable agricultural practices.** This model is more participatory than traditional extension training; it has been applied globally to disseminate regenerative agricultural practices, particularly Integrated Pest Management. Although it tends to rely on donor funding, public-private partnerships may lead to more lasting impacts. For example, the smallholder-owned Kenya Tea Development Agency (KTDA) has been running farmer field schools to promote regenerative agriculture since 2008, initially in partnership with Unilever and IDH (The Sustainable Trade Initiative), and later with the Rainforest Alliance.
- **Training design should match farmers' needs and constraints.** Approaches to delivering training in regenerative agriculture should be able to adapt to farmers' contexts – which change over time as well as across different locations. For example, the Marcatus Mobile Education Platform (see case study below)

gave extension officers the tools and know-how to create their own training videos, thereby enabling them to shape future training content in response to emerging issues. Selecting appropriate trainers is also key – factors such as gender, language and affinity with farmers should be considered. High levels of mobile phone ownership, even by resource-poor households, provide an emerging opportunity to innovate in training delivery.

Principle 2: Provide smallholder farmers with access to markets

Accessing high value markets is vital to creating positive opportunities for smallholder farmers

- **Subsistence farming is in decline.** While most smallholders produce, at least partially, to sell in the market, these markets tend to be informal and low-value. Selling into informal markets has some upsides for smallholders (traders buy all the harvest, in cash), but also significant downsides: low prices, weak negotiating power, and poor access to technical assistance, including for regenerative agriculture.
- The term "access to markets" usually refers to access to high-value markets for cash crops. **There are several reasons why high-value markets can be desirable for smallholders:**
  1. Opportunities for higher income
  2. Links to better practices, skills and knowledge, and sometimes increased finance or financed inputs, for example as part of contract farming
  3. More predictable, consistent and contract-based sales
  4. With the right support (see Principle 1), smallholders can achieve high quality standards.

Several obstacles and challenges prevent smallholders accessing higher value markets

- **Cash crops can compete with food crops** on smallholder land, meaning households tend to buy rather than grow their food (and so meet their food security needs)
- **The price and value of high-value crops may be much lower than expected,** subject to large fluctuations, and lower than emerging domestic markets for staples. Prices can be volatile and below cost of production, as seen with tea, coffee, vanilla and passion fruit crops.
- **Dependence on one crop can create high exposure to risk,** by undermining diversity and resilience (see Principle 3)
- **Quality (and sometimes sustainability) standards demanded by buyers may be difficult or impossible for smallholders to meet;** these can include specifications for inputs, labour and irrigation. Even if standards are met, farmers may still find their crop is rejected or receive penalties for breach of contract. This is particularly the case in horticulture value chains (see case study).
- **Dependence on one buyer leaves smallholders with little negotiation power.** This can arise when local market for the crop is thin or absent, if there are no alternative markets, or a full harvest is contracted with no option for secondary market.
- **Lack of infrastructure and facilities** may make it difficult for farmers to store, transport and sell their products at high value markets.
- **Finally, production of high-value crops may put heavy demands on soil fertility and water resources.** This is one reason why regenerative agricultural practices are critical.

Better access to training, services, information, finance, and stronger farmer associations will support market access

- Many countries are making progress in addressing structural issues, including improving infrastructure, transportation, communications, education and extension. For instance, the rise of mobile technology in sub-Saharan Africa has improved information flows and enhanced competition among traders, benefiting farmers.
- Value chains, driven largely by buyers and shaped by increased consumer awareness, have also progressed to better support farmers, by improving price transparency/information, enhancing access to finance and promoting better practices in contract farming (such as outgrower models).

- Access to training (see Principle 1) has proven a critical dimension for improving market access, improving both productivity and quality.
- Income diversification (see Principle 3) is another important element, building smallholder resilience and reducing exposure to risk and dependence on a single cash crop.
- Finally, strong producer organisations and greater collective agency is key to enable farmers – particularly women – to access services and training and to grow their negotiating power.

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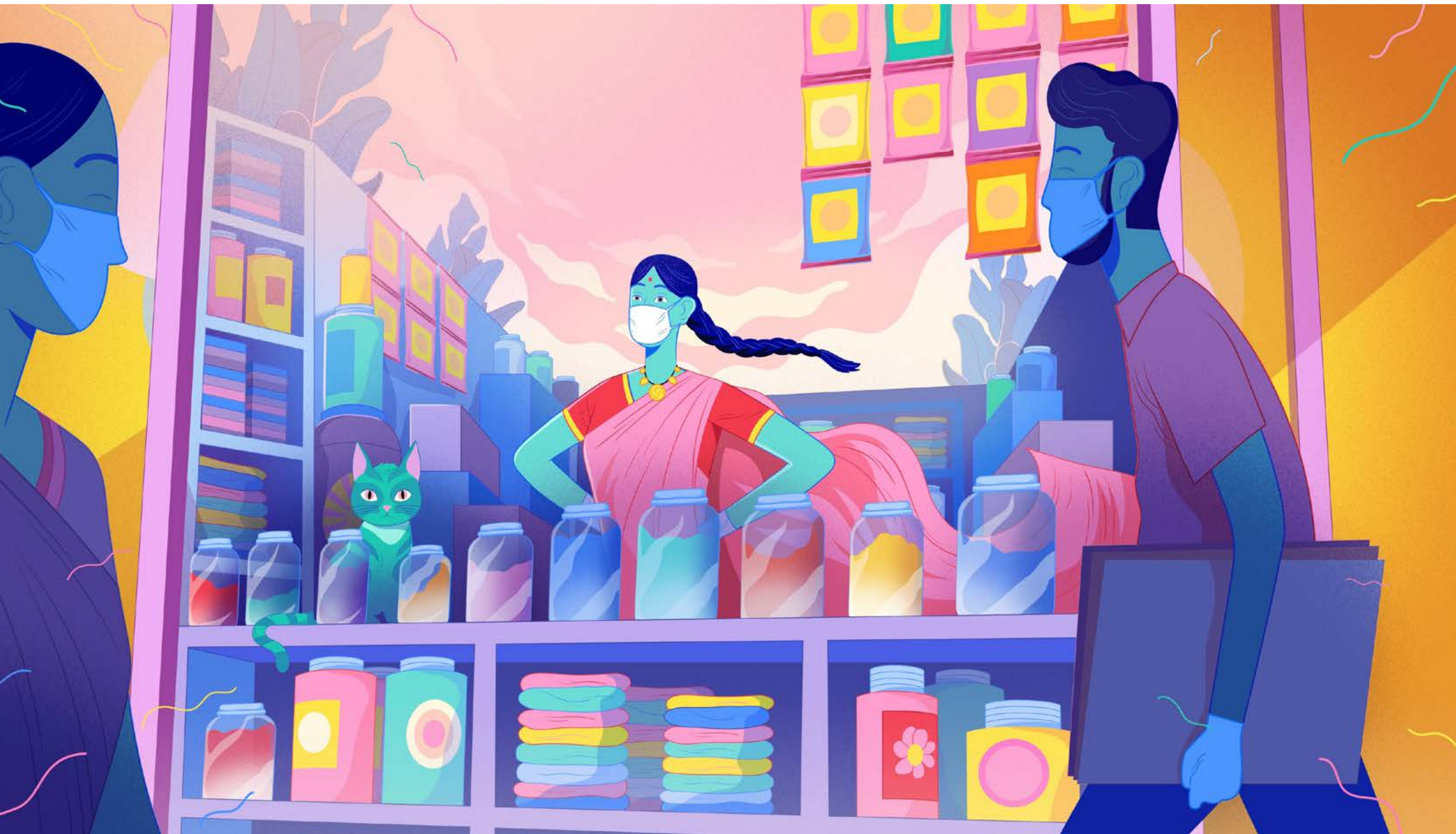

