



Federal Ministry  
for Economic Cooperation  
and Development



# What is sustainable agriculture?

Published by

**giz** Deutsche Gesellschaft  
für Internationale  
Zusammenarbeit (GIZ) GmbH

- BMZ ..... German Federal Ministry for Economic Cooperation and Development
- FAO ..... Food and Agriculture Organization of the United Nations
- GAP ..... Good Agricultural Practices
- GIZ ..... Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH
- HAFL ..... Hochschule für Agrar-, Forst- und Lebensmittelwissenschaften  
(School of Agricultural, Forest and Food Sciences), Bern University of Applied Sciences
- RISE ..... Response-Inducing Sustainability Evaluation

# Contents

|  |           |
|--|-----------|
| <b>The challenge – food for all</b> .....                            | <b>4</b>  |
| <b>The solution – sustainable agriculture</b> .....                  | <b>6</b>  |
| <b>Sustainable agriculture</b> .....                                 | <b>7</b>  |
| <b>Definitions</b> .....   | <b>8</b>  |
| <b>There are many aspects to sustainable agriculture</b> .....       | <b>10</b> |
| RISE – making sustainability measurable .....                        | 11        |
| Soil management – possible without ploughing? .....                  | 12        |
| Livestock farming has many facets .....                              | 12        |
| Organic farming – can it feed the world? .....                       | 13        |
| Mineral fertilisers – a blessing or a curse? .....                   | 13        |
| Genetically modified seed .....                                      | 14        |
| Seed – from commercial or farm-based production? .....               | 15        |
| Agricultural biodiversity – can it save us? .....                    | 16        |
| Smallholders – better farmers? .....                                 | 16        |
| Agricultural technology – mechanization for everyone? .....          | 17        |
| Crop protection – with or without chemicals? .....                   | 18        |
| Gender equality – what is its role in sustainable agriculture? ..... | 20        |
| The framework – how can we promote sustainable agriculture? .....    | 21        |
| Climate change – how much is attributable to agriculture? .....      | 21        |
| Water – how much does agriculture need? .....                        | 22        |
| ‘Agripreneurs’, the farmers of the future .....                      | 22        |
| Knowledge – strengthening the agricultural innovation system .....   | 23        |
| Food security – at risk from biofuels and steak dinners? .....       | 24        |
| Is food loss inevitable? .....                                       | 25        |
| <b>Conclusion</b> .....  | <b>26</b> |
| <b>Sample projects</b> .....   | <b>28</b> |
| Bolivia .....  | 28        |
| East Timor .....   | 29        |
| Burkina Faso and Niger .....   | 30        |
| Ethiopia .....   | 31        |

# The challenge – food for all



The world's population is likely to reach 9 billion by the middle of this century. The Food and Agriculture Organization of the United Nations (FAO) believes that 60 per cent more food will be needed by 2050 to sustain all these people. Where possible, this food should be produced where it is needed – in developing countries. These countries will have to increase their production substantially to reach this goal, and this will have implications for the limited natural resources on which farming depends, particularly water for irrigation and livestock farming, land for growing crops and grazing, and limited nutrients, such as phosphate.

In many places, soil has already suffered lasting damage while water resources are often overused or polluted by fertilisers and pesticides. Agricultural biodiversity has dwindled as farming has become industrialised. These negative effects have heightened global awareness of the fact that agriculture does more than simply produce food, animal feed and energy. It also has impacts on the climate, human health, and global ecosystems.

# The solution – sustainable agriculture



Against this backdrop, how can we shape future agricultural production so that we guarantee food security for the world's population without destroying the resource base? The answer is that we need productive yet sustainable agriculture that conserves resources. Growth cannot be at the cost of natural resources and must be made as independent as possible of consumption of resources.

## **SUSTAINABLE AGRICULTURE**

- Puts the emphasis on methods and processes that improve soil productivity while minimising harmful effects on the climate, soil, water, air, biodiversity and human health.
- Aims to minimise the use of inputs from non-renewable sources and petroleum-based products and replace them with those from renewable resources.
- Focuses on local people and their needs, knowledge, skills, socio-cultural values and institutional structures.
- Ensures that the basic nutritional requirements of current and future generations are met in both quantity and quality terms.
- Provides long-term employment, an adequate income and dignified and equal working and living conditions for everybody involved in agricultural value chains.
- Reduces the agricultural sector's vulnerability to adverse natural conditions (e.g. climate), socio-economic factors (e.g. strong price fluctuations) and other risks.
- Fosters sustainable rural institutions that encourage the participation of all shareholders and promote the reconciliation of interests.

Conventional or organic agriculture? Industrial or small-scale production?

The debate about sustainable agriculture typically ranges between these alternatives. However, the issue is rather more complex, as sustainability hinges on many factors. The following sections will explore in greater detail the key points of the debate surrounding sustainable farming.

# Definitions





## **ORGANIC FARMING**

does not use synthetic pesticides and mineral fertilisers but attempts to work with natural methods and cycles. A number of associations and certification systems exist, but farmers can of course produce in an organic way without certification.

## **CONVENTIONAL FARMING**

is not a clearly defined concept, but the term is generally used in literature to refer to farming with synthetic pesticides and fertilisers. Therefore 'conventional farming' frequently denotes nonadjustable farming practices, although this is not necessarily the case.

## **INDUSTRIAL AGRICULTURE**

is typically considered to be a highly mechanised form of plant and animal production using high-yielding varieties or high-performance breeds. It is often also used to mean non-sustainable production, although this need not be the case.

Good agricultural practices (GAP) are production methods governed by law, regulations and guidelines. These practices set minimum standards for sustainable farming. One example is GLOBAL G.A.P., a voluntary standard set by the food industry.

## **AGROECOLOGY**

is defined by Martin and Sauerborn in their 2013 book of the same name as the science of the relationships of organisms in an environment purposely transformed by man for crop or livestock production.

## **CLIMATE SMART AGRICULTURE**

is defined by the FAO as an approach to developing the technical, policy and investment conditions to achieve sustainable agricultural development for food security under climate change. It aims to bring about a sustainable increase in agricultural productivity and income, adapt and build resistance to climate change, and reduce greenhouse gas emissions.

## **INTEGRATED PLANT PRODUCTION**

is a site-specific and environmentally sound production method. It uses all suitable and reasonable crop cultivation, plant nutrition and protection processes in the best possible combination to limit harmful organisms while respecting economic and ecological requirements. This approach aims to guarantee yields and commercial success in the long run.

