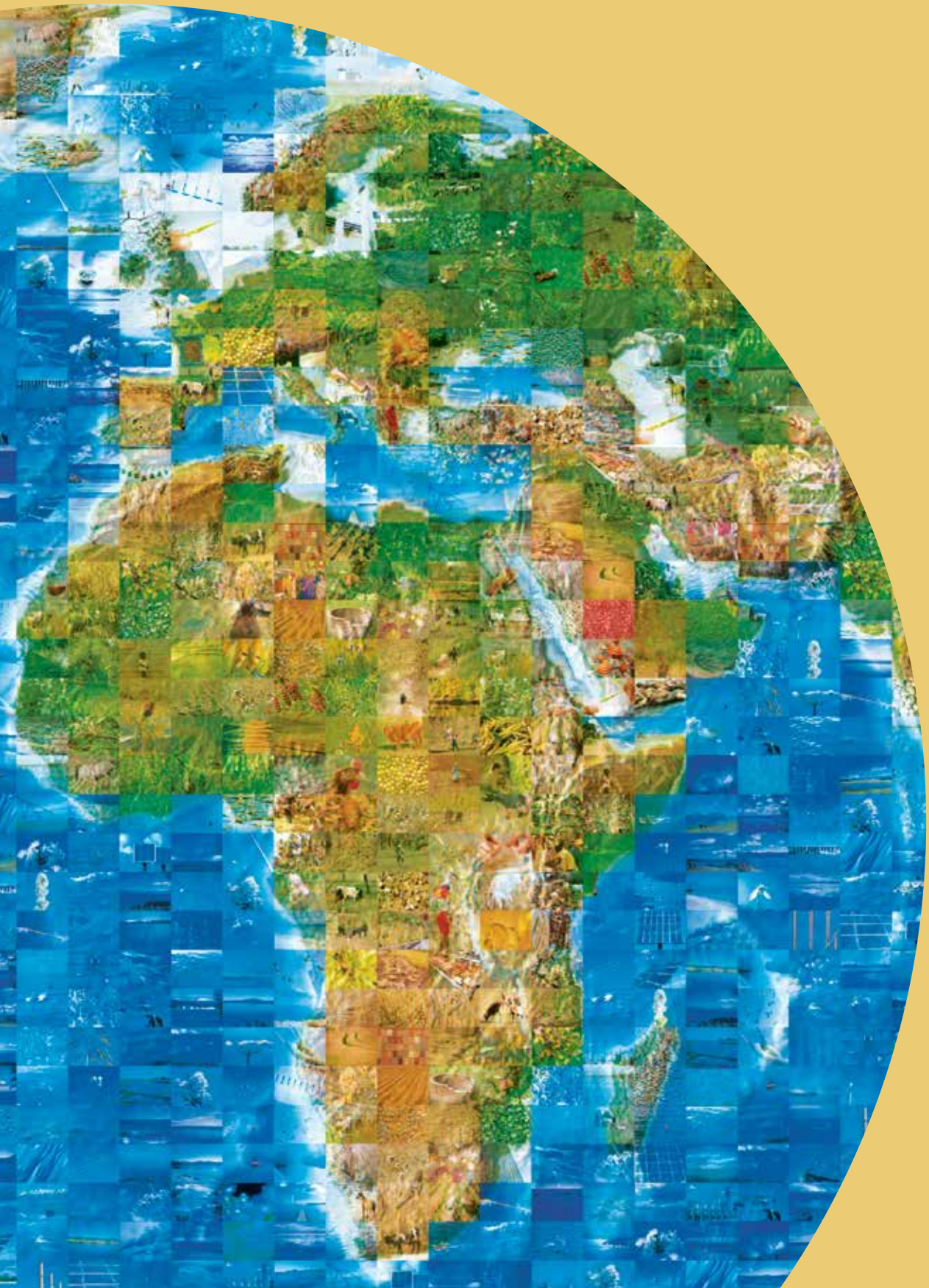
Agriculture at a Crossroads

IAASTD findings and recommendations for future farming



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About the IAASTD Report

Modern agriculture is producing more food per capita than ever before. At the same time, according to estimates from the Food and Agriculture Organization (FAO), almost 800 million people of today's world population of seven billion are currently chronically undernourished. An additional two billion people are suffering from micronutrient deficiencies, lacking key vitamins and minerals. In 2014, 1.9 billion people were overweight, and of these, 600 million were obese. Climate change is presenting an enormous new challenge to agriculture while the world population is predicted to increase to 9.7 billion by 2050. Whether clean water, fertile soils, forests, wetlands and other natural resources, as well as the biodiversity of the planet, will be available to future generations in a condition that enables them to survive will depend crucially on the way we produce our food and on what we eat. An enormous share of human-induced greenhouse gas emissions result directly or indirectly from agricultural production and the subsequent processing, storage, transport and disposal of food. One-third of the world's population obtains its livelihood from agriculture. Agriculture and food is by far the world's largest business and therefore closely linked to sustainable development.