Principle 3: Support smallholder farmers in income diversification

Cash crops and intensive farming expose smallholders to risk

- Smallholder farmers depend on cash to pay for expenses such as education, healthcare, transportation and – increasingly – food.
- Depending on one cash crop for all or most of their income exposes farmers to risk. The most common threats are climate or seasonal variabilities like drought or flooding, pests and disease, and price fluctuations. In the case of high-value crops such as vanilla, theft is an additional concern (see case study). Knowing how to diversify their sources of income is essential to help farmers navigate these threats.

Income diversification is not equally or easily possible for all

- **Wealthier smallholders appear to benefit more, and more often,** from the opportunities for income diversification, sometimes due to their better access to education, which puts them in a better position to secure good off-farm employment.
- **Location and geography matter.** Farmers closer to markets and with transportation networks can diversify their income more easily. However, farmers may also rely on 'environmental income', which is the use of wood for fuel, wild food, and other non-timber forest products. For poorer farmers, this can account for up to a third of their household income.

Diversified income may come from on-farm and off-farm sources

- **Off-farm employment** can be a major source of income. Smallholders may mix farming with part-time jobs outside of the farm; some household members can be employed full time off the farm – this can be especially important for women (see WEE). With more people migrating from rural areas, money sent from relatives has become another increasingly important source of income for farmers.
- **On the farm,** additional income can be generated in several ways. Many farmers **diversify their crops** to offset seasonal fluctuations or to carry them over until cash crops are mature, or use a mix of staples and cash crops. Some farmers engage in **mixed agroforestry production systems** as a strategy to reduce exposure to long term price decreases and fluctuations in commodity markets. Other farmers rely on **on-farm processing** such as milling or brewing to add value to their existing crops. In recent years, **tourism** has also been used as an additional source of on-farm income. Finally, some farmers seek **alternative outlets**, such as local or informal markets, to sell lower quality produce that is rejected by some buyers.

Crop diversification, agroecological practices, farmer associations and social protection schemes all contribute to income diversification and increased resilience

- **Growing different crops with different growing and harvesting periods** is one way to manage seasonality. For example, supporting vanilla producers to produce coffee and/or cocoa helps them manage price fluctuations (see vanilla case study).

- **Agroecological practices including intercropping and agro-forest systems** create opportunities for additional sources of income, while enhancing environmental sustainability.
- **Membership in producer organisations, preferably farmer owned and independent of any single supply chain,** helps farmers to access information, technical assistance and other benefits of collective action (for example, the pooling of resources such as capital and labour, or sharing costs of transport and equipment).
- **Social protection schemes,** especially cash transfers delivered together with training, have helped farmers invest in their farms, purchase inputs and achieve better access to markets.

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Principle 4: Support women's economic empowerment

Wider socio-economic development is held back by lack of women's economic empowerment

- **Empowering women economically is important for achieving gender equality & thriving communities.** In low-income countries, women make up on average 43% of the agricultural workforce, but face gender-specific barriers which limit their productivity (for example, childcare and domestic responsibilities). Cultural norms may also shape the type of agricultural work women do. For example, women tend to participate less in the production of high value cash crops, which is often linked to their limited access to and control over land.
- **Addressing economic empowerment is particularly important because women are over-represented within economically disadvantaged groups.** In general, women are more likely than men to be in low-wage, part-time jobs. Despite playing a crucial role in agriculture, women's work is largely undervalued and underpaid.
- **Women's economic empowerment is also an avenue for tackling inequality more broadly.** Given the size of women's contribution to the economy, removing barriers to their success could lead to productivity increases which benefit whole societies. Women's increased income and decision-making power within the household has also been shown to benefit children's health and education.

Economic empowerment is complex, and needs to be addressed in a holistic way

- Women's economic empowerment does not lend itself to being measured against simple indicators; successful interventions tend to include a number of factors in combination, such as training, finance and peer support.
- Successful interventions seek to empower women within the social context of their households and communities, working with men as well as women to achieve this.
- Awareness raising campaigns about positive role modeling and challenging stereotypes should

be considered an integral part of the holistic approach.

Women smallholders face greater barriers to improving agricultural productivity, and to improving economic status

- Women in low-income countries tend to have less education and scarcer access to finance, farm inputs and extension services than men.
- Women usually control less land and cultivate smaller and less fertile plots than men. This limits their ability to cultivate cash crops at scale (often the only way to make them financially viable in markets characterized by price volatility).