# There are many aspects to sustainable agriculture



## RISE – MAKING SUSTAINABILITY MEASURABLE

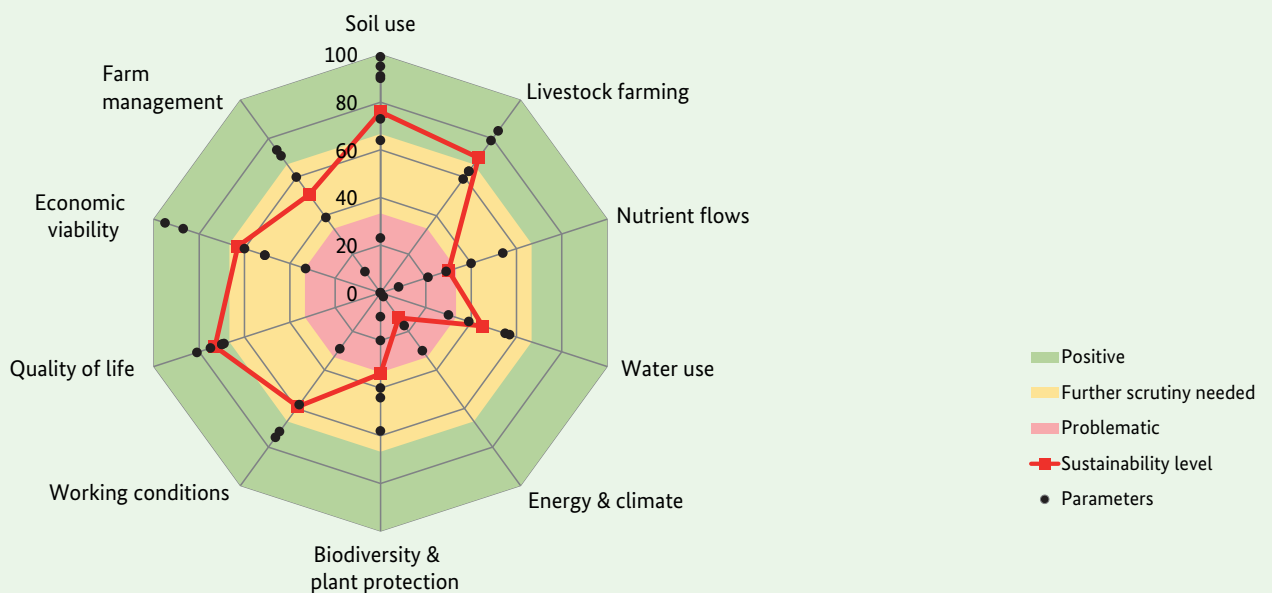
How can agricultural sustainability be documented and evaluated? Switzerland’s School of Agricultural, Forest and Food Sciences in Bern has developed the Response-Inducing Sustainability Evaluation (RISE) method to assess sustainability in as objective and universal a way as possible. RISE has been in use since 2000 and has been utilised by a range of organisations to evaluate several hundred farms of varying sizes. The Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH has been using the RISE method since 2012.

RISE aims to make the sustainability of farm operations measurable and communicable. It profiles a single farm operation, using interviews to gather information about 10 sustainability indicators, such as soil use and livestock farming (see the illustration below) across the economic, ecological and social dimensions, and then evaluating it. RISE does not certify farms but instead provides a basis for advice on farming practices. Farms receive an evaluation

of their sustainability so that the farm manager can take immediate action to improve it.

GIZ’s use of RISE has so far shown that farms located in a single region often have similar patterns. By analysing small samples of representative groups, development cooperation programmes can identify shortcomings and develop advisory strategies.

Even though development cooperation typically involves family-run businesses, it often does not do especially well when it comes to sustainability. Economic criteria (e.g. profitability and operations management) and ecological aspects (e.g. nutrient management and carbon footprint) are frequently in need of particular improvement. Family-run smallholder farms are not, therefore, necessarily more sustainable than large operations. In addition to helping to advise farms, RISE can also provide valuable insights for policy advice, since some shortcomings in sustainability are the result of the structural framework rather than of farm management.



*RISE results diagram.*  
The red line shows the classification of a farm in relation to 10 indicators of environmental, social and economic sustainability

## SOIL MANAGEMENT – POSSIBLE WITHOUT PLOUGHING?

Conservation agriculture is a farming method that largely forgoes tillage and involves permanent organic mulch cover and extended crop rotation. These methods make the soil much less susceptible to wind and water erosion: its structure improves, it can better absorb and store water, fewer nutrients are washed away, and the number of soil-dwelling organisms increases. All in all, crops can draw on more nutrients. In a best-case scenario, the soil releases fewer greenhouse gases and may store more carbon in the form of humus. This method can also improve soil preservation. Over the past six years, an average of 8 million hectares of conservation agriculture has been brought into cultivation each year around the world. However, people understand conservation agriculture in many different ways, giving rise to different definitions.

As with conventional agriculture, the drawback of conservation agriculture is that the use of herbicides has until now been virtually unavoidable. The absence of ploughing requires changes to weed management if wheat, soy, maize and other agricultural crops are to have a chance against weeds. Special machinery is also needed, for instance for direct sowing, and the method requires substantial knowledge. Smallholders in developing countries typically have neither, making it a challenge for them to introduce conservation agriculture. In addition, some crop residues are left on the field and are unavailable for use as fuel or animal feed or for other purposes. As a result, this method has so far been used mainly in North and South America and Australia. These regions frequently combine conservation agriculture with genetically modified crops, monocultures and total herbicides. Crops are often not rotated, thus losing many of the benefits of conservation agriculture, so this cannot be considered sustainable agriculture.

## LIVESTOCK FARMING HAS MANY FACETS

Demand for animal products is growing around the globe. The livestock revolution has been a widely recognised phenomenon since the late 1990s. As

with the green revolution for crops, intensifying livestock production has been one response by the agricultural sector to market and consumer demand. Worldwide meat production has tripled over the past 30 years and is expected to double again by the 2030. Milk production has also increased by 50 per cent in the last 20 years: India has led the way, with 16 per cent growth, followed by the US, China and Brazil. These increases in production are being driven by global population growth and rising incomes, especially in towns and cities. Livestock farming currently accounts for about one third of agricultural GDP in developing countries.

Around the globe, large, industrial-scale companies exist alongside medium-sized market-oriented enterprises and smallholders practicing subsistence farming and selling locally. These different types of businesses fulfil a variety of goals that need to be taken into account in planning responses to future challenges.

