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# What is sustainable agriculture?

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# The challenge – food for all

The world's population is poised to reach 9 billion by the middle of this century and over the next 40 years, 70% more food will be needed to sustain all these people. Most of this additional food will have to be produced where it is needed, namely in developing countries. These countries will have to double their production to achieve this goal, with implications also for the natural resources that farming depends on and especially water, land for cultiva-

tion and mineral fertilisers. All of these are available in only limited amounts. In many places, the soil has already suffered long-term damage, and water resources are often overused or polluted by fertilisers and pesticides. Agricultural biodiversity has decreased 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 impacts on the climate and the health of global ecosystems.



Diversity safeguards the future;  
a market in Cameroon

# The solution – sustainable agriculture

Against this backdrop, how do we make sure that future agricultural production guarantees food security for the world's population without destroying its own resource base? The answer is that we need productive, yet sustainable agriculture. Growth must not be detrimental to resources and must not rely on consuming resources.

The debate about sustainable agriculture typically focuses on whether farming should be conventional or organic, on an industrial scale or small-scale. 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 discussion surrounding sustainable farming.

## 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 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 and that agriculture can also generate additional products
- provides long-term jobs, 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. climatic) and socio-economic factors (e. g. strong price fluctuations) and to other risks.



Maize is one of the most important crops in Bolivia

## Definitions

### **Organic farming**

does not use synthetic pesticides and mineral fertilisers and attempts to work with natural methods and cycles. A number of associations and certification systems exist, but organic production does not have to be certified.

### **Conventional farming**

is not a clearly defined concept but the term is generally used in the literature to refer to farming with synthetic pesticides and fertilisers. Therefore ‘conventional farming’ frequently denotes non-sustainable farming practices.

### **Industrial agriculture**

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

### **Good agricultural practices (GAP)**

are production methods governed by laws, regulations and guidelines. These practices set minimum standards for sustainable farming. One such example is GLOBALG.A.P., a voluntary standard set by the food industry.

### **Integrated plant protection**

is a production method adapted to the location that is environmentally sound. It uses all suitable and reasonable crop cultivation, nutrition and protection processes in the best possible combination. Integrated plant protection also harnesses both bio-technical progress and the natural constraints of harmful organisms (integrated pest management). This approach aims to guarantee long-term dependable yields and commercial success.



# There are many sides to sustainable agriculture

## Soil management – possible without ploughing?

'Conservation agriculture' has been a focus of attention in recent years as a farming method that involves no tillage, 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 absorb and store water better, 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 even store more carbon. Over the past ten years, an average of 6 million hectares of conservation agriculture has been brought into cultivation each year.

The main drawback of conservation agriculture is that the use of herbicides has been virtually inescapable up until now. The lack of ploughing requires changes to weed management if wheat, soy, maize and other agricultural crops are to grow successfully. Special machines are also needed, for instance for direct sowing, as well as a great deal of expertise. Smallholders in developing countries typically have neither, making it a challenge to introduce conservation agriculture. Thus it has so far become established mainly in North and South America and Australia. These regions frequently combine conservation agriculture with genetically modified plants and total herbicides to produce monocultures and crops are often not rotated, thus losing many of the benefits of conservation agriculture, so this cannot be considered sustainable agriculture.



Traditional cultivation in Africa – tilling the soil with a hand hoe

### Organic agriculture – can it feed the world?

Organic farming is one type of sustainable farming. It has potential, especially for farms that still rely on traditional and extensive agricultural methods. Changing over to organic cultivation could significantly boost yields, for instance in sub-Saharan Africa, even though the boost always depends on the baseline. Other types of sustainable farming would also deliver much higher yields if better-quality seed and fertilisers were used, if soil were better cultivated or if rainwater were used more.

Switching to organic farming typically leads to a sharp drop in yields compared with intensive farming at prime locations with healthy soil and decent rainfall. Yet we need the high yields that intensive farming brings to feed the world's population. Therefore organic farming cannot feed the world alone in its present form but will instead have to be combined with other sustainable production methods.

### Mineral fertiliser – a blessing or a curse?

The past decade's increases in agricultural yields would have been impossible without mineral fertiliser. Subsidy schemes have made mineral fertiliser much cheaper in many developing countries and have thus helped to boost food production and improve food security.

Until now, insufficient attention has been paid to the adverse effects on the soil and the environment of improper use of mineral fertiliser with the exception of nitrous oxide emissions and their impact on climate change and nitrate leaching. Many tropical soils are acidic by nature, and mineral fertiliser speeds up the acidification process. Consequently, soil productivity deteriorates rather than improves in the long term and the fertiliser cannot have its full effects. Most soils do not have enough phosphorus, with the result that in the industrialised countries, soil is often over-fertilised, while in Africa a shortage of fertiliser results in under-fertilisation of the soil.