Successful interventions challenge structural barriers while building individual capacity

- **Rights-based interventions create an enabling environment for economic empowerment.** For example, in Ghana, changes to the law permitted the transfer of cultivated land from husbands to wives, allowing women greater access to cocoa production and control over income from its sales.
- **Market-oriented approaches seek to integrate women into economic structures;** these may focus on creating new value-chains or improving women's access to markets, including through certification. For example, non-timber forest products in West Africa – a traditional area of economic activity for women – return more income when associated with the development of markets and professionalisation of producer groups led by women.
- **Financial services aimed at women are widespread.** Micro-loans and savings programmes tend to be combined with training in financial literacy and business skills. This helps women to diversify their incomes by enabling them to expand other income-generating activities. Formal and informal groups are crucial for providing this support. Village savings and loans associations (VSLAs) currently serve 11.5 million women across 73 countries who cannot access formal banking and are important networks of trust with benefits for members that go beyond developing positive savings/investment behaviors.
- **Collective action is an important channel for accessing hard-to-reach resources and services.** Farmer groups and cooperatives provide women with peer support and informal services such as childcare, as well as access to resources. The Self-Employed Women's Association (SEWA) in India has supported its 1.5 million members to establish women-owned cooperatives, including producer groups whose members pool resources, share market information and increase female smallholders' bargaining power.

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Principles 5 and 6: Provide men and women with training in business skills; Support farmer cooperatives to professionalise

Without financial literacy and business management skills small farmers struggle to plan and invest to improve returns, resilience and sustainability. There is already a large and persistent gap between supply and demand for rural and agricultural finance; this is felt most keenly by small producers. The capacity to maintain and share farm records and budgets is critical to access financial literacy and business management skills. Marketing and contract negotiation are also important skills to secure a good price for their produce.

Many development agencies recognise this need and integrated business skills in training curricula alongside the extension of new agricultural technologies. This can work well for individual farmers Better still where smallholders aggregate and create farmer owned business structures like cooperatives to pool their assets and improve their access to support services. However, the inclusion of women in cooperative structures has been a challenge in many contexts.

A good cooperative structure, managed to professional standards, can deliver efficient sharing of ownership, voice, risk and rewards between members. Clarity on rights, roles and responsibilities, systems of accountability, decision making and dispute resolution within the cooperative help members to assess costs, benefits, risks and opportunities of membership, and thereby commit to a common purpose, strategy and plan. The level of business awareness among members is one key factor in the success of the cooperative model. And of course, the cooperative itself can enable cost effective access to training and capacity building, not least in the area of business skills and organisational development.

There is large variability between geographies. In Africa less than 3 percent of the population are cooperative members. By contrast, in countries like India and China, well organized cooperatives hold important shares of markets for agricultural products. Strong, professionally managed cooperatives are able to expand their service offer to agro-processing, input supply and technical advice to members e.g. for obtaining VSS certification.

Determining factors for capacity development in business management and cooperative working:

- Basic levels of literacy among smallholders, influencing their individual capacity to comprehend and apply business skills and associated technology
- Sustained engagement of agencies (public, private or civil society) who are concerned with resilience and welfare of smallholder producers: concerns that may be linked to changing perceptions on environmental and social risk, new market trends, socio-economic pressures, political commitments etc.
- History and culture of cooperative movements and their reflection in national policies and legislation, which could have both positive and negative aspects

- The Land tenure context. Absence of formal title will preclude the use of land as loan collateral, which could have implications for accessing to finance to make farm business investments
- Resistance to change in the 'business-as-usual' modalities of engagement and trade with small-holders, maybe led by vested interests of actors in the supply chain
- The importance of economies of scale for the markets and production functions where small producers seek to engage. Can smallholders build a business that plays to their strengths in terms of efficient labour use, responsive and intensive land management? Or will their smaller scale of operation, even when aggregated into cooperatives, count against them.
- Objectives for cooperation that recognise the value of supporting income diversification for members and inclusion of women in cooperative membership.

Current trends

Rural financial services, viewing farmers as clients rather than beneficiaries, are introducing new models of agricultural insurance, digital payments, and savings accounts which can be delivered directly to rural households by digital channels. There are online budget tools to help individual farmers estimate their costs, cash flows and profits. New forms of lending to smallholders have been introduced based on projected cashflows rather than property value, while aggregation of farmers via the cooperative model is overcoming diseconomies of small scale to bring new sources of finance into play.

Service providers are moving their focus from farm productivity to profitability and considering the whole household economy, with farming being just one of a range of economic activities, livelihood strategies, social dynamics, and aspirations.

There is growing interest from impact investors in service delivery to smallholder farmers. Such invest-

ment may be best channeled through different service providers to match the needs of farmers at different stages on a range of pathways to transition. However, of the service-delivery models available, evidence suggests farmer-led models like cooperatives have a higher impact on farmer profitability. There is increasing recognition of the value of this type of model in which local people, living with the consequences of their decisions, reconcile competing needs from landscapes in businesses they control.

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CASE STUDIES

1 Building the business skills of cocoa farming families: an inclusive approach from Indonesia

Background

Cocoa is an important factor in the livelihoods of 1.7 million smallholder households in Indonesia. With prices lagging well behind GDP growth in recent years, cocoa could only remain a viable and attractive livelihood option for these households if productivity increased.

In 2012, the **Sustainable Cocoa Production Program (SCPP)** was conceived as a public-private partnership to support continuous improvement in both economic and environmental performance of the sector across 10 provinces and 57 districts in Indonesia. It was designed to promote better production practices and deliver the assurances on sustainability demanded by international buyers.

From 2012 to 2020, the SCPP facilitated capacity-building activities across multiple aspects of cocoa farming livelihoods: agricultural, environmental, financial, and social and nutritional. The programme reached a total of 165,000 smallholder cocoa farmers in 57 districts across 10 cocoa-producing provinces in Indonesia.

Interventions and enablers

- 1,659 master trainers from the NGO, private and public sector were trained to deliver a series of modules in a 'farmer field school' (FFS) format; 6,339 cocoa producer groups were established and supported.
- In total, 91,626 cocoa farmers received training in financial practices and 110,282 in environmental practices.
- Farmers with strong influence in their networks and those with a track record as early adopters were targeted to participate, to optimise impact.
- To scale-up the training and provide ongoing support, the most innovative farmers from the FFS were enabled and encouraged to coach individual farmers within their networks.
- Modules on Good Business Practice and Climate Smart Agriculture were important elements in the training.
- For support on Good Business Practice, the programme's approach (referred to as 'Transformative Coaching') focussed on family business units, wherever possible working with husband and wife together.
- This approach sought to develop participatory visioning and planning skills, allowing farmers to draw up and continuously improve their own farm business plans.
- The Climate Smart Agriculture component promoted the integration of livestock in cocoa production. Goats and shade trees were introduced into the farming system; tree foliage provided fodder for the goats. Livestock biowaste was then used to produce compost, replacing inorganic fertiliser in the cocoa plantations. By closing the 'nutrient cycle', it was possible to minimise use of non-renewable resources and lower cocoa production's carbon footprint.