The two IAASTD Co-chairs Hans Herren and Judi Wakhungu, UNEP Executive Director Achim Steiner and IAASTD Director Robert T. Watson

The IAASTD process

It was against this backdrop that the World Bank and the United Nations initiated a unique international scientific process to evaluate the state of global agriculture, its history and future: the International Assessment of Agricultural Knowledge, Science and Technology for Development (IAASTD), commonly known as the World Agriculture Report. More than 400 scientists from all continents and a broad spectrum of disciplines worked together for four years with the aim of answering the following question:

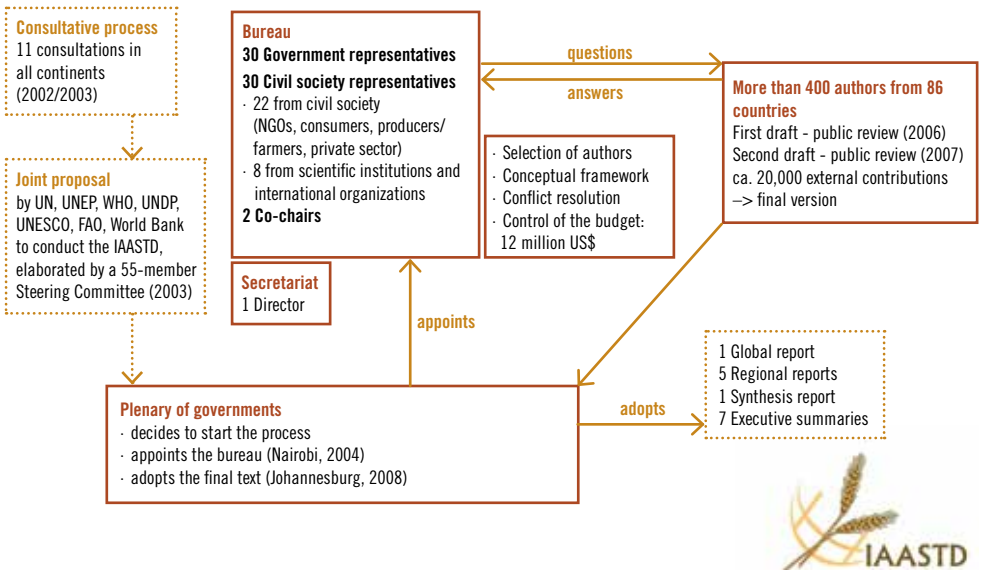
"How can we reduce hunger and poverty, improve rural livelihoods and facilitate equitable, environmentally, socially and economically sustainable development through the generation of, access to, and use of agricultural knowledge, science and technology?"

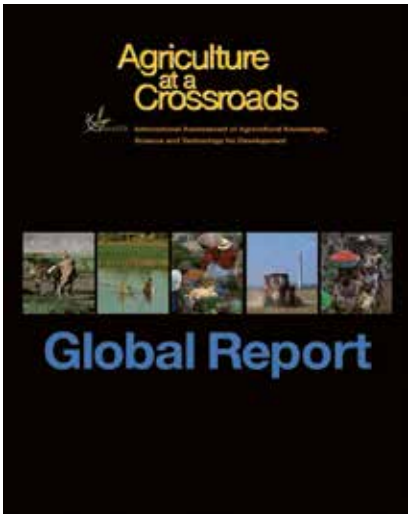
In 2008 in a five-day marathon session in Johannesburg, government representatives adopted the IAASTD summaries line by line.

For several decades, the World Bank had seriously neglected investments in the agricultural sector. The IAASTD was hence set up to take stock of global agricultural knowledge and evaluate where and how the World Bank could best invest in the agricultural development of the poorest countries. The aim was to find out which future approaches should be adopted by the 15 international agricultural research centers (CGIAR) administered by the World Bank and which role the controversial technique of genetic engineering should play in feeding the world's hungry.
Professor Robert T. Watson, the then chief scientist at the World Bank, became the Director of and driving force behind the IAASTD. In the 1980s, he initiated NASA's groundbreaking report on ozone depletion and from 1997 to 2002 he was Chair of the Intergovernmental Panel on Climate Change (IPCC).

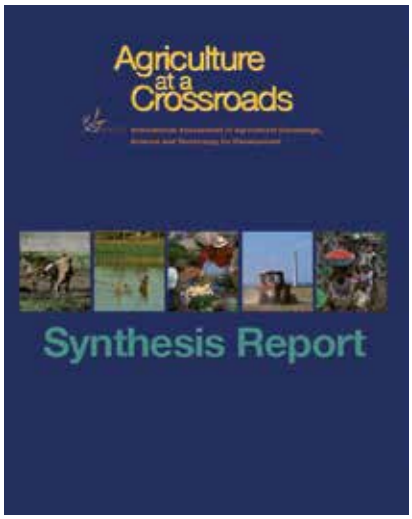
IAASTD authors, Bob Watson and the delegate of the Kingdom of Bhutan were dancing after the IAASTD was finally adopted after five years.

IAASTD - process, structure, stakeholders





"The Bureau agreed that the scope of the assessment needed to go beyond the narrow confines of science and technology and should encompass other types of relevant knowledge (e.g., knowledge held by agricultural producers, consumers and end users) and that it should also assess the role of institutions, organizations, governance, markets and trade. The IAASTD is a multidisciplinary and multistakeholder enterprise requiring the use and integration of information, tools and models from different knowledge paradigms including local and traditional knowledge." (Global, p. IX-X)



The 58 signatory states

Armenia, Azerbaijan, Bahrain, Bangladesh, Belize, Benin, Bhutan, Botswana, Brazil, Cameroon, China (People's Republic of), Costa Rica, Cuba, Democratic Republic of the Congo, Dominican Republic, El Salvador, Ethiopia, Finland, France, Gambia, Ghana, Honduras, India, Iran, Ireland, Kenya, Kyrgyz Republic, Lao People's Democratic Republic, Lebanon, Libya, Maldives, Republic of Moldova, Mozambique, Namibia, Nigeria, Pakistan, Panama, Paraguay, Philippines, Poland, Republic of Palau, Romania, Saudi Arabia, Senegal, Solomon Islands, Swaziland, Sweden, Switzerland, United Republic of Tanzania, Timor-Leste, Togo, Tunisia, Turkey, Uganda, United Kingdom of Great Britain, Uruguay, Viet Nam, Zambia

The structure and functioning of the IAASTD were very similar to the IPCC, yet with one fundamental difference: While the IPCC was only managed by government representatives, the states and UN institutions participating in the IAASTD set up a bureau for the process comprising of 30 government representatives and 30 representatives from civil society. The latter included companies such as Syngenta and Unilever, and scientific institutions worked side by side with farmers, consumer groups and NGOs, such as Greenpeace and the Pesticide Action Network. This bureau agreed on the basic questions to be answered and jointly selected the authors of the report, taking great care to achieve a well-balanced representation of all continents and genders, and different disciplines and backgrounds.