Livestock farming is an important source of income for about 180 million smallholders and provides a livelihood for the poorest people: small sharecroppers, female-led households, and landless farmers. These groups make up nearly one fifth of the world's population. Pigs and poultry are in demand, since they can find food in rural and urban environments alike. Cows, sheep, goats, camels and other ruminants graze on marginal grasslands and turn fibres that humans cannot digest into high-quality food and by-products, such as leather. Animal manure provides nutrients and organic substances as an alternative to chemical fertilisers, and thus helps to preserve soil fertility or is used to operate biogas plants. Buffalo, oxen and camels pull equipment for soil cultivation, sowing, harvesting and transportation. 200 million extensive livestock keepers use vegetation cover in remote mountainous regions or semi-deserts, often the sole way of utilising these marginal regions.

While smallholder livestock farming provides a livelihood for millions of people, medium-sized and large companies supply large numbers of consumers with relatively cheap products through complex value chains. However, production methods, especially those used by industrial livestock farmers, are increasingly unacceptable, attracting criti-

cism from consumer, environmental and animal welfare groups, especially in prosperous countries. Animal welfare, health issues, economic subsidies, the sources of feed, and negative environmental impacts face frequent criticism. Recent debate has also focused on livestock farming's contribution to climate change through greenhouse gas emissions from ruminants, erosion of forests for grazing, the planting of soy for feed, and manure management. The criticism is leading to mounting calls to cut meat consumption and animal numbers.

### ORGANIC FARMING – CAN IT FEED THE WORLD?

Organic farming is one potential method of sustainable farming. For small-scale farmers who practice extensive farming with low yields, switching to organic cultivation can boost yields, for example by improving nutrient cycles. However, other types of sustainable farming can also deliver the same or, in most cases, higher yields if better-quality seed and fertilisers are used, the soil is better cultivated and greater use is made of rainwater.

Switching to organic farming typically leads to a sharp drop in yields compared with intensive farming at prime locations with healthy soil and good

rainfall. Yet we need the high yields that intensive farming offers to feed the world's population. Therefore organic farming alone will not be able to feed the world in its present form but will instead have to be combined with other sustainable production methods.

### MINERAL FERTILISERS – A BLESSING OR A CURSE?

The increases in agricultural yields over recent decades would have been impossible without mineral fertilisers. Subsidy schemes have made mineral fertilisers much cheaper in many developing countries, helping to boost food production and improve food security.

So far, apart from a focus on nitrous oxide (N<sub>2</sub>O) emissions and their impact on climate change and nitrate leaching, insufficient attention has been paid to the adverse effects on the soil and the environment of improper use of mineral fertilisers and of the use of unsuitable fertilisers. However, it should be noted that nitrate leaching is often connected to intensive livestock farming and the associated generation of liquid manure – in other words, organic fertiliser.



*Camel husbandry in Ethiopia*



*Livestock and dairy farming*

Many tropical soils are acidic by nature, and mineral fertilisers speed up the acidification process. Consequently, soil productivity deteriorates rather than improving in the long term and the fertiliser cannot have its full effects. Most soils do not have enough phosphorus. In industrialised countries, soil is often over-fertilised with phosphate, whereas in developing countries, a shortage of mineral phosphate fertiliser and under-use of organic fertilisers results in under-fertilisation of the soil.

Production of synthetic nitrogen, which today makes up approximately 72 per cent of the nutrients applied through mineral fertilisers worldwide, is energy-intensive. The remaining nutrients are potassium (15 per cent) and phosphorus (13 per cent), which are mined from natural deposits. Both resources are significant, with enough phosphate available for at least 100 or more years and enough potassium for more than 250 years at current consumption levels and under current economic conditions.

If the use of mineral fertilisers is to be sustainable, new concepts are needed for providing soil with nutrients. Wherever possible, organic fertilisers (manure, compost and green manure) should meet the need for basic nutrients, with mineral fertilisers used only to cover any shortfall. Sewage sludge can also play a role, although contamination, for instance from heavy metals, is a problem. Tailored fertiliser strategies are crucial to guaranteeing that cultivated plants absorb the maximum amount of nutrients. Soil analyses are needed for this reason. Nitrogen produced as a result of the symbiosis between rhizobia and roots is a key factor in soil nitrogen supply.

The targeted use of soil organisms, such as mycorrhizae, can also improve the supply of phosphate and other nutrients, but is still costly at present.

## Genetically modified seed

The use of genetically modified plants in farming remains controversial. The main criticisms relate to environmental risks, the level of concentration on the seed market, the expansion of patent protection for seeds, which creates new dependencies for farmers, and the adverse effect on organic farming. However, the challenge of significantly increasing global production of food and agricultural raw materials and of meeting new challenges, such as climate change, support the use of all available technical innovations. We need transparent research, preferably publicly funded, into the risks of gene technology. Any risks identified must be set against the benefits to assess whether to use genetically modified plants.



*Young plants, Morocco*

Genetically modified varieties are predominantly supplied by a small number of multinational seed companies, but this could change if national and international agricultural researchers make seeds available as global public goods - in other words, without licence fees. These varieties might, for

## SEED – FROM COMMERCIAL OR FARM-BASED PRODUCTION?

Most farmers in developing countries use their own seeds and propagating material. These are adapted to local conditions, cultural needs and families' nutritional habits but typically do not produce very high yields and are often of problematic quality. These farm varieties compete with modern varieties, which have different properties, such as drought tolerance, resistance to certain pests and very high yields. High-productivity seeds have enabled global cereal production to almost triple over the past 50 years.

Modern varieties all share very similar properties, and just a few varieties frequently dominate production. To best prepare farmers for climate change and other future challenges, characteristics such as resistance to new diseases, pests and drought are becoming increasingly important. Traditional varieties often have these characteristics.

In addition to cultivation techniques, plant breeding provides another opportunity to significantly

improve yields from smallholder farming in developing countries. Modern varieties can be combined with local regional varieties or their characteristics, and farmers and professional seed growers can work hand in hand. National and international agricultural research institutes and non-governmental organisations are the main actors involved in participatory seed cultivation. This is especially crucial for cultures in which cultivation and seed production have limited commercial potential for the private sector. The result may be better regional varieties that are not protected by patents and so are freely available for further breeding.

However, commercial high-yield hybrid seeds are also crucial to enhancing productivity. Although hybrid seeds lose their beneficial properties in subsequent generations, they are still worth buying annually if yields are high enough. Hybrid seeds are wide-spread and exceptionally successful worldwide in both conventional and organic farming. However, suppliers and local availability of these seeds, together with advice on how to use them, are required for the use of high-quality seeds to become more widespread.

instance, tolerate salt or drought, which would help small-scale farmers in regions hit especially hard by resource degradation and climate change.