Synthetic nitrogen, which today makes up approximately 72% of the nutrients applied through mineral fertiliser worldwide, takes a significant amount of energy to produce. Potassium (15%) and phosphorus (13%), which are exploited from natural deposits, account for the remainder. These resources are finite, so new strategies are needed for providing the soil with nutrients to make the use of mineral fertiliser sustainable. Wherever possible, organic fertiliser (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. Nitrogen produced as a result of the symbiosis between fungus and roots is a key factor in soil nitrogen supply.

## Seeds – from commercial or farm-based production?

Most farmers in developing countries use their own seeds and propagating material. These items are adapted to local conditions, cultural needs and families' nutritional habits, but typically do not produce very high yields. These farm varieties compete with modern seeds and propagating material, which feature enhanced properties, such as higher drought tolerance, better resistance to certain pests or very high yields. High-productivity seeds have revolutionised farming yields and paved the way for global cereal production to almost triple between 1950 and 2000.

Modern varieties all share very similar properties. In order to prepare farmers for climate change and other future challenges, diverse 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. The outcome may be better local seeds that are not protected by patents and are freely available for further breeding. However, commercial high-yield hybrid seeds are also essential to enhance productivity. Hybrid seeds lose their beneficial properties in subsequent generations but are still worth buying annually if yields are high enough. Hybrid seeds are widespread and exceptionally successful worldwide in both conventional and organic farming. However, seed firms 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 wide-spread.



Sorghum bicolor

### 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 increases farmers' dependency, and the adverse effect on organic farming. However, the challenge of significantly increasing global production of food and agricultural raw materials supports the use of all available technical innovations. We need transparent research, preferably publicly funded, into the risks of gene technology. Any risks ascertained must be set against the benefits to assess the benefit of using genetically modified plants. Genetically modified varieties are mostly supplied by a small number of multinational seed companies, but this could change if national and international agricultural researchers made seeds available as global public goods - in other words, without licence fees. These varieties might, for instance, tolerate salt or drought, which would help smallholders in regions hit especially hard by resource degradation and climate change.





## Agricultural biodiversity – will it save us?

Agricultural biodiversity encompasses the species, varieties and breeds that are used or available in agriculture. It is essential for productive, efficient and sustainable farming. The loss of diversity in agricultural crops was and remains attributable to increasing agricultural intensification and industrialisation. A similar trend has emerged in animal husbandry.

Three quarters of the world's cultivated plants and 690 livestock breeds have been irretrievably lost since the middle of the 19th century and 20% of our agricultural livestock breeds are at risk of extinction.

Around four fifths of the world's 925 million starving people live in rural areas. Most of them are farmers and livestock owners. Their survival relies on a wide range of local crop varieties and locally adapted animal breeds in at times challenging environmental conditions. Hunger and poverty can be combated only if farmers are put in a position to farm successfully under these conditions and manage the scant resources available to them better and more sustainably. We therefore need to preserve and unlock the significant potential of agricultural biodiversity. Places that no longer traditionally preserve varieties by using them, as is the case today for millet in the Sahel region or potatoes in Peru, always pay the price. Approaches to tackling the problem exist, but there are still no long-term solutions aside from storing seeds and material for propagation in gene banks. It is also important to recognise that in helping farmers to adapt to climate change, agricultural biodiversity is an important new genetic reserve and insurance policy for the future, increasing its significance.



Diversity in the tomato world

**Who are smallholders?**

The term 'smallholder' encompasses a very diverse group. The spectrum ranges 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 overwhelmingly practise 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% of all agricultural businesses worldwide are smallholder operations, and in many developing countries, more than 90% of farmers are smallholders.

**Smallholders – better farmers?**

Environmentally harmful farming methods are not only characteristic of many industrial or intensive agricultural businesses; smallholders practising extensive farming frequently also destroy the soil and the environment. Many live and farm on land that is more environmentally susceptible than prime agricultural locations. Poverty is generally the cause, but a lack of knowledge can also lead to improper resource management. Smallholders frequently do not use pesticides as prescribed and spread them without wearing protective clothing. People suffer poisoning time and again, and food is contaminated.