Outcomes: stronger farming businesses; improved income while reducing carbon footprint

At household level, the programme's more gender-balanced and holistic coaching practices delivered action learning on business skills while also strengthening social networks for women and men at all levels. Female inclusion and income diversification strategies were inherent in the SCPP approach.

The percentage of women participating in trainings did not exceed 20%; however, this represents a significant advance on the traditionally low level of women's involvement in tree crop production.

SCPP participants increased farm productivity by 19% (with yields up from 508 to 603 kg/ha/year). At the same time, GHG emissions from participants' cocoa farms dropped by 24%.

Beyond establishing more than 6,000 cocoa producer groups, the SCPP has enabled their professionalisation. This has aided groups in achieving Voluntary Sustainability Standards (VSS) certification and accessing responsible cocoa supply chains.

From a 2016 baseline, net attributable income for cocoa farmers in the programme increased by

US$22.7 million. This contributed to a 55% reduction in the percentage of programme participants living below the US$2.50 poverty line.

Lessons learned

Integrating the development of cocoa farm business skills with conventional interventions to boost efficiency and sustainability has produced a synergy, multiplying positive results in terms of farm family welfare and regenerative agriculture. Targeting leading farmers within peer networks has also increased the programme's impact, establishing an effective and lasting influence on farmers' behaviour, specifically the uptake of climate smart production practices.

Transformative coaching's focus on family business units has increased women's engagement, enabling them to make a greater contribution to protecting and improving community wellbeing and the environment. This goes some way toward correcting the gender imbalance in cocoa farming.

2 A model cooperative: professionalism benefits palm oil farmers in Honduras

Background

Honduras is Central America's largest exporter of palm oil products. The country's 18,000 palm oil smallholders and their cooperatives play a major role in the sector. Cooperatives have been crucial to ensuring that smallholders can participate in a competitive market, and that they have the right support and training to do so. **The Salama Cooperative** (Salama), established more than 50 years ago at the height of a peasant empowerment movement, is a leading example of the cooperative enterprises that have allowed smallholders – and the sector as a whole – to thrive.

However, Salama has travelled long road to achieve its current success. In its early years, the cooperative faced serious financial difficulties when efforts to produce grains and citrus failed. It then decided to specialise in palm oil and built a close relationship with Hondupalma, one of the largest palm oil cooperatives in Honduras. Salama invested in its own mill; it nurtured new smallholder cooperatives to increase the volume of palm fruit milled there. The Salama Cooperative now has capacity and agency to determine its own future direction and commercial partnerships. As a small cooperative that has grown into a strong sustainable business, Salama can serve as a model for similar organisations.

Interventions and enablers

- Favourable government policy and legislation: political momentum and strong regulation in the 1970s enabled Salama and many other cooperatives to establish themselves on a sound footing, with good systems of internal governance, clear legal status and prudent financial management and reporting. A national institute was established by law to provide oversight, training and advice to cooperatives, reducing risks of mismanagement or malfeasance.
- External technical support: Salama receives support on training, organisational development, business administration, health and safety, and legislation from the Union Nacional de Campesinos (National Peasant Union) and

from other governmental and non-governmental institutions.
- Peer support: when the young Salama Cooperative faced serious financial difficulties, the Hondupalma Cooperative stepped in to provide organisational and technical support, helping Salama to build a business model based on palm oil production as well as providing a route to market.

Outcomes: a strong, sound cooperative; wide benefit sharing

Today's Salama Cooperative is a well governed, profitable institution with robust and transparent internal governance. It provides secure livelihoods for a new generation of member farmers and for many non-members in the community in which it is rooted. Members' yields and the profits returned from their palm oil plantations are significantly greater than those achieved by smallholders working alone, selling their palm fruit on the open market. The Cooperative has also facilitated International Sustainability and Carbon Certification (ISCC) for members and is working towards certification from the Roundtable on Sustainable Palm (RSPO), enabling access to important export markets.

Salama has 58 active members, 46 men and 12 women; around 40 of whom work their own plantations. Other members hire local labour and the cooperative itself has 457 employees, largely recruited from the local community and often relatives of existing members. The Board includes two women members and all female associates have full rights in the General Assembly.

The Salama Cooperative is well positioned to access technical support from external agencies. It also maintains its own technical team to support both members and independent smallholders who supply palm fruit to the Salama mill. This cooperative has helped many such smallholders with advice and finance to invest in their palm oil plantations, and to form themselves into new cooperatives. Just as Hondupalma helped Salama to develop and grow, Salama is now supports a new generation of cooperatives to do likewise. It currently supports and sources palm fruit from nine local farmer cooperatives and associations, representing more than 700 members.

Salama also provides social services including education, health and security to improve the welfare of members and non-members in local communities.

Lessons learned

The most critical factors in Salama's successful evolution and professionalisation have been:

a. The relatively tight government regulation of cooperative governance, cultivating prudent and responsible management of cooperatives resources
b. Having a strong model and mentor (Hondupalma) to steer Salama down a pathway of commercial viability and success
c. Access to the technical support needed to move into oil palm cultivation.

It can be noted that local agri-business and downstream buying companies were not well positioned to play a positive role in this case. Evidently their involvement was not essential, although it may be argued that the export market for palm products created by international buyers has been a crucial factor in the growth of palm oil cooperatives in Honduras generally and for Salama in particular. In other circumstances, the professionalisation of cooperatives could be supported, but not delivered (and certainly not imposed) by buying companies.

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3 Greater sustainability for small tea farms: linking training and certification in India

Background

India is the world's second biggest tea producer, with an estimated 80% of its produce going to the domestic market. Assam is the largest tea-growing region, where it is estimated that around 144,000 smallholders engage in tea production. But the Indian tea sector has changed in recent years: foreign demand has decreased, domestic demand has risen. Historically cultivation was dominated by large formal estates, but the number of small tea growers has grown steadily since the 1990s. In Assam, small growers now produce roughly half of the region's tea crop. Smallholder-produced tea is largely consumed in the domestic market.

Most smallholders are unregulated and part of the informal economy; they are not bound by labour laws set out in the Plantations Labour Act (which covers gardens of over five hectares) and most are not registered with the Tea Board of India. This excludes the majority of smallholders – many of whom may be relatively new to tea growing – from accessing information and training in sustainable practices.