The IAASTD process brought together agronomists and economists with biologists and chemists, as well as ecologists, meteorologists, anthropologists, botanists, medical scientists, geographers, historians and philosophers. It also included some holders of traditional and local knowledge from diverse cultural backgrounds. This unique diversity of participants enabled a holistic perspective on all essential ecological, economic, social and cultural aspects of agriculture. The report strives for a historic perspective, which looks back over the past 50 years, but also for a future perspective, looking forward 50 years if possible. Besides the global report, the IAASTD consists of five separate regional reports and one synthesis report. It also includes seven executive summaries for decision makers which were adopted sentence by sentence by an intergovernmental plenary.

Breaking new ground

The IAASTD's approach differed from mere assessments of science and technology that choose certain solutions as a starting point and then look for the problems that could be solved with this technology. The IAASTD, by contrast, first identified key questions and main challenges in eleven public stakeholder consultations held in all continents in 2003 and then asked for available approaches to resolve them. The fact that all disciplines, stakeholders and cultures were included and that thousands of external comments were considered for the final version of the report was both an unusual and refreshing process for the highly specialized academic and technical experts. The venture of giving the final say in the wording of both the questions and answers of the report (except the summaries) to truly independent experts was also a new experience for the governments and UN institutions.

In early 2008, shortly before the final draft of the IAASTD was presented, both the company Syngenta and CropLife International (the association of global agrochemical companies) withdrew from the process in a last-minute decision. At the final plenary session in April 2008, three governments (USA, Canada and Australia) did not sign the report, although they welcomed the assessment as a "valuable and important contribution". In both cases, the main motive was the critical assessment of genetic engineering and industrial agriculture as compared to small-scale farming and the role of global trade with agricultural commodities. These late withdrawals did not affect the quality of the IAASTD but complicated the dissemination and acceptance of the report in some government, economic and scientific circles in the years that followed.

Despite these setbacks, the IAASTD represents a promising starting point and provides the opportunity for a new view and holistic discussion on the past and future of food and agriculture. It presents a clear message: "Business as usual is not an option!" This was the title of the press release announcing the adoption of the IAASTD by 58 governments in April 2008 in Johannesburg. The title of the report itself is "Agriculture at a Crossroads": A thorough and radical overhaul of present international and national agricultural policies is necessary to meet the enormous challenges of the 21st century. We cannot respond to the challenges of the coming decades with the methods of the past. The IAASTD does not offer so-called "silver bullet" solutions; in fact it warns us against believing such solutions exist, be they of technological, economic or political nature. Instead, it provides a comprehensive and interdisciplinary analysis of the state of agriculture and a wide range of

"Agriculture has a footprint on all of the big environmental issues, so as the world considers climate change, biodiversity, land degradation, water quality, etc. they must also consider agriculture which lies at the center of these issues and poses some uncomfortable challenges that need to be faced. We've got to make sure the footprint of agriculture on climate change is lessened, we have to make sure that we don't degrade our soil, we don't degrade the water and we don't have adverse effects on biodiversity. There are some major challenges, but we believe that by combining local and traditional knowledge with formal knowledge these challenges can be met." (IAASTD Director Bob Watson)

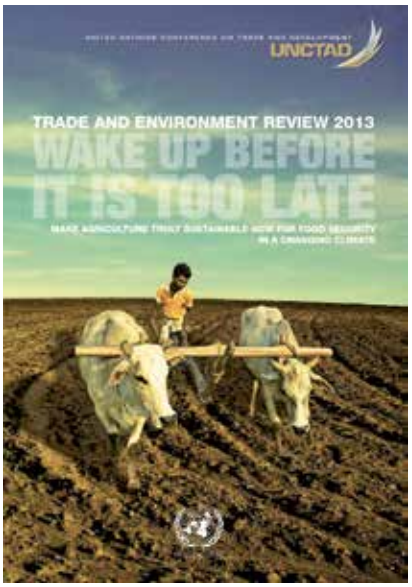
promising approaches. The determined implementation of these possible solutions and a combination of approaches could help us overcome the current crisis.

Eight years later: positive effects and new challenges

A lot has happened in the eight years since the publication of the IAASTD. The ink of the 58 signatory states was still wet when the world food situation took a dramatic turn. In 2008, a dangerous mix of weather-related crop failure, increased demand for biofuels and meat as well as excessive speculation in agricultural commodity futures markets, in combination with overhasty reactions, caused prices for grains and other agricultural commodities soar to historic highs. People in the cities of the Arab world and Asia took to the streets to protest against exploding prices for bread and rice. Overnight, hunger, the constant silent companion in remote rural areas, made it to the front pages and even became a threat for those in power. A second price spike followed in 2011.

These price hikes, the growing demand for biofuels and animal feed as well as the search of investors for secure investment opportunities has generated interest in agricultural commodities and their most important basis – fertile soil. The acquisition of large areas of land by investors, especially in countries with weak governance and insecure land rights, has emerged as a new threat to the livelihoods of rural people and small-scale farmers while speculators are harvesting enormous returns from farmland.