Alternatively, farmers put too much fertiliser on the soil, with the consequences already described. However, even where fertiliser and pesticides are not used, soil can degrade through improper management or be lost through erosion. On the other hand, many smallholders embracing traditional practices make a significant contribution to preserving the existing diversity of agricultural crops and livestock and indigenous farming knowledge. The conclusion is that the better farmers are not smallholders per se but all those who use sustainable farming practices at all levels of production. Nonetheless, smallholders are by far the largest and, hence, the most important group in the transformation of agriculture in developing 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 is equally important. Besides water and land, these resources mainly comprise fertiliser, seeds, pesticides, machinery and draught animals, but also

credit and, often, workers. Small-scale farmers are still often excluded from the formal credit market in many places because they cannot offer banks any collateral. In particular, growth-oriented sustainable farming needs development infrastructure and access to functioning markets. Modern communication technologies play an increasingly vital role: it is now hard to image daily life without mobile phones and Internet access, even in remote rural areas.

### Agripreneurs, the farmers of the future

'Agripreneurs', farmers who think and act entrepreneurially, will be critical for sustainable farming in the future. Agripreneurs use resources optimally and sustainably. They not only provide food but their products also serve energy, raw materials and animal feed markets. Another group of farmers will be involved in agriculture simply as a sideline and generate a portion of their income from other activities. Payments for eco-system services - the efforts that farmers can make to maintaining or fostering eco-systems for the community - may thus also play an important role.



Parched soil due to a  
lack of rain in Niger



A small dam in Mali built with German support

### 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 in many regions of the world, above all in developing countries, will dwindle and food supply shortages will become more prevalent.

But farming is not only a victim of climate change; it is also a contributor to it. Almost one third of global greenhouse emissions are directly or indirectly linked to agriculture. More than half result from changes in land usage, for instance the conversion each year of 13 million hectares of forest into land that is often not used sustainably. In addition to carbon dioxide, farming mainly releases methane and nitrous oxide. The primary sources are fertilisers, improper soil management, the burning of crop residues, wet rice cultivation and livestock farming, notably cattle.

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

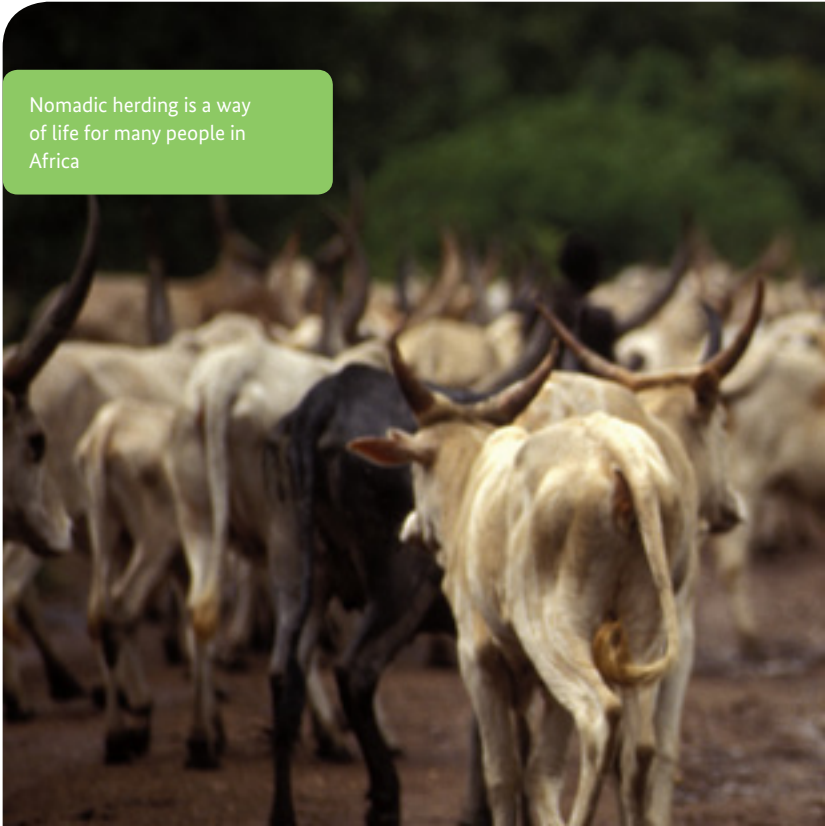
Improvements in fertiliser management, cultivation practices and soil management can help to mitigate greenhouse emissions from farming. However, gains in productivity and efficiency can also play a part, for instance by alleviating the pressure on existing forests and thus helping to preserve them.

## Water – how much does agriculture need?

There is already a water shortage but demand is spiralling. The United Nations Food and Agriculture Organization (FAO) estimates that if current practices are maintained, population growth will boost the demand for water from farming alone by another 50% by the middle of this century. Urban water demand will also climb, as will that of industry, making the situation even more critical.