Smallholders in Assam have little bargaining power within the tea supply chain. They sell their green tea leaves either to the tea factories of large estates or to 'bought leaf factories', often through middlemen. Tea manufacturing is also highly concentrated in the region, dominated by just a few large players.

The 'farmgate' price of tea has declined over the past two decades, while the price of labour, energy and farm inputs has increased. For many small-holders in Assam, cultivating tea is becoming an increasingly unsustainable source of income.

Given the high rate of domestic tea consumption, and the growing proportion of small tea growers supplying the sector, it was clear that India needed a context-specific sustainability standard. In 2013, **'Trustea'** was launched. Funded by the Sustainable Trade Initiative (IDH), Hindustan Unilever and Tata Global Beverages, this national sustainability code tackles challenges around working conditions, environmental degradation and contamination, and climate change. It also responded to a perceived increase in domestic concern for food safety, traceability and sustainability among the growing middle class.

Small tea growers tend to not be represented by associations with a voice in the industry, so their active inclusion within the Trustea programme marks a turning point.

Interventions and enablers

- Trustea connects with small growers through the tea factories. After an initial assessment, implementation partners then deliver practical on-farm training, often to groups of producers, including through 'farm support centres'. Trustea works with the Tea Research Association to ensure this training is tailored to smallholders. Support centres establish demo plots for sustainable practices, but also provide training in business skills and management to strengthen farmer cooperatives.
- The trainings include important sustainability practices, including soil management and conservation (including soil testing); shade tree planting; green leaf plucking and trapping; proper use of fertilisers; integrated pest management; and composting of organic matter. Just over half of all small tea growers in Assam have learned and adopted systems for managing chemical runoff and sewage. Trustea has also developed guidelines for implementing Integrated Pest Management in the programme areas.
- Through Trustea, small tea growers have been helped to identify areas prone to soil erosion. Around 78% of the small growers Trustea works with in Assam have conducted a soil test.
- The code has introduced a method for recording the use of agrochemicals, production quantities and other details needed for farm management. The 'farm diary' method was designed to be easy to use for small tea growers and supports the practical realisation of sustainability practices learned through training.

Outcomes: increased sustainability practices; partnerships established to grow remit

To date, 65,000 small tea growers are affiliated with Trustea; most will have received at least basic training in sustainable practices. By the end of 2019, 48% of Indian tea was verified by Trustea.

Reaching smallholders and ensuring compliance with certain environmental standards (such as fertiliser application), has been more challenging than working with estates. This is often due to small-holders' financial pressures.

Trustea is planning to go 'beyond certification'. It has partnered with the Small Tea Grower Sustainability (STGS) Platform, which supports producers to diversify their income through intercropping and provided a health insurance scheme during the COVID-19 pandemic, among other initiatives. Trustea has also partnered with UN Women to deliver trainings on preventing the sexual harassment of women, which will ultimately be delivered to both small tea growers and plantation tea workers. So far, the programme has reached 300,000 women across India, contributing to an improved working environment.

Lessons learned

Tea producers generally acknowledge the environmental benefits of the interventions and have increased knowledge of both the sustainability challenges and solutions in tea growing. However, some producers have voiced a need for training on quality and productivity, and a desire to take part in evaluations of the trainings.

The programme's success in reaching small tea growers at scale stems in part from building a network of local agents on the ground who are connected with producers. These can be 'agri-entrepreneurs' as well as local leaders, who are often a crucial point of contact for small tea growers.

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4 Empowering Rwanda's female farm workers: local delivery of an inclusive campaign

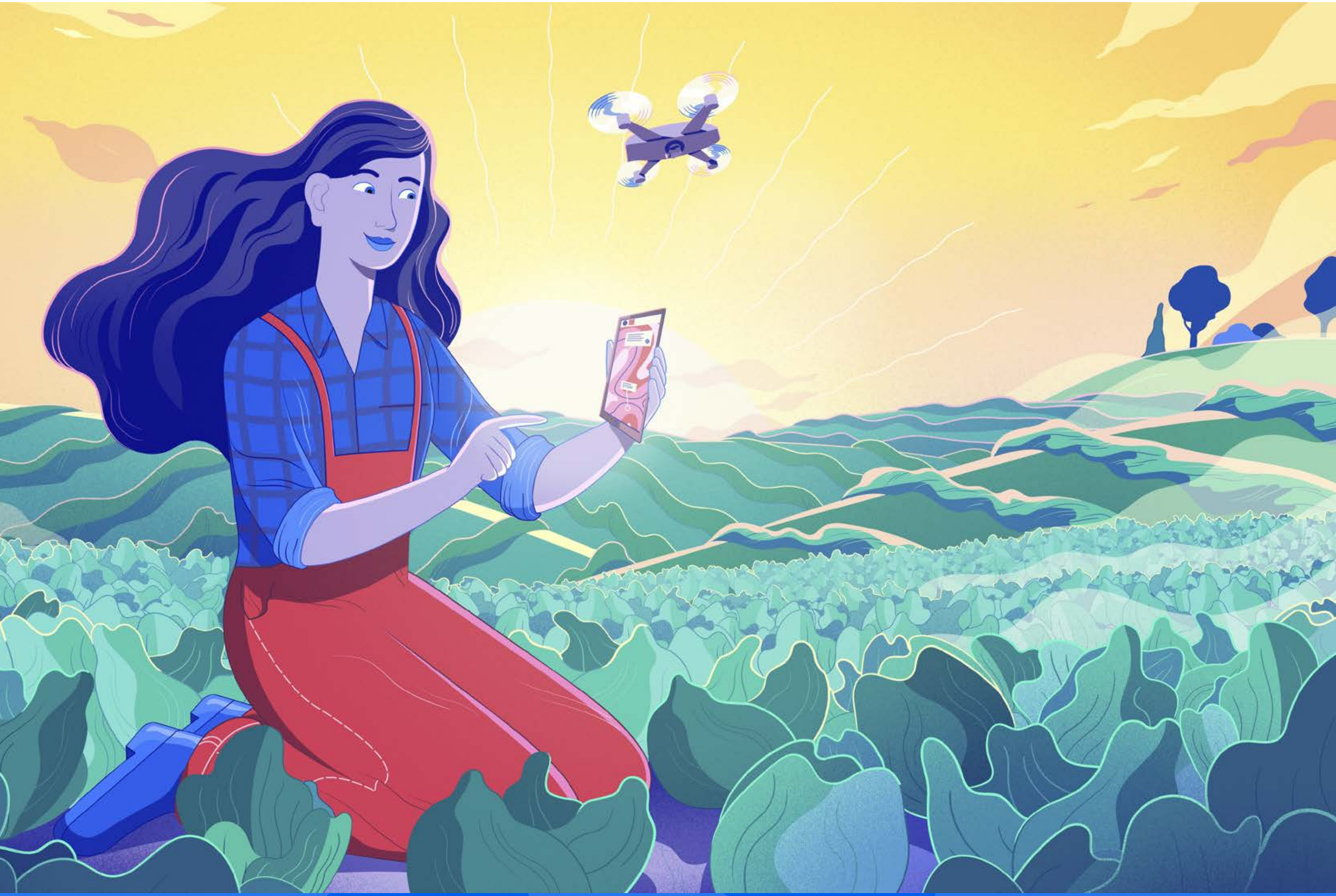
Rwanda's horticultural sector is relatively young compared to its neighbours Kenya, Uganda and Tanzania. As in other East African countries, horticulture – to supply local supermarkets but mainly for exports – is seen as an opportunity to access high-value markets and increase farmer's income. Over the past decade or so, the Government of Rwanda has prioritised horticulture as an important sector for growth in trade and exports, increasing its funding and creating an enabling environment for investment.