The proportion of genetically modified plants grown is also constantly rising, including in developing countries and emerging nations. In 2014, 68 per cent of the world's cotton already came from genetically modified varieties. Methods also exist that are not, or not clearly, identified as gene technology but are becoming increasingly significant: marker-assisted breeding, smart breeding, genomic selection (including for livestock), nature-identical genetic engineering and cis-genesis (genetic modification without foreign genes). A few of these methods could be of interest to organic farmers, although this view is currently generally dismissed.



*Millet in a seed bank in Ethiopia*

## AGRICULTURAL BIODIVERSITY – CAN IT SAVE US?

Agricultural biodiversity includes the species, varieties and breeds that are used or available in a country's agriculture. It is essential for productive, efficient and sustainable farming. The loss of diversity in agricultural crops and animal breeds has been and remains attributable to increasing agricultural intensification and industrialisation.

Three quarters of the world's crops and 690 livestock breeds have been irretrievably lost since the mid-19th century. 20 per cent of our agricultural livestock breeds are at risk of extinction.

Around four fifths of the world's 805 million starving people live in rural areas. Most of them are farmers and livestock owners who rely for their survival in sometimes challenging environmental conditions on a wide range of local crop varieties and locally adapted animal breeds. Hunger and poverty can be combated if these crops and breeds are well adapted and farmers can produce their own seed and propagating matter from these plants. Moreover, biodiversity improves resilience to the impacts of climate change.

### Who are smallholders?

The term 'smallholders' encompasses a very diverse group, ranging from medium-sized agricultural enterprises that are fully integrated into the market economy – a group that is very common in many Asian countries – to micro-enterprises that predominantly practice subsistence farming and include three quarters of the world's poor. The common denominator is frequently having two hectares of land or less. Approximately 85 per cent of farms around the globe are smallholder operations, and in many developing countries, more than 90 per cent of farmers are smallholders. In Asia, smallholders often farm much less than a hectare (10,000 m<sup>2</sup>).

We therefore need to preserve and unlock the significant potential that agricultural biodiversity offers. Today, smallholders preserve varieties by using them, as is the case for millet in the Sahel region, potatoes in Peru, and local vegetable varieties around the globe. Where agricultural diversity is not used in the fields, seed has to be preserved in community, national or international gene banks, which has significant costs and safeguards only a portion of the genetic resources.

It is also important to recognise that agriculture biodiversity is an important genetic reserve and an insurance policy for the future in helping farmers to adapt to climate change. This is a further reason why this practice is important.

## SMALLHOLDERS – BETTER FARMERS?

Which agricultural model is best suited to bring about sustainable growth in agricultural production? While some commentators advocate intensive, industry-based production models, others are in favour of farming being based on smallholders. Indeed, smallholders make up by far the largest and,



*Cultivating young rice plants*



therefore, the most important group in restructuring agriculture in developing countries, and this is unlikely to change any time soon. However, environmentally harmful farming methods are not only characteristic of industrial or intensive large agricultural businesses: smallholders practicing extensive farming can also damage the soil and the environment. Many live and farm on land that is more environmentally vulnerable than prime agricultural locations.

A lack of knowledge about modern techniques is a further cause of improper resource management. For instance, smallholders often do not use pesticides as prescribed, which can result in humans being poisoned and food and the environment being contaminated. Improper use of fertiliser is another common problem. Even if fertilisers and pesticides are not used, soil can degrade through inadequate management or be lost through erosion. Considerable damage may be caused to soil and flora by consistently excessive numbers of livestock, by grazing inappropriately heavy animals on slopes, and by grazing livestock at unfavourable times and for unfavourable periods.

However, many smallholders in developing countries who follow traditional practices make a significant

contribution to preserving the existing diversity of agricultural crops and livestock and indigenous farming knowledge adapted to each situation. According to the FAO, small-scale farmers farming less than two hectares make up 85 per cent of all farmers and manage about 12 per cent of agricultural land. Considering the key role that they play in food security in developing countries, we need to foster the strengths of these smallholders and address their shortcomings to ensure that they operate in a way that is economically, ecologically and socially sustainable.

## **AGRICULTURAL TECHNOLOGY – MECHANIZATION FOR EVERYONE?**

Agricultural technology has been a key driver behind the global increase in agricultural productivity. Automating processes from sowing to harvesting increases yields and enhances efficiency and can help to avoid losses during harvesting and subsequent processing. Mechanization helps to overcome labour shortages and safeguards production through timely soil cultivation, sowing, efficient weed and pest control, faster harvesting, and better storage and processing. The use of manual devices, draught animals

### **Integrated pest management**

Integrated pest management (IPM) means the careful consideration of all available pest control techniques and subsequent integration of appropriate measures that discourage the development of pest populations and keep pesticides and other interventions to levels that are economically justified and reduce or minimise risks to human health and the environment. IPM emphasises the growth of a healthy crop with the least possible disruption to agro-ecosystems and encourages natural pest control mechanisms.

or tractors may be considered, depending on the size of the farm and the situation. The right technology depends on financing but also on field size and gradient, farmers' level of education, supply of spare parts, and availability of workshops to maintain and repair machinery. Equipment must be easy to handle, robust and affordable for smallholders.

We recommend that farmers join forces to share equipment, for instance by creating machinery pools, so that equipment is easier to afford. Private service providers have materialised in a number of countries offering to operate machinery in exchange for payment.

Commercial producers offer a large variety of equipment to meet different needs. Other machinery has been developed locally for specific applications but is still not very widespread, despite its potential, since it is not known regionally or is only partly functional. Imported commercial equipment often needs to be adapted to the local context, which can be achieved in close cooperation with machinery producers and farmers.

Successfully introducing agricultural technology requires that both users and suppliers know how to use and maintain it. Farmers face the challenge of sacrificing traditional production methods and original models and of keeping pace with technological progress.

However, automation can also cause problems if machinery is not used properly (for example, if tractors compact soil or if the field is uneven because soil was not cultivated properly). These may be reduced through advice and training.

Because it replaces manual labour, agricultural technology may have negative effects on the hiring of temporary or permanent farm workers and their families. These workers are often from the poorest sectors of the population. On the other hand, developing countries are already facing a labour shortage, so agricultural technology can be very helpful and even necessary.



*A diverse range of tomatoes*

## CROP PROTECTION – WITH OR WITHOUT CHEMICALS?

Disease, pests and weeds are putting crops at risk and can lead to more or less losses in yields. Smaller harvests mean less food available for consumers and less income for farmers, wasting the resources already invested in production – working hours, wages, seed and fertiliser – and using farmland and producing greenhouse gas emissions for no reason.