However, there are not only new challenges that have emerged since the publication of the IAASTD, but also positive developments that give rise to hope for change. In the scientific debate and the political discourse, some key messages of the report have fallen on fertile ground, including in international institutions. Terms such as agroecology and food sovereignty have even arrived at institutions such as the FAO. There is talk of a paradigm shift in agriculture that requires moving from input-intensive models of ever-increasing agricultural production to a more sustainable pathway that protects natural resources. "Wake up before it is too late", was the title of a UN report published in 2013 that called for radical changes in agriculture and food production. Farming in rich and poor nations alike should shift from monocultures towards a greater variety of crops, reduced use of fertilizers and other inputs, greater support for small-scale farmers and more locally focused production and consumption of food, the authors recommended. A recent report from experts around former UN Special Rapporteur on the Right to Food, Olivier De Schutter, repeated the IAASTD's message, calling for a paradigm shift from industrial agriculture to diversified agroecological systems. Input-intensive crop monocultures and industrial-scale feedlots must be consigned to the past in order to put global food systems onto a sustainable track, they argued.



Pointing the way to a sustainable future

The IAASTD's answers to the question of how to reduce hunger and poverty, improve rural livelihoods and facilitate equitable, sustainable development have not lost relevance since its publication back in 2008. Many global problems remain unsolved while climate change and a growing world population give rise to new challenges. Although the UN described the Millennium Development Goals (MDGs) as "the most successful anti-poverty movement in history" when they expired in 2015, some targets were missed and progress is uneven across countries and regions. At least 800 million people worldwide are still chronically undernourished. In September 2015, world leaders made a new attempt with the adoption of the 2030 Agenda for Sustainable Development. It includes 17 global goals and a subset of 169 targets which aim to end poverty and hunger, fight inequality, tackle climate change and protect natural resources, among other objectives. This time, the goals apply to developed and developing countries alike. Goal 2, that wants to end hunger, achieve food security and improved nutrition for all, promote sustainable agriculture and double the agricultural productivity and incomes of small-scale farmers, clearly bears the trademark of the IAASTD.

This brochure presents a selection of the IAASTD's key messages and recommendations enriched with updated information, facts and figures as well as new insights from other publications. It also touches new developments and topics that were not covered by the report. Interspersed throughout the text are literal IAASTD quotes as well as a collection of so-called flagship projects – examples of projects, success stories and promising approaches that demonstrate that sustainable agriculture and food systems are indeed possible. We would like to thank our supporters and hope that this brochure will help readers to actively engage in the debate on the future of food and agriculture and to take action in their own communities, businesses, supermarkets and kitchens.

Further information

This brochure, the whole English text of the IAASTD, its synthesis and the five regional reports, as well as background information and updates can be found online at:
www.globalagriculture.org

The official website of the IAASTD can be found here:
bit.ly/unep-iaastd

Hunger in Times of Plenty

"There is recognition that the mounting crisis in food security is of a different complexity and potentially different magnitude than the one of the 1960s. The ability and willingness of different actors, including those in the state, civil society and private sector, to address fundamental questions of relationships among production, social and environmental systems is affected by contentious political and economic stances." (Synthesis, p. 4)

According to estimates from the Food and Agriculture Organization (FAO), some 795 million people, almost one in nine, are currently undernourished and are not getting enough food regularly in order to lead an active and healthy life. At the same time, agriculture is producing more food than ever before, both in total numbers as well as on a per capita basis, despite the fact that world population is growing. If harvests were used entirely and as effectively as possible as food, they could already feed 12 to 14 billion people today.

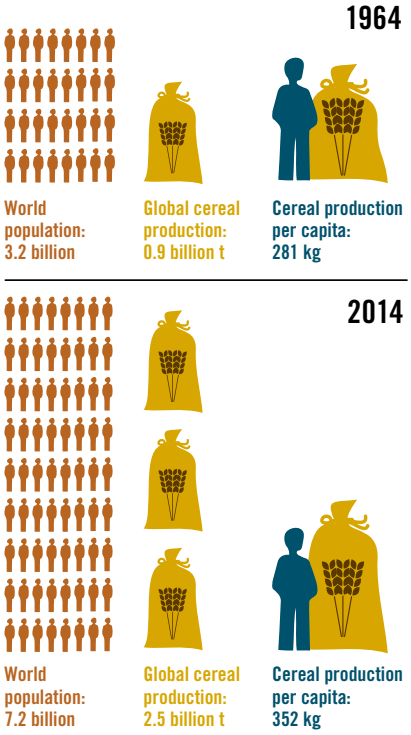
The changeable history of the fight against hunger is as old as humanity whose populations had to adapt again and again to changing environmental conditions, epidemics and other adversities. For the first time since the beginnings of agriculture, humanity now has the means at its disposal to overcome world hunger. Ever since the famous sentence of J.F. Kennedy in 1963 that "we have the capacity to eliminate hunger from the face of the earth in our lifetime – we need only the will", politicians have committed themselves to this goal and then always failed to achieve it.

At the 1996 World Food Summit in Rome, heads of state and government solemnly vowed to halve the number of people suffering from hunger to 420 million by 2015. The United Nations had already declared food an inalienable human right in 1948. However, today, people affected by hunger still do not have effective means of enforcing their right to adequate food and freedom from hunger. If they really wanted to, all governments worldwide could ensure that their citizens have enough to eat. A few countries, such as the world's least developed countries, would have to accept temporary foreign aid for this purpose. India, China, Pakistan, Bangladesh and Indonesia, however, where more than half of the world's hungry live, do certainly not belong to these countries.

Victims of natural disasters such as drought and floods, or of conflict and civil war, make up the minority of people affected by hunger. The picture of hunger and misery painted by the media does not depict the silent majority of those unable to lead a normal life due to a chronic lack of food. Undernourishment makes them too weak to learn and work normally, causes irreparable damages and makes those affected susceptible to infectious diseases and parasites. Mothers and children in their first years of life are hit hardest by malnutrition. The 1,000 days between a woman's pregnancy and her child's second birthday are considered critical to the physical growth and brain development of a child. Every year, almost six million children under the age of five die; one-third of them due to pneumonia, diarrhea and malaria. UNICEF estimates that nearly half could survive with better nutrition. The number of children with stunted growth is even higher than that of underweight children. Stunting causes irreversible cognitive and physical damage, perpetuating the cycle of hunger and poverty in the next generation.