The horticulture sector relies on both small and large-scale farms, many of which are foreign owned. Most farm workers are women, largely employed occasionally or informally. In addition to the uncertainty of lacking contracts or access to social protection schemes, many women are victims of sexual harassment, and must cope with demands to fulfil household work in addition to their wage labour. Where organisations or cooperatives exist to defend workers' right, leadership positions tend to be occupied by men.

In 2015, the **'Women at Work' campaign** began, funded by the Dutch Ministry of Foreign Affairs and coordinated by NGO Hivos. The campaign partnered with women's rights and labour organisations in East Africa to promote decent work for women in the horticulture sector. The Rwanda Women's Network and Haguruka, a women's rights NGO, worked with horticulture farms ranging in size from less than ten employees to hundreds. Most of the farms grow vegetables or produce flowers for export.

Interventions and enabling factors

At the start of the campaign, most farms lacked gender-sensitive workplace policies to promote women's economic empowerment. Most female workers did not have proper employment contracts, and due to the informal nature of the sector, employers were often not making social security



contributions on the women's behalf. This meant that women going on maternity leave were only entitled to six weeks' paid leave, rather than twelve. In the case of the smaller farms, the absence of a management structure also meant that female employees did not know how to report incidences of gender-based violence – or did not feel comfortable reporting it to the farm boss.

As part of the campaign, the Rwanda Women's Network and Haguruka delivered trainings to both farm workers and managers, men and women, on gender equality, women's leadership, financial literacy, labour rights and gender-based violence. The project supported businesses to put in place policies to provide job security and benefits to women farmers, as well as mechanisms to report and address gender-based violence.

The campaign also contributed to strengthening and promoting leadership skills for women. Although many of the small farms the campaign worked with are owned and run by women, there was a perceived social taboo around women taking on leadership roles among the farm workers. Women workers indicated a reluctance to put themselves forward for better-paid supervisor positions, because the longer hours associated with the role would interfere with their caring responsibilities. Moreover, income earned from horticulture jobs can be a source of interpersonal conflict between women and their husbands, sometimes leading to sexual violence. The project supported the owners of small farms to grow their businesses by organising exchange visits and workshops with larger farms.

Outcomes: women are organising to increase and apply their rights

- The trainings in financial literacy inspired women farm workers to set up gender committees on the farms, providing a channel for women to voice their needs and concerns and to report sexual harassment. Haguruka also set up mobile legal clinics to aid women in taking legal action, and represented some workers in court.
- Following the financial literacy trainings, some female workers also set up savings groups, increasing their financial independence and allowing them to build homes and pay for school fees.
- The campaign worked with farm managers to support the adoption of policies which would promote women's economic empowerment, including gender equality policies.

Lessons learned

This campaign showed that women's empowerment is not just an economic proposition. Women are attracted to the horticulture sector in order to increase their income and financial independence, but wages alone are not enough to overcome other challenges. Empowerment required a broader approach that focused on leadership, worker's rights, financial literacy and the prevention of sexual harassment, among other aspects.

An inclusive approach was key: the gender committees set up on the farms included both men and women, and the trainings on sexual harassment were aimed at all workers. This was important for ensuring a lasting change in business practices and culture. The husbands of women farm workers were also invited to take part in some trainings, to help address issues around gender inequality at the household level.

5 Building the resilience of vanilla farmers: the Vanilla for Change Programme

Background

Vanilla is grown exclusively by smallholders. There is strong worldwide demand, and it can be a very significant source of income. Moreover, vanilla production lends itself to sustainable production: it is naturally organic, provides a habitat for lemurs and other animals, and can be used in agroforestry systems.

But while vanilla production can offer significant benefits and opportunities, it is also characterised by extreme market volatility. During a recent boom, vanilla was briefly as valuable, by weight, as silver. When prices are high, farmers are tempted to harvest early, which affects quality, and there are serious issues with theft. When there is oversupply and the prices collapse, farmers have little incentive to invest in production or skills. Moreover, most of the world's vanilla comes from one country – Madagascar – exacerbating the volatility of the market.

The Sava region of Madagascar shows vanilla's pitfalls and opportunities. It produces most of the world's best vanilla—and is also one of the poorest regions in the country. Vanilla brings profits when prices are up, but for the most part vanilla production does not provide a sustainable source of income. Depending on it is a high-risk proposition. Farmers do not have the incentives to invest in production because they don't have assurance of the returns; apart from the volatility of the price and risk of theft, they have poor access to services such as technical assistance and finance.

The **Vanilla for Change Programme**, which has been running since 2016, is supported by Unilever, the German international cooperation agency (GIZ), Save the Children, and Symrise (one of the world's largest vanilla buyers). The project's aim is to improve resilience and ensure that vanilla can deliver long-term benefits for smallholder farmers.