All farming should be based on good agricultural practices (GAP) to keep pest infestation and disease to a minimum. These practices include crop rotation, adapted cultivation techniques and seeds, and balanced fertiliser use. The target is healthy and, thus, resilient plant stocks that require less pest control.

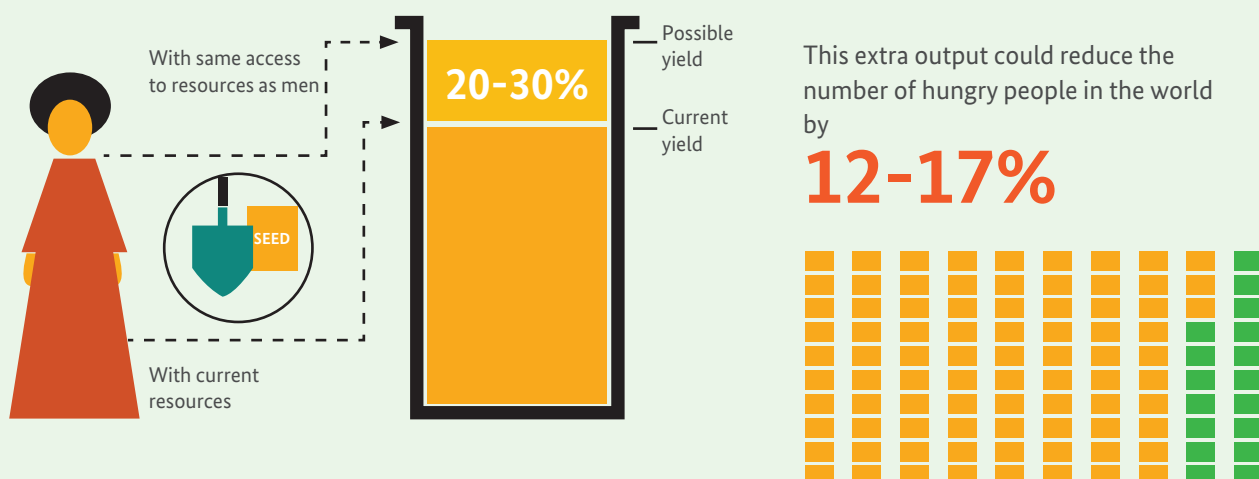
Where protective measures are needed, the concept of integrated pest management (IPM) has proved valuable. IPM dictates that protective measures are not taken until damage reaches certain thresholds and involves using available biological measures to fight disease.

A drop in yields should be accepted if it is not worth taking actions to protect crops. The amount of chemical pesticide used is to be kept to a minimum, and less harmful agents should be used. This is in keeping with the rules of the FAO Code of Conduct on the Distribution and Use of Pesticides, which is the international point of reference for dealing with pesticides, from the point of sale to the disposal of empty containers.

However, IPM has yet to reach many farms. Farmers either do not know about disease, damage thresholds and tools (e.g. modern pesticides, safe equipment and protective clothing) or do not use this knowledge because advisory and information services (e.g. weather forecasting) are not available. IPM is a knowledge-intensive process that requires training.

Smallholders have in many cases not received adequate information and training and often suffer poisoning because they choose the wrong pesticide, do not use it properly or do not clean machinery correctly.

If women had access to resources, on-farm yields could **INCREASE BY 20-30%**.

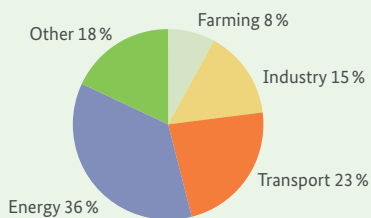


## GENDER EQUALITY – WHAT IS ITS ROLE IN SUSTAINABLE AGRICULTURE?

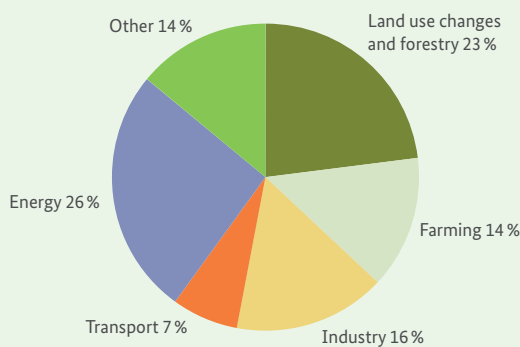
People working in agricultural production are a diverse group, varying by gender, age and/or ethnic origin. Their access to resources, such as land, loans, resources and markets, often varies dramatically from group to group. For example, women make up an average of 40 per cent of the agricultural workforce in developing countries and thus play a key role in providing their families with food and their households with a livelihood. Agriculture is becoming increasingly feminised in the wake of wars, disease, death from HIV/AIDS, and emigration by male family members. More and more women are also taking on roles that were originally male ones or assuming sole responsibility for agricultural production and livestock farming. Nonetheless, women in many countries are prevented from having access to and control over land and cattle for traditional reasons or by law. The same is true of access to services, resources, agricultural advice, innovation and

marketing. Women are also almost wholly unrepresented in rural organisations and institutions in many regions, and have a lower level of education and less information than men. This prevents women from having an equal say in decision-making processes within rural organisations and from influencing policies and strategies at the municipal level. Closing this gender gap could increase agricultural production by between 20 per cent and 30 per cent and reduce the number of starving people around the globe by between 12 per cent and 17 per cent (see below). Similarly, ethnic minorities and young people are often barred from access to a variety of opportunities for development. It is therefore essential for all groups to have an equal share in development for agriculture to be economically, ecologically and socially sustainable. This approach is the only way for the rural population to reach its full economic potential, for food security to be achieved, and for poverty – with all its associated ramifications for people and the environment – to be combated structurally. In most instances, these groups require targeted support that is tailored to their circumstances.

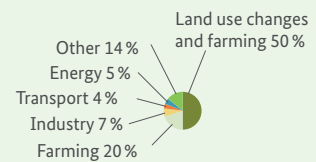
High-income countries



Medium-income countries



Low-income countries



## THE FRAMEWORK – HOW CAN WE PROMOTE SUSTAINABLE AGRICULTURE?

Education, knowledge and agricultural advice are essential for sustainable farming, especially by smallholders in developing countries. Access to resources, land and water is, however, equally important.

Land use right issues must, therefore, be resolved. Another key aspect is training for smallholders and their organisations. Small-scale farmers are still often excluded from the formal credit market in many places because they cannot offer banks any collateral. Last, but not least, growth-oriented sustainable farming needs development infrastructure and access to functioning markets.