More than enough

Global cereal production and world population

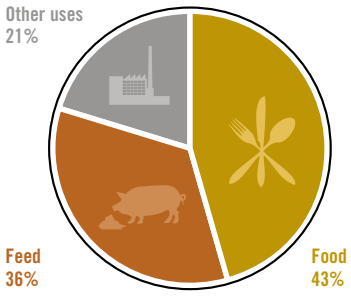


Source: FAOSTAT (2016)

The world's agricultural production is growing faster than its population. But only 43 percent of the global cereal production is used directly as food. The remainder is used as animal feed, or is burnt or processed into fuel and other industrial products.

Utilization of world cereal production

Total utilization in 2015: 2.5 billion tons



Source: FAO (2016)

Hunger can only be overcome locally

More than 70 percent of the hungry live in rural areas. They are small-scale and subsistence farmers, pastoralists, fishermen, rural workers and landless people who directly depend on local land and water use. These rural poor frequently do not have secure access to sufficient amounts of food. Access to land, water and means of production, as well as training, know-how and a minimum of social protection in emergency situations determine whether or not the human right to sufficient and nutritious food is fulfilled in the first place. Moreover, additional employment opportunities in rural areas prove a decisive factor. Therefore, a central message of the IAASTD report is that hunger is primarily a rural problem that can only be overcome locally in the long term. Accordingly, regional self-sufficiency with food is, wherever possible, the essential backbone of sustainable rural development.

Over the past few decades, the situation of the rural poor in many regions of the world has deteriorated dramatically. Small-scale farmers have been displaced, their income has steadily decreased and their yields have stagnated. Especially in Africa, the HIV/AIDS epidemic has left millions of families and communities without their most active members and the burden of additional costs and extra work in order to care for the sick and orphaned. It is mostly young men who look for work in the cities, leaving women, children and the elderly behind, often in precarious situations. Rather than building up reserves for anticipated crises or crop failures, or producing surpluses they could sell to obtain money for investments, they only manage to grow food for their survival.

Misery and rural exodus

Rural exodus is shifting hunger and poverty to the slums and suburbs of the growing mega-cities, where money is an even more decisive factor than in rural areas. For poor people who spend much of their income on food, already modest increases in food prices will have a dramatic effect. An explosion of food prices such as in the years 2008 and 2011 therefore caused thousands of people whose livelihoods were threatened to take the streets. Their hunger revolts, mainly in the cities, contributed to the fact that governments in Asia and Africa today take self-sufficiency in food at least somewhat more seriously than at the time the IAASTD was adopted.

A question of political will

A recent FAO report confirmed that social protection programs could also contribute to eradicating hunger and breaking the cycle of rural poverty, especially if combined with agricultural policies. In poor countries, schemes such as cash transfers and school feeding programs offer a viable way to provide vulnerable people with opportunities to move out of extreme poverty and hunger and to improve their children's health, education and life chances. These programs allow households to access more food – often by increasing what they grow themselves – and also make their diets more diverse and healthier. However, the lack of political stability or will is often impeding the fight against hunger. In many of the hardest hit countries, weak governments at the national and regional level frequently have other priorities than the population's food security. Humanitarian and development aid can even become an important source of income for those in power, who use the misery of the population to their own advantage. The failure of many governments in the fight against hunger is thus often caused by corruption, incompetence, war and internal conflict. The arrogance and ignorance that urban elites display with respect to rural development present further problems. The erosion and collapse of state rule, especially in remote rural regions, often leads to local violence and exploitative structures in which little value is given to human life.

Definitions

There are many different terms to define hunger and malnutrition. These are the basic FAO concepts.

Undernourishment/chronic hunger
"A state, lasting for at least one year, of inability to acquire enough food, defined as a level of food intake insufficient to meet dietary energy requirements." The global hunger figures FAO publishes each year refer to this state. For the purpose of its annual report, FAO uses the term hunger synonymously with chronic undernourishment.

Undernutrition
"The outcome of undernourishment and/or poor absorption and/or poor biological use of nutrients consumed as a result of repeated infectious disease. It includes being underweight for one's age, too short for one's age (stunted), dangerously thin for one's height (wasted) and deficient in vitamins and minerals (micronutrient malnutrition)."

Malnutrition
"An abnormal physiological condition caused by inadequate, unbalanced or excessive consumption of macronutrients and/or micronutrients. Malnutrition includes undernutrition and overnutrition as well as micronutrient deficiencies."

Source: www.fao.org/hunger/glossary/en/

30 years of agroecology and the "Zero Hunger Program" in Brazil

Agroecological vegetable spiral with integrated chicken farming near Erechim

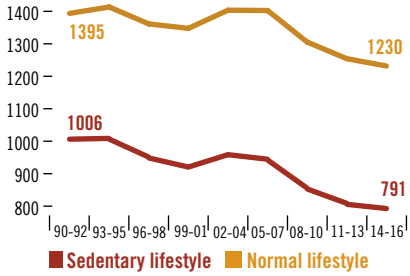
In 1978, in reaction to the Green Revolution, the Evangelical Church founded CAPA (the Support Centre for Small Farmers) as a counselling organization for small-scale farmers in the south of Brazil. Many local farming families had emigrated from Germany in the 19th century and worked on farms of between one and twenty hectares in size. The farmers did not want to follow the agroindustrial growth-oriented model with its monocultures and agrochemicals, either for financial reasons or for ethical considerations. CAPA focuses on a model that would today be called agroecology, organic farming or food sovereignty. At one time an organization recommended to poor families by priests, CAPA has become an independent organization with some 50 employees, advising approximately 7,000 families.