Interventions and enablers

The project has focused on building the resilience of farmers so that they are better able to withstand the ups and downs of vanilla production and prices. Key interventions to improve resilience include:

- Access to advisory services, including on risk diversification and entrepreneurial skills, through Farm Business Schools in which more than 4500 farmers participated. Farmers were trained on economic activities to diversify their income, such as animal husbandry and planting other crops like cocoa and ginger.
- Strengthening of producer's associations and cooperatives by improving their management and delivery of services to members.
- Enhancing financial literacy and farmers' ability to save, including through support for village savings and loans associations (VSLA). Savings provide buffers in the lean season and funds to invest in new businesses.

The programme has taken a holistic approach that addresses the multiple challenges faced by vanilla farmers, including health, education, and nutrition. A major focus has been on enabling and empowering young people to break the generational cycle of poverty and eliminating child labour and exploitation – a big problem in vanilla farming.

Outcomes

- By 2020, 75% of farmers had seen improvements in their standard of living across several indicators including higher incomes, improvements in housing, purchasing new land, and more education for children.
- 60% of producers increased their income through diversification. Farmers' non-vanilla income increased by almost a third, mostly due to livestock farming and non-agricultural activities.
- Farmers were able to take advantage of high vanilla prices during the boom and invest them to improve their homes and their livelihoods. Farmers are now better able to manage their cash flow, and more than half of the producers have been able to start saving for unforeseen events.

- More than 120 VSLA groups were formed, benefitting over 2000 members – three quarters of whom were women.
- Through the Sustainable Vanilla Initiative, the programme has engaged other stakeholders in the sector. The programme has sought to contribute to sector-wide learning by galvanising businesses to support sustainable vanilla sourcing, as well as a more integral approach to smallholder livelihoods. The development of a sector-wide child protection code of conduct was another important milestone.

Lesson learned

Providing opportunities to diversify income has been crucial to improve the cash flow and incomes of vanilla farmers. This reduces their dependency on vanilla and acts as a buffer to mitigate the volatility of the vanilla market.

The programme has also shown the importance of adopting a holistic approach. In addition to income diversification, farmers are better able to understand and manage their finances, and through the VSLAs they have a means to save and access credit when they need it. A more stable and well managed income, complemented by improved knowledge of health, nutrition and sustainable agricultural practices, together provide a foundation for breaking the poverty cycle and offer greater possibilities for the next generation.

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6 Increasing product quality and producer income: certifying coconut oil in Indonesia and The Philippines

Background

Global demand for coconut is growing exponentially and outpacing supply. It is predicted that the coconut industry's worth could rise from about US$11.5 billion in 2018 to US$31 billion in 2026. The top producing countries are Indonesia, the Philippines, India, Brazil and Sri Lanka, and the main cash products are copra (the dried kernel) for oil, husk for fibre, and tendernut for coconut water. Whole mature nuts are also sold to factories producing desiccated coconut, coconut milk and very recently virgin coconut oil. This rapid growth is driven by the commodity's popularity in the cosmetics and food industries, where coconut is promoted as a healthy and sustainable product. There is tremendous market potential but also significant production challenges for sustainable coconut.

The coconut crop is dominated by smallholder production (accounting for 70 to 95%,depending on the region) and is a major contributor to the livelihoods of more than 11 million farmers worldwide. Ninety-five percent of these farmers are resource-poor smallholders with limited information and access to market, finance and technical know-how. They also tend to be poorly organised and receive extremely low prices for their harvest. In the Philippines, the world's second-largest coconut produce, the average coconut farmer earns less than US$1 a day. Coconut production is also characterised by complex supply chain structures, and the industry is largely an informal one, which tends to increase vulnerability of workers.

Production challenges to this crop include natural disasters, severe extreme weather events and pest and disease outbreaks caused by climate change, all of which tend to increase farmers' exposure to shocks and vulnerability. Combined with ageing trees (resulting in low yields) and falling commodity prices, these challenges lead to low income and low incentive to invest in coconut production, despite growing market demand. There are potential market incentives to clear new lands for coconut plantations, but without the technical know-how this could lead to deforestation.

Running from 2015-2019, the **Sustainable Certified Coconut Oil project (SCNO)** sought to improve the quantity of sustainably produced and certified coconut oil, while also increasing the incomes of smallholder coconut farmers' on the islands of Mindanao and Southern Leyte in the Philippines and on Amurang, North Sulawesi, in Indonesia. If successful, the project would make it possible for companies to source sustainable coconut oil.

SCNO is a public-private partnership, developed as part of the develoPPP.de program of Germany's Federal Ministry of Economic Cooperation and Development (BMZ). Partners include Cargill, BASF, Procter & Gamble (P&G), GIZ and other national partners.

Interventions and enablers

- The project trained farmers in relevant business skills and in enhanced farm management practices, based on applying Good Agricultural Practices (GAP) and enhanced intercropping techniques.
- Farmers also received training in replanting and integrated pest management, to increase farm resilience.
- Finally, the project aimed to monitor, evaluate and disseminate its results.

Outcomes: higher productivity, higher incomes; access to markets

- More than 3,700 farmers – over half of them women – received training. If this group, about 1,600 received additional training on Sustainable Agriculture Network (SAN) standards, which meet internationally recognised sustainability criteria.
- SNCO trained farmers achieved higher farm productivity levels, diversification of income sources and higher incomes.
- The farmers that were trained to comply with internationally recognised sustainability standards received the Rainforest Alliance Sustainable Agriculture Standard certification and received a premium price for their produce.
- Since 2018, the first Rainforest Alliance Certified™ coconut oil has been in production in the Philippines, with the support of this partnership.
- On average, farmers have been trained and certified report a 47% higher agricultural income compared to those who did not participate.
- Productivity for certified farmers rose 26% compared to those who did not receive training.
- Through the project, the partners were able to establish the Sustainable Certified Coconut Oil (SCNO) supply chain, which seeks to be both sustainable and transparent.

Lessons learned

The success of SCNO rested on the combined expertise of each partner: Cargill provided training to smallholder farmers and set up the structures for certification; BASF and P&G Crude processed the refined oils. The companies shared their understanding of the market trends, while GIZ contributed capacity building and project promotion.

To guarantee local ownership, GIZ also managed project implementation in close collaboration with the Philippines Coconut Authority, the Agricultural Training Institute and other partners, including the Rainforest Alliance, local universities and NGOs.

Once farmers had the opportunity to learn about coconut farming as a business and its potential to improve their livelihoods, they became keen to receive training and learn from one another on how to comply with the Sustainable Agricultural Standards and the Rainforest Alliance certification process.