Modern information and communication technologies are playing an increasingly vital role in farming and downstream sectors. It is now hard to image daily life without mobile phones and internet access, even in remote rural areas. They are increasingly being used for agricultural services, too, such as sharing market prices and providing advice.

The International Water Management Institute estimates that 56 per cent of global rainfall evapotranspires from our forests, savannahs and pastures. Another 4.5 per cent is used to produce food and feed through rain-fed agriculture. This precipitation, which is directly evapotranspired by vegetation and the soil's surface, is referred to as 'green water'.

Almost 40 per cent of precipitation does not return to the atmosphere immediately but instead enters rivers, lakes, groundwater and glaciers as 'blue water'. People extract roughly 9 per cent of this 'blue water' from surface water and ground water. On a global average, 70 per cent (2,700 km<sup>3</sup>) of this 9 per cent extracted water is used for agricultural irrigation to make up for inadequate rainfall.

## CLIMATE CHANGE – HOW MUCH IS ATTRIBUTABLE TO AGRICULTURE?

Farming is one of the sectors hit hardest by climate change. If the atmosphere continues to warm as projections currently suggest, harvests will dwindle in many regions of the world, particularly in developing countries, and food shortages will become more prevalent.

But farming is not merely a victim of climate change: it is also a contributor to it. About one third of global greenhouse gas emissions are directly caused by agriculture and the conversion of natural areas into farming land. Roughly half of greenhouse gas emissions from farming are released in the form of nitrous oxide (N<sub>2</sub>O) from highly fertilised land, methane (CH<sub>4</sub>) from livestock farming, rice production and manure, and carbon dioxide (CO<sub>2</sub>) from fuel consumption for machinery and electricity, but above all from the degradation of humus through improper soil use. The other half is caused by land use change, for instance the conversion each year of 13 million hectares of forest into agricultural land that is then often not used sustainably.



*A small dam in Mali built with German support*

It is a different story in terms of the contribution made by developing countries to greenhouse gas emissions. Most global greenhouse gas emissions are generated by medium-income countries, with poor countries generating a negligible proportion. Prosperous countries are responsible for a significant proportion of global emissions and produce by far the largest greenhouse gas emissions on a per capita basis.

Agriculture accounts for 60 per cent of the world's methane and nitrous oxide emissions. Methane is 25 times more harmful to the climate than carbon dioxide and nitrous oxide is 300 times more harmful.

Improvements in fertiliser management, cultivation practices and soil management can help to lower greenhouse emissions from farming. However, gains in productivity and efficiency (such as reducing post-harvest losses) can also play a part by alleviating the pressure on existing forests and thus helping to preserve them.

### 'Agripreneurs', the farmers of the future

Agripreneurs – farmers who think and act entrepreneurially with a long-term perspective – will be critical to sustainable farming in the future. Agripreneurs use resources optimally and sustainably. Not only do they provide food, but their products also serve energy, raw materials and animal feed markets. Another group of farmers are involved in agriculture simply as a side-line and generate a proportion of their income from other activities. Payments for ecosystem services – the efforts that farmers can make to maintain or foster ecosystem functions for the community, for instance in protecting ground water and against flooding – may also play an important role.

### WATER – HOW MUCH DOES AGRICULTURE NEED?

There is already a shortage of water in many countries, but demand is spiralling. The Food and Agriculture Organization of the United Nations (FAO) estimates that, if current practices are maintained, population growth will boost the demand for water from farming alone by a further 50 per cent by the middle of this century. Urban and industrial demand for water will also soar, making the situation even more critical.

Farmers will, therefore, have to use water more sustainably in the future. One option is to adopt cultivation methods that make better use of rainwater, the sole source of water for 72 per cent of land used for farming. Solutions include small retention basins, dams, river weirs, contour lines and conservation soil management. These techniques can actually raise groundwater levels by improving water infiltration.

Another option is to use water sparingly, for instance through low-loss distribution of irrigation water in pipes rather than using open ground chan-



nels, choosing sprinklers or soaker hoses instead of flooding entire fields, or using furrow irrigation. However, to avoid any negative consequences, it is important that the quantity of water extracted matches the amount of renewable water resources. In addition, salinisation can occur because there is no longer enough water to wash salt away. Sometimes, the absolute amount of water used does not decrease despite introducing water-saving irrigation methods since the area to be irrigated was increased at the same time.

Fair and transparent distribution of water resources both among agricultural users and the different sectors (agriculture, households and industry) is equally important. Integrated watershed management – which attempts to balance out the amount of water available and the varying claims to water – has proved useful.

## KNOWLEDGE – STRENGTHENING THE AGRICULTURAL INNOVATION SYSTEM

Sustainable farming requires a lot of knowledge: farmers must make optimal use of resources, take

environmental conditions into account, reduce risks and, where possible, serve different markets. These practices make them ‘agripreneurs’, who think and act entrepreneurially. But other agricultural stakeholders, such as individuals working for research institutes, training and advisory service providers, processing and marketing companies, and civil society as a whole, must also constantly generate new knowledge and integrate existing insights.

This is the only way for farmers to meet the future challenges facing their sector, using a wide range of information sources. Many farmers’ indigenous knowledge often includes elements such as context-based experience that must be reflected in and integrated into development measures. Many production systems require modern resources, which farmers must learn to use properly. Integrating production into national, regional and global markets to safeguard smallholders’ income and competitiveness also requires new knowledge and networks, especially in developing countries. Today, there is more and more discussion of the need to strengthen ‘agricultural innovation systems.’ All agricultural stakeholders are viewed as sources and users of knowledge who need to be connected functionally and exchange information with one another. Iden-

Extensive livestock grazing uses land that is not available for cultivation. However, the greenhouse gas emissions involved in producing 1 kg of meat are higher than with more intensive farming.



*Nomadic herding is a way of life for many people in Africa.*

tifying and disseminating context-based innovation will only be possible once a functioning knowledge exchange between farmers, researchers, advisors and buyers is in place. This innovation must be economically viable and ecologically sustainable and offer farmers long-term opportunities.

## FOOD SECURITY – AT RISK FROM BIOFUELS AND STEAK DINNERS?

Fuel or food? This question has frequently shaped public debate in recent years. Energy crops, food crops and fiber crops, such as cotton, compete for agricultural land and thus pose a potential risk to global food security. Worldwide demand for biofuels, together with a variety of other factors such as population growth, demand for higher-quality nutrition and speculation, have resulted in rising food prices, a trend first brought to the world's attention in dramatic fashion in 2008 when social unrest erupted in a number of countries.