CAPA's main guiding principle is to enable a family to produce enough to feed itself and to cultivate a sufficient variety of products on its land. It also aims to ensure that the farmers gain market access for their goods produced with agroecological methods since farmers are unlikely to shift away from cash crops if they cannot generate a secure income from this alternative form of food production. CAPA developed different marketing channels for agroecological produce. This was initially done through cooperatives and farmers markets. In 2000, CAPA convinced the regional government of São Lourenço, south of Porto Alegre, to start a pilot project: to prepare school meals (which are subsidized by the state) exclusively from produce grown by local small-scale farmers using agroecological production. The Lula government supported the approach of promoting both a healthy diet and fair prices for local farmers by introducing the Zero Hunger (*Fome Zero*) program and a new school meals program, which later became both a nationwide breakthrough. The ingredients for at least 30 percent of the currently 47 million school and kindergarten meals per day have to be supplied by the 4.3 million local small-scale farmers. In areas where CAPA is working, often school meals are entirely provided by small-scale farmers. Since the amount of food that can be bought from one supplier is limited, producing for the school feeding program is only attractive for small farmers. Many farmers supply the schools directly and take part in the preparation of the meals. Healthy school meals depend on variety and the same holds true for the self-sufficiency of farms. Kindergartens and schools have now become an important market for small farmers and along with it also for the concept of food sovereignty that forms the foundation of the program.

bit.ly/CAPABr bit.ly/BrotBrazil

Less calories, less hungry people

Number of undernourished people in millions acccording to assumed calorie needs



Source: FAO (2016b)

Global hunger statistics: flexible curves and goals

The ways in which undernourishment and the goals in the fight against hunger are defined has a large impact on the global number of hungry people and the success in achieving these goals. The number of undernourished people published by the FAO each year refers to an average from the past three years and is based on complex assumptions and calculations, as well as national statistics of different independence and quality. Many of these assumptions and figures have proved to be highly flexible.

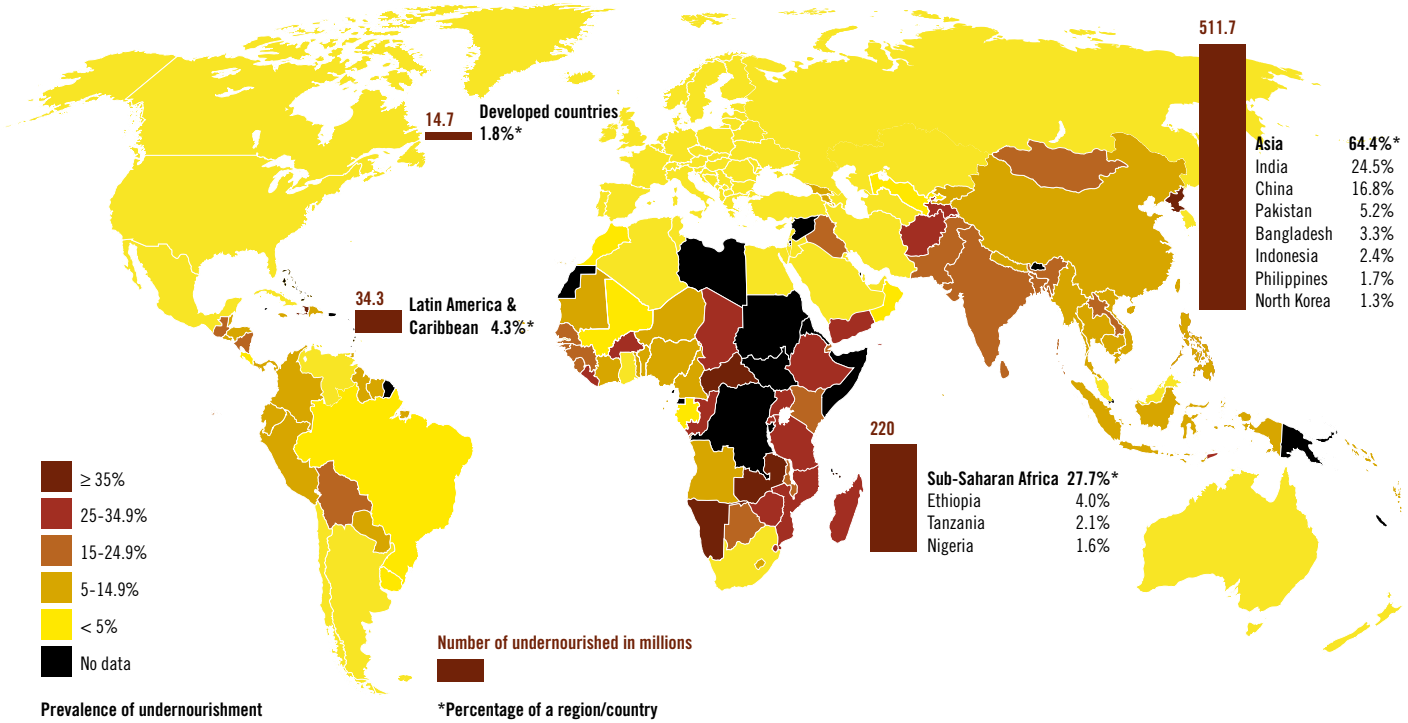
The basis of these calculations is a persons' daily energy requirement. Only a person with an inadequate calorie intake lasting for over one year is counted as hungry. The FAO assumes a sedentary lifestyle, which is typical of office work but is hardly the case for farmers engaging in hard physical labor. The minimum dietary energy requirement for this lifestyle is 1,844 kilocalories per day on global average. For Angola, for example, only a minimum of 1,676 calories is assumed because people are shorter in height. If the calculations were based on a normal lifestyle, for which FAO sets a daily global average of 2,023 kilocalories, and even 1,796 calories for Angolans, the number of hungry people would rise from 791 million to 1.23 billion people in the period 2014-2016.