Globally, farming draws on an average of around 70% of the withdrawn renewable water resources. Some 219 million of the world's 287 million hectares of irrigated land is found in developing countries. More than 30 countries are already facing a growing water shortage.

Farmers will have to use water more sustainably in the future. One option is to embrace cultivation methods that make better use of rainwater, the sole source of water for 72% of land used for farming. Other solutions include small retention basins, dams, water-spreading weirs, contour lines and conservation soil management. These techniques can even increase groundwater levels where they have fallen in many arid areas, in particular because of excessive water extraction. Another option is to use water sparingly, for example through drip irrigation – a method whereby plants receive only as much water as they need. But this practice can also have negative environmental consequences and lower the groundwater level, for example, because only a fraction of the previous amount of water penetrates the ground. In addition, salinisation can occur because there is no longer enough water to wash away salt. Fair distribution of water resources and management of water catchment areas is equally important.



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



### Food security – threatened by bio-fuel and steak consumption?

Food or fuel? This question has increasingly shaped discussions about agricultural production in recent years. Energy crops, food crops and plants to use for materials, such as cotton, are competing for agricultural land and can thus pose a risk to food security. Global demand for bio-fuels, together with general speculation and a variety of other factors, has sparked higher food prices, a trend that was first brought to the world's attention in dramatic fashion in 2008.

Bio-fuels have a better carbon footprint than fossil fuels in terms of their use, which makes them more sustainable. But producing biofuels is highly resource-intensive, and monocultures threaten species diversity. Bio-fuels frequently end up causing greenhouse gas emissions because rainforests are cleared

or too much fertiliser is utilised to grow the crops needed to produce them. On the other hand, combined with sustainable cultivation practices they can also generate jobs and incomes in rural areas, which can help to improve food security. We must design land use and productivity in a way that enables the sustainable production of enough food, energy and materials. However, feeding the world's steadily growing population must clearly take precedence.

The same is true of the increasing cultivation of animal feed. Our appetite for meat is large, with worldwide production up by two thirds between 1987 and 2007, and it will continue to grow. Pigs and poultry are fed mainly on cereal and soy. Considerable amounts of cereal and soy are also used for cattle (dairy and meat production) in addition to green fodder. In 2005, for example, almost one third of cereals consumed in developing countries ended up in the feeding trough. Moderate meat consumption can thus also help to secure nutrition for the world's population in the future.

Two to three kilos of feed are needed to produce each kilo of chicken, and ten kilos of feed for each kilo of beef.



Harvested crops are threshed and stored, Peru



### Post harvest – transport to warehouse and then what?

Up to one third of the annual cereal harvest is lost in developing and emerging countries and as much as 40% of perishable products like roots and tubers, fruit and vegetables. Some is literally lost during harvesting and transportation, some is eaten by mice, beetles or moths, and some rots or goes mouldy. Mould is especially hazardous because it can form invisible toxins.

Post-harvest losses cause serious economic losses because they occur after a great deal of money and work has already been invested in production. Quality losses have an impact on prices or even make produce unsellable. On a purely mathematical basis, in fact, the amount of food written off to post-harvest losses would be enough to solve the hunger problem. Post-harvest protection is therefore one quick way to improve food security in the long term without the need for additional resources. The techniques already exist; they just have to be applied. Feeding the world's population would be possible, at least theoretically, if all the food simply thrown away worldwide could be put to use.





### **The Green Economy**

Lower harmful carbon dioxide emissions and less pollution, more efficient use of energy and other resources, no additional biodiversity loss, and preservation of eco-systems and their contribution to the environment: a green economy means switching to sustainable practices, growth and social justice. Policy-makers and businesses must work hand in hand to conserve the environment and fight poverty.



The United Nations Environmental Programme (UNEP) put sustainability at the top of the political and economy agenda in 2008, the peak of the economic and food prices crisis, with its Green Economy Initiative.

Sustainability has long been an obvious priority for the German Federal Ministry for Economic Development and Cooperation (BMZ) and the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ), especially within the context of farming, and they were already supporting sustainable farming projects in the 1970s and 1980s. UNEP believes that farming should be the driving force behind the green economy in developing countries.



# Conclusion

Sustainable farming is viable and already practised successfully in many places around the globe. It has the potential to increase yields and feed a growing world population for the next hundred years without destroying our living conditions. Implementing sustainable farming in both developed and developing countries requires growing awareness of sustainability among policy-makers, businesses and consumers, as well as sharing the necessary knowledge with producers. And the framework has to be right: policy-makers must commit to sustainable agricultural developments, we need to strengthen associations and civil society, and we need markets and access to them. All of this is possible provided the will is there to achieve it.