Biofuels have a better in-use carbon footprint than fossil fuels, which initially makes them appear more sustainable. But a closer look reveals that their

production is highly resource-intensive and uses water and soil. Biofuel production in monocultures influences the diversity of cultivation systems and biodiversity. Rainforest deforestation and the excessive use of fertilisers for growing energy crops also reduces biofuels' carbon footprint.

In addition, sustainable cultivation practices can create jobs and generate income in rural areas, which in turn helps to improve food security. The priority is to design land use and productivity in a way that enables food and plants to be produced sustainably for energy and material use. This is possible when food and energy crops are grown together and by-products and residues used efficiently. However, feeding the world's steadily growing population must clearly take precedence.

The same is true of the growing cultivation of animal feed. The global appetite for meat is large; worldwide production to serve the world's growing population almost quadrupled between 1963 and 2014 and is expected to grow by a further 50 per cent by 2050. Pigs and poultry are mainly fed on cereal and soy, considerable amounts of which are also used, along with forage, to feed cattle for dairy and meat production. About 40 per cent of the cereal consumed around the globe ends up in cattle

## The 'bioeconomy'

The use of fossil fuels, such as coal and oil, causes significant damage to the environment by releasing carbon dioxide and other greenhouse gases. These resources are also finite, so they should increasingly be replaced by renewable energy sources (e.g. wind and solar energy) and renewable raw materials. The bioeconomy uses biogenic resources, such as plants, animals and microorganisms, in all sectors of the economy. Besides traditional sectors, such as agriculture, forestry and fishing, the energy sector and the chemicals industry are also increasingly using renewable raw materials. The production and use of agricultural, forest and aquatic products should be environmentally friendly and resource-efficient.

In recent years, more than 20 countries around the world have developed bioeconomy strategies. For instance, Germany published its 'National Research Strategy BioEconomy 2030' under the leadership of the Federal Ministry for Education and Research (BMBF) in 2010. Its 'National Policy Strategy on Bioeconomy' followed in 2013, which laid out targets, conflicting goals and areas for tangible action to implement the bioeconomy. At European level, the 'Innovating for Sustainable Growth: A Bioeconomy for Europe' strategy was adopted in 2012.

These strategies underscore the precedence that food security takes over the use of renewable raw



feeding troughs: more than 70 per cent of land used for farming worldwide is used for livestock farming and feeding. However, a large amount of the land used for livestock farming is suitable only for this purpose, such as the pastureland used by nomads in the Sahel region.

Moderate meat consumption can therefore help to secure nutrition for the world's population in the future.

### IS FOOD LOSS INEVITABLE?

The Food and Agriculture Organization of the United Nations (FAO) estimates that worldwide, about one third of all food is lost between field and fork. This translates into approximately 1.3 billion tonnes of food each year. The value of the cereal lost in sub-Saharan Africa is estimated at US\$ 4 billion annually – enough to feed 48 million people. In the same region, up to 50 per cent of all fruit and vegetables are lost, around 20 per cent of all fish and sea food, and about 25 per cent of all milk. Some

of these losses occur during harvesting, transportation and processing and some are the result of food being eaten by rodents, beetles and moths. Some also rot or goes mouldy. Mould is especially hazardous because it can form invisible toxins, especially aflatoxins. And in developed countries, a significant proportion of processed foodstuffs is thrown away.

Food loss causes serious damage to businesses and the economy. The greenhouse gases generated during agricultural production and processing also damage the climate. And food loss increases land and water consumption, which can heighten existing conflicts over land and water.

It is internationally accepted that food loss has to be reduced. However, it is also considered unrealistic for food losses to be eliminated altogether. We know that there are a large number of options for decreasing post-harvest losses, but whether and how they are used depends on the cost-benefit analysis, socio-economic factors, and market access.

materials in the energy sector and in industry. Rising demand for agricultural and forest products must not have a negative impact on development policy targets in emerging economies and developing countries. In other words, poor sectors of the rural population must not be prevented from having access to land and water resources. German development cooperation also supports the promotion of sustainable agriculture in developing countries and emerging economies to provide food and other renewable resources. These programmes attach great importance to conserving natural resources, biodiversity and ecosystem services.



*Donkey carts used for transportation in Ethiopia*

# Conclusion



Sustainable agriculture is possible and is already being practiced successfully in many places around the globe. It has the potential to boost yields and feed the world's growing population for a century or more without destroying the resources we need for our survival. Rising awareness of sustainability among policy-makers, entrepreneurs and consumers is essential if sustainable agriculture is to be

implemented in both developed and developing countries. Moreover, the required knowledge must be shared with farmers and the right framework conditions must be in place. Policy-makers must commit to sustainable agricultural development, associations and civil society must be strengthened, and markets and market access must exist. All of these things are feasible if there is the will to act.

# Sample projects

## BOLIVIA

### PROGRAM TO PROMOTE SUSTAINABLE AGRICULTURE

PROAGRO is a trilateral programme involving the governments of Bolivia, Germany and Sweden. It promotes access to water and water availability for agricultural production, which form the basis of smallholder farming in semi-arid parts of Bolivia. Farmers also face uncertain yields and are vulnerable to increasingly unreliable rainfall patterns caused by climate change.

The programme provides information about the impact of climate change. The programme works with farmers to find ways to improve production, safeguard yields and ensure the sustainable use of productive resources. Making water management more efficient underpins this work. The programme makes active use of local knowledge.



The approaches introduced by the programme pave the way for technical, social, economic and ecological benefits when using natural resources. Existing knowledge is tapped and new knowledge is generated by 'learning by doing'.

More than 12,000 families have seen their access to irrigation water improve – 20,000 ha now have access to irrigation water. More land is irrigated, and production is reliable despite irregular rainfall. Farmers' water user organisations are well structured and water rights have been secured. Conflicts over water have been minimised. Family income has risen by about 130 per cent as a result of these measures.

With PROAGRO's support, the Bolivian Government has launched a national irrigation programme that publishes guides to planning and designing small-scale irrigation systems.

## EAST TIMOR

### AGRO-BIODIVERSITY: PROTECTION THROUGH USE

Timor-Leste (East Timor), a nation on the island of Timor to the north of Australia, is a hotspot for agricultural species biodiversity (agro-biodiversity) but is at risk from population growth, unsustainable farming practices, deforestation, monocultures, invasive plants, and the trend towards focusing on a few high-yield varieties.

Feliciano Sarmento is one of the pioneering farmers working to preserve agricultural diversity. Working with his wife and 30 other families living in one of the villages in the Nino Konis Santana National Park, he is cultivating local varieties of rice, maize, cassava and beans, among many other crops. He uses conservation agriculture practices and is achieving higher yields. Feliciano and his colleagues have turned a stony ridge into a productive vegetable garden with a lot of compost – and hard work.