In 1996, the World Food Summit set the ambitious goal of halving, by 2015, the *absolute* number of hungry people worldwide. The Millennium Development Goal (MDG1) in 2000 was then cunningly adapted to only halve the *proportion* of undernourished people – and only in developing countries. The base year was moved back to 1990 to take advantage of progress in China during the 1990s and of global population growth. In 2009, the FAO warned that more than a billion people were suffering from hunger. The MDG deadline was approaching. Then, in 2011, the FAO changed its methodology. The new method now includes revised figures for food supply, food loss and population data. It assumed that people are less physically active and smaller and that distribution inequalities are less marked than previously thought. In addition, the number of hungry people for 1990 increased from previous estimates of 786 million to 990 million in 2015. Almost as if by magic, these and other assumptions changed the curves illustrating the number of hungry people, which finally started to turn downwards.

The newly adopted UN Sustainable Development Goal 2 has the aim of completely eradicating hunger and malnutrition by 2030. Progress towards the achievement of this goal will once again depend on the definition of accompanying indicators and targets. If world leaders take their SDG commitment seriously, decisive action has to be taken from the start instead of glossing over statistics when the year 2030 is approaching.

SDG 2, target 1:
By 2030, end hunger and ensure access by all people, in particular the poor and people in vulnerable situations, including infants, to safe, nutritious and sufficient food all year round

The world map of undernourishment



Source: FAO (2015), data for the period 2014-2016

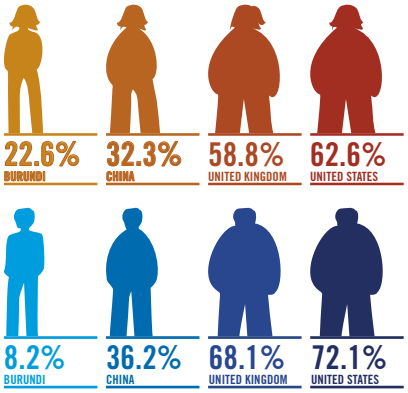
Health: Food or Cause of Illness?

Firstly, hunger is a lack of calories. A healthy diet, however, does not merely consist of enough energy, but also depends on a balanced mix of proteins, carbohydrates and fats as well as a large variety of essential micronutrients, such as iron, zinc, iodine, minerals and vitamins. Worldwide, two billion people are suffering from one or even several micronutrient deficiencies, with often fatal consequences. Short-term emergency measures, such as distributing vitamin A to infants and pregnant women, can save lives in acute cases and alleviate symptoms. Adding micronutrients to foods can also help. The key to a balanced and healthy diet, however, lies in the cultivation and consumption of a range of plants and other products with different vitamins and minerals, as well as in a way of processing food that preserves the quality of its ingredients. This holds true for the food self-sufficiency in rural areas and highly processed foods in urban supermarkets.

"Although the world food system provides an adequate supply of protein and energy for over 85% of people, only two-thirds have access to sufficient dietary micronutrients. The supply of many nutrients in the diets of the poor has decreased due to a reduction in diet diversity resulting from increased monoculture of staple food crops (rice, wheat, and maize) and the loss of a range of nutrient dense food crops from local food systems." (Synthesis, p. 54)

Overweight around the world

Prevalence of overweight in 2014 for adults aged 18 years or older in different countries



Source: WHO (2015)