Conducting trainings in the local language is key as many farmers have a limited knowledge of English. Ensuring women attended the farmers business schools was vital, as in the project sites women usually control the household's finances.
Developing intercropping is key for the farmers' livelihoods as it diversifies income streams (necessary as copra prices are volatile); this must be supported by tailored training that meets both the farmers and the market needs.

Scaling up this kind of initiative requires a marketing strategy to be in place; to inform buyers about the entire supply chain, the positive impact of the certification scheme, and the importance of paying a premium. Without such strategy it might be difficult finding a market, as cheaper oil is available.

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7 A platform for training small farmers in southern India on climate-smart agricultural practices for gherkin production

Background

The cultivation of gherkins as an export-oriented cash crop has been promoted in South India since the 1990s, due to the region's favourable climatic and soil conditions. Smallholders grow gherkins through contract farming, through which they are provided with inputs such as seeds and pesticides, as well as advice and training from field extension officers. Smallholders tend to derive income from the cultivation of other cash crops in addition to gherkins and may also engage in animal farming and off-farm income-generating activities.

Contract farming can have benefits for smallholders, such as providing access to credit, inputs and training, and de-risking the cultivation of new, often high-value crops for export. However, smallholders have weak bargaining power within contract farming arrangements, and tend to benefit less than medium- or large-farms in terms of yields and incomes. In the South Indian gherkin market, it seems common for farmers to switch suppliers from one year to another; this is likely driven at least partly by farmers' perceptions of their relationship with suppliers, and the extent to which they feel supported.

Gherkins are water- and are labour-intensive. Few data exist on the gendered division of labour in gherkin farming, however, three quarters of extension officers surveyed by Marcatus QED reported that women do half or more of the on-farm work.

In recent years the sector has seen a fall in demand from foreign markets (particularly Russia) as well as declining yields and crop failures, caused by drought, unpredictable rainfall, pests and diseases. Providing large numbers of smallholders in hard-to-reach rural areas with information and training which could help to tackle these issues, is costly and time-consuming, and presents a challenge for suppliers. Moreover, illiteracy (which is higher among women) can be a barrier to delivering training through the use of written materials.

The Marcatus Mobile Education Platform is a video training programme developed by Marcatus QED (Marcatus), a global agri-food sourcing company which works with suppliers who together contract around 18,000 families farming gherkins in South India. Supported by the Enhancing Livelihoods Fund, and local and international partners, the programme aims to improve suppliers' ability to teach farmers about sustainable agricultural practices, in particular through the use of video technology. The assumption is that farmers' yields, and therefore their incomes, would improve through the uptake of climate-smart agricultural practices. The programme also aims to improve women's access to training and education, both by facilitating their participation in training sessions, and by showcasing women in leadership and decision-making roles within the training content.

Interventions and enablers

Launched in 2015 in Karnataka and Tamil Nadu, the platform provides field extension officers with a digital textbook and videos on sustainable agricultural practices, such as drip irrigation, pest management, fertilizer and manure application, and farmer health and safety. Tablets were supplied so that extension officers could view the material with farmers in the field. Marcatus also provided its suppliers with video cameras and training on how to make videos themselves, so that extension staff can record videos of local farmers demonstrating or talking about the practices in their local language (Tamil or Kannada). Extension staff have been given handheld projectors and speakers in order to screen the videos to large groups of farmers.

Outcomes

- At the outset of the programme, a digital textbook was developed, and field officers were trained in video production; over 60 videos were created as part of the initial 'curriculum', covering nearly 30 topics and featuring local farmers.
- By providing suppliers with the equipment and know-how to create their own videos, the programme has empowered extension staff to adapt to farmers' changing needs and respond to emerging issues with new videos in future.
- Nearly 400 extension officers (all men) have received training on the platform. All officers had some exposure to training materials on gender sensitivity; 150 attended workshops with a gender component and 67 team leaders and decision makers took part in a session with a gender expert.
- Over 10,500 farming families attended a training session or received training through the platform. Just over half of all attendees were women.
- An estimated 65% of the families who received the training later adopted one of the sustainable agricultural practices they learned about. In an evaluation, Tamil-speaking respondents reported that pest management practices had benefited them the most; for Kannada-speakers, drip irrigation, staking, and proper application of fertilizer and manure were most important.
- A randomised control trial found that gherkin yields were on average 20% higher compared to previous years. Incomes also rose by around 22%, although this could not be confidently attributed to the mobile education platform.

Learnings

- Partnering with suppliers and their field extension officers, coupled with the use of video technology and group screenings, appears to be an effective way to reach marginal smallholders in a supply chain dominated by contract farming.
- Part-way through the programme it became clear that field officers had not fully understood how to represent women as leaders in the videos; as a result, gender experts were brought in to deliver more in-depth gender-awareness training sessions to team leaders and decision-makers in the supplier companies. The materials produced as part of the curriculum, including the 'train the trainer' materials, the digital textbook and the videos, were reviewed for their gender sensitivity and improved.
- The programme did not have a clear pathway for empowering women in the gherkin supply chain beyond improving their participation in trainings. For example, it did not explore the specific barriers that women face in being leaders and

decision-makers within the gherkin sector in Tamil Nadu and Karnataka. Although the gender trainings appear to have shifted the attitudes of field officers towards women farmers, overall the benefits for women appear limited so far.

- Significant differences were observed between farmers in Tamil Nadu and those in Karnataka. On average, Tamil speakers had smaller plots and derived less of their income from gherkin farming, growing them only for one season (compared to two in Karnataka). Although Tamil farmers had seen fewer videos through the programme, overall they were less likely to want to learn about new practices from videos and were less satisfied with the videos. Tamil respondents were more likely to find the videos difficult to understand, which may suggest differences in the quality of videos in the two regions.
- The impact of the training on farmers was constrained by other factors – for example, sources of stress in farmers personal lives', as well as the size of farmers' land. Farmers with smaller plots were less able to take risks by adopting new practices. However, positive and trusting relationships between farmers and suppliers, as well as clearly explaining the purpose of the training to farmers, appears to have increased adoption of sustainable practices.
- The gherkin industry in South India is competitive, and it seems common for farmers to switch suppliers from one year to another. This makes it difficult to understand the long-term benefits both for suppliers delivering the training, but also to evaluate the impact on farmers.

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