Feliciano is part of one of 26 groups of farmers receiving support from a pilot programme launched by the East Timor Ministry of Agriculture that is being undertaken with GIZ as part of German development cooperation. The motto of the project, which aims to bring about sustainable management of Timor-Leste's agricultural biodiversity, is 'protection through use'.

There are many reasons to preserve agricultural biodiversity. Farmers know that having a diverse range of crops can help them to better survive extreme weather events: putting their crops on a broader footing helps to minimise the risk of losing harvests. Local varieties can achieve yields on degraded soils where new, more challenging varieties fail. These varieties are also easier to store and better reflect the tastes of the local population. Cultural factors and traditional ceremonies are also especially important to preserve certain species and varieties in Timor-Leste (e.g. red and black rice, millet and types of yams).

The programme supports the development of value chains to ensure financial benefits for farmers alongside the non-monetary benefits of preserving agro-biodiversity. Feliciano and his colleagues sell chilli pods grown from a local perennial variety, which are used to produce chilli powder. Other groups of farmers have started to sell the mint that grows wild and thrives in their rice fields to supplement their income from rice. Since local rice is produced without sprays and pesticides, dried mint is sold as a virtually organic tea at shops in the capital, Dili.



## BURKINA FASO AND NIGER

### CLIMATE CHANGE: RESISTING THE ENCROACHMENT OF THE DESERT ON WATER AND SOIL RESOURCES

The Sahel region endured severe droughts in the 1970s and 1980s. Rapid population growth and an expansion of arable land, combined with inappropriate farming methods, has increased the pressure on land and led to soil degradation and, ultimately, desertification. As the use of external resources such as mineral fertilisers has grown, the population's knowledge of traditional local soil conservation practices has dwindled.



For almost 20 years, the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) has worked on behalf of the German Federal Ministry for Economic Cooperation and Development (BMZ) to support two western African nations – Burkina Faso and Niger – in sustainable resource management for farming and in rehabilitating degraded soil. The projects worked with farmers and livestock owners to develop water and soil conservation and protection measures and complementary measures, such as land usage management and multivillage agreements on preserving natural resources. All three projects systematically included livestock ownership. All in all, more than 500,000 ha of land were involved in these measures. On average, about 200 kg more millet is now harvested per hectare, the equivalent of one person's cereal requirements for a year. The increase in the local groundwater level allows vegetables to be grown during the dry season, improving income and allowing for a more varied diet.

## ETHIOPIA

### SUSTAINABLE LAND MANAGEMENT: REHABILITATING SOIL IN THE HIGHLANDS

Traditional farming in Ethiopia's densely populated highlands is characterised by cultivation on steep slopes and, often, overgrazing and deforestation. Land degradation is increasing as a result: each year, up to 1.5 billion tonnes of fertile farmland are lost, creating deep erosion channels many metres wide. Up to 300 km<sup>2</sup> of arable land becomes unusable for farming each year because of degradation, reducing yields and thus food security.

The Ethiopian Government has, therefore, launched a national programme for sustainable land management that is cofinanced by several donor organisations. GIZ is working on behalf of the German Federal Ministry for Economic Cooperation and Development (BMZ) to support implementation of the programme in six of the country's regions. GIZ is providing advisory services to the Ethiopian Ministry of Agriculture on managing the programme. Advisors at different administrative levels are receiving training and coaching on disseminating knowledge among farmers.



This work focuses on disseminating knowledge of soil and water conservation measures within the context of sustainable watershed management. Initially, infrastructure measures are being implemented as a community initiative, for instance to protect against erosion. Smallholders and user groups who have received training make greater use of resource-efficient farming techniques on their fields and grassland. Soil fertility and water availability improve, and farmers can generate more income because natural resources are being conserved. As a result, there is an incentive to ensure that these measures continue.

All in all, by 2014, 200,000 ha of agricultural land had been rehabilitated. This has boosted productivity by up to 35 per cent and resulted in a significant increase in income for 80,000 households or about 400,000 people. The success of the programme means that the Government is now rolling out these methods in other regions. Land that was originally affected by degradation is thus again becoming a key factor in ensuring food security.

Published by

Deutsche Gesellschaft für  
Internationale Zusammenarbeit (GIZ) GmbH

Registered offices

Bonn and Eschborn, Germany

Sector Project Sustainable Agriculture (NAREN)

|                            |                            |
|----------------------------|----------------------------|
| Friedrich-Ebert-Allee 40   | Dag-Hammarskjöld-Weg 1 - 5 |
| 53113 Bonn, Germany        | 65760 Eschborn, Germany    |
| T +49 (0) 228 44 60 - 0    | T +49 (0) 6196 79 - 0      |
| F +49 (0) 228 44 60 - 1766 | F +49 (0) 6196 79 - 1115   |

naren@giz.de

[www.giz.de/nachhaltige-landwirtschaft](http://www.giz.de/nachhaltige-landwirtschaft)

Author and editor

Dr. Stephan Krall

Translation

Abigail Dahlberg and Janet Fraser for GIZ Language Services

Design and layout

Ira Olaleye

Printed by

druckriegel, Frankfurt

Printed on FSC-certified paper

Photo credits

Title, p. 27, p. 28: © GIZ/Klaus Wohlmann; p. 2, p. 6, p. 8, p. 13, p. 20, p. 21: © GIZ/Guenay Ulutunçok; p. 4: © GIZ/Eberhard Groll; p. 12, p. 16, p. 19, p. 23: © GIZ/Stephan Krall; p. 24: © GIZ/Charlotte Haeusler; p. 26: © GIZ; p. 29: © GIZ/Andreas Springer-Heinze

As at

December 2015 (English version)

GIZ is responsible for the content of this publication.

Commissioned by

Federal Ministry for Economic Cooperation and Development (BMZ)  
Division Rural Development and Global Food Security

Addresses of the BMZ offices

|                             |                            |
|-----------------------------|----------------------------|
| <b>BMZ Bonn</b>             | <b>BMZ Berlin</b>          |
| Dahlmannstraße 4            | Stresemannstraße 94        |
| 53113 Bonn, Germany         | 10963 Berlin, Germany      |
| T +49 (0) 228 99 535 - 0    | T +49 (0) 30 18 535 - 0    |
| F +49 (0) 228 99 535 - 3500 | F +49 (0) 30 18 535 - 2501 |

[poststelle@bmz.bund.de](mailto:poststelle@bmz.bund.de)

[www.bmz.de](http://www.bmz.de)