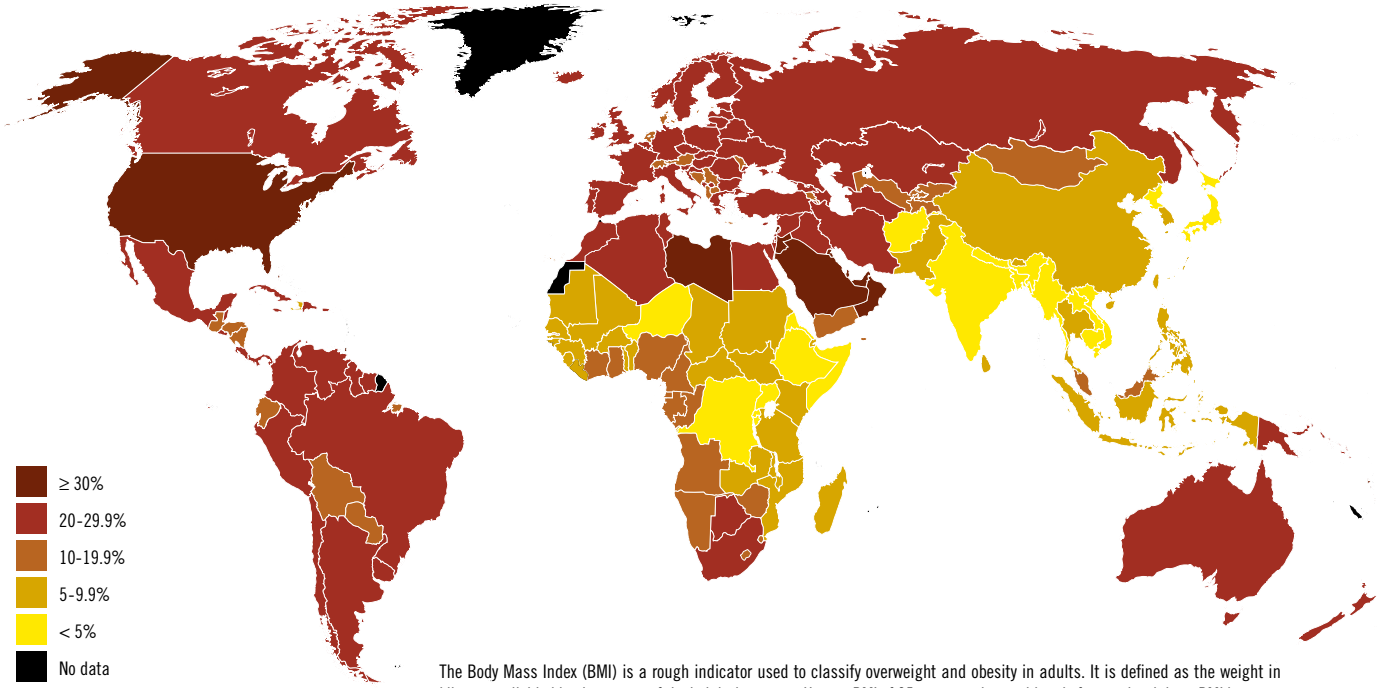
Malnutrition and obesity

According to the World Health Organization (WHO), 1.9 billion people were overweight in 2014, a third of them obese. Over the past decades, this "global epidemic" has been spreading rapidly. If current trends continue, 2.7 billion adults worldwide will be overweight or obese by 2025. A major driver of overweight or obesity is the consumption of energy-dense foods in combination with a lack of physical activity. In 1980, just one in four of all adults were overweight; in 2014, 39 percent of the world population was affected, not only in industrialized nations but also in emerging economies and developing countries. Being overweight is considered a major cause of chronic conditions such as diabetes, high blood pressure, strokes and certain cancers.

Undernutrition, obesity and malnutrition combined are responsible for most non-communicable diseases and health problems. They afflict almost half of the world's population, albeit to different extents. What is more, they have a common root cause, namely the separation and disconnection of food production from consumption. The IAASTD argues that it is essential to reestablish these links at all levels in order to bring food

"A focus on increased production and food security rather than diet quality has contributed to a rise in obesity worldwide and the double burden of under- and overnutrition in developing countries." (Global, p. 196)

The world map of overnutrition



Prevalence of obesity in adults (BMI ≥30) in the population of a country

The Body Mass Index (BMI) is a rough indicator used to classify overweight and obesity in adults. It is defined as the weight in kilograms divided by the square of the height in meters. Up to a BMI of 25, a person is considered of normal weight, a BMI between 25 and 30 is defined as overweight and a person with a BMI of over 30 is considered obese. Someone who is 1.75 meters tall and weighs 76 kilograms has a BMI of 25 whereas with a weight of 92 kilograms, the same person would have a BMI of 30.

Source: WHO (2015), data for the year 2014

providers and consumers closer together. The fine cuisines of this world could show us the way. Many plant-based products, a few but high-quality animal products and as much variety as possible are the secret of Tuscan, Chinese, Indian and Oriental top chefs, who make use of the rich traditions of simple regional cuisines.

"Fiscal policies should take into account impacts on public health. Agricultural subsidies, sales taxes and food marketing incentives or regulations could be refocused to improve nutrition and public health as a primary aim, for example by promoting production and consumption of more healthy foods such as fruits and vegetables." (Synthesis, p. 56)

The IAASTD underlines that public policies, too, could help to ensure diet quality and diversity: they should be refocused to improve nutrition and public health. The former UN Special Rapporteur on the Right to Food has made a series of recommendations that include: taxing unhealthy products; regulating foods high in saturated fats, salt and sugar; cracking down on junk food advertising; overhauling agricultural subsidies that make certain ingredients cheaper and supporting local food production, so that consumers have access to healthy, fresh and nutritious foods. In 2014, Mexico became one of the first countries to impose a tax on sugary drinks, which led to a 12 percent drop in sales in the first year. The United Kingdom recently announced plans to follow this example.

SDG 2, target 2.2:
By 2030, end all forms of malnutrition

SDG 3, target 3.9:
By 2030, substantially reduce the number of deaths and illnesses from hazardous chemicals and air, water and soil pollution and contamination

Food or cause of illness?

Food safety regulations and laws forbidding the contamination of drinking water are among the oldest laws in the world. The IAASTD warns that food safety in developing and industrialized countries is increasingly threatened by new and persistent dangers. Microbial food contamination from bacteria (e.g. staphylococcus, salmonellae and E. coli), fungi, viruses or parasites is currently topping the list of health hazards, often leading to acute symptoms. Food scandals are only the tip of the iceberg.

Exposure to or poisoning from pesticides, heavy metals and other residues, such as dioxins, polychlorinated biphenyls (PCBs) or synthetic hormones, often goes unnoticed due to the length of time it takes for symptoms to develop. If chronic symptoms appear subsequently, it is often difficult to identify the exact causes in individual cases. This also applies to the effects and the interaction of a large number of new chemical substances and food additives to which consumers are exposed today. New disorders and conditions such as allergies, hyperactivity and certain types of cancer are on the rise.

Globally, there are nearly 1.7 billion cases of diarrheal disease every year. Each year, diarrhea kills around 760,000 children under five.

Foodborne illness is a common public health problem, also in the US. The Centers for Disease Control estimate that each year roughly one in six Americans (or 48 million people) get sick, 128,000 are hospitalized and 3,000 die of foodborne diseases.

Source: WHO (2013); CDC (2013)

The increasingly expensive and complex technical safety standards, established in response to the growing health hazards of the global food system, bring with them a number of negative consequences. Small-scale producers are unable to comply with the requirements of sophisticated traceability and labelling systems, which were created by industrialized nations and international corporations to monitor food from farm to fork. These standards, for example the guidelines of the Codex Alimentarius established by FAO and WHO or the sanitary and phytosanitary measures (SPS) of the World Trade Organization have the effect of concentrating the market. In industrialized countries, they hamper traditional forms of food production and thus also the quality of food. Developing countries are often unable to bear the cost of such hygiene standards and monitoring systems. As a result, they are commonly applied exclusively