# Sample projects

## India

**Joint venture:  
managing water  
catchment areas**

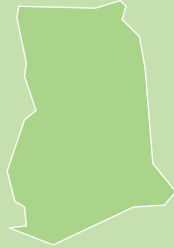


Life has become much better in many Indian villages over the past few years. Cereal production has quadrupled, drinking water is more abundant and of much better quality, the protective vegetation cover has increased, employment has risen four-fold and women are more confident and generate their own income. These are just a few of the visible results of new and environmentally friendly land management practices in India.

The Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH worked on behalf of the German Federal Ministry of Development and Cooperation (BMZ) with government agencies, various non-governmental organisations and village self-help groups to support better use of natural resources. The projects covered nine water catchment areas in a number of Indian states and included conservation measures, such as building retention dams, planting grass, trees and hedges, and building terraces. Over a number of years, this, combined with measures to prevent run-off and enhance cultivation methods, improved soil fertility and crop yields. The project also set up a credit programme that was primarily used by women and helped them to carve out their own source of income. The constant sharing of experience and knowledge among all stakeholders and the involvement of villagers from the outset played a major role in making these measures sustainable.

## Ghana

Better knowledge  
about integrated  
pest management



Ghana's official plant protection policy propagates a combination of preventative, technical and restorative measures with an emphasis on largely eliminating the use of pesticides that can cause environmental damage. However, in recent years, the reality has been different, mainly because measures have not been adapted to local conditions and because government experts' knowledge is not passed on to smallholder businesses.

This is where a project by the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH, implemented on behalf of the German Federal Ministry for Economic Cooperation and Development (BMZ), came in. It focused on introducing integrated pest management in selected rural areas of Ghana. To this end, the project first recommended using gentle pesticides and encouraged farmers to combat pests with biological and traditional means. At the same time, GIZ worked on behalf of the BMZ to advise Ghana's Government to include integrated pest management in the agricultural support objectives and to impose restrictions on using hazardous pesticides. Farmers also received training and advice on integrated pest management methods. The risk to farmers, consumers and the environment decreased: there were fewer pesticide accidents, and food and water contamination showed a lasting improvement. Beneficial insects were also protected. Farming households' income improved by up to 73% thanks to gains in output and quality. This success enhanced the acceptance and dissemination of integrated pest management techniques. Sustainable pest management methods are now being established in other areas of Ghana based on this encouraging outcome in the project regions.



## Burkina Faso and Niger

**Climate change: resisting the  
encroachment of the desert  
on water and soil resources**

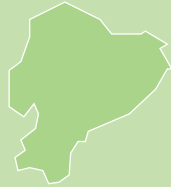


The Sahel region endured severe droughts in the 1970s and 1980s. High population growth and an expansion of arable land combined with unsuitable agricultural methods increased the pressure on soils and led to soil degradation and, ultimately, desertification. As the use of external resources such as mineral fertiliser grew, the population's knowledge of traditional local soil conservation practices dwindled.

For almost 20 years, the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) worked on behalf of the German Federal Ministry for Economic Cooperation and Development (BMZ) to support 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 multi-village agreements on preserving natural resources. All three projects systematically included livestock ownership. Conservation measures also triggered an increase in groundwater levels, which in turn made the soil more productive. All in all, roughly 5,000 km<sup>2</sup> became more fertile or were restored to agricultural use. Approximately two million people are benefiting and are in a better position to cope with climate change.

## Ecuador

**Adding value:  
preserving biodiversity in  
cocoa cultivation**



Small family-run businesses are the main growers of cocoa in Ecuador. Traditional fine cocoa grades are generally hybridised with bulk grades. These hybrids are gradually displacing the genetic make-up of fine cocoa. Pests and disease frequently cause a substantial drop in yields, but low-income smallholders cannot afford expensive pesticides or the mineral fertilisers that will increase yields. Producers' earnings from raw cocoa are minimal and often barely cover production costs. The main profits are made in Europe and the US.

The Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) has supported small-scale cocoa producers on behalf of the German Federal Ministry for Economic Cooperation and Development (BMZ) for a number of years, and over 10,000 producers have benefited to date. A close partnership with chocolate producers and better cultivation methods, sometimes to organic standards, are paying off. Producers are now paid roughly one third more for their beans. Higher incomes are also helping to preserve biodiversity and cultivation methods in mixed agro-forestry systems: the rainforest's giant trees are left untouched, and because smallholder families now earn enough, they no longer cut down the rainforest and grow maize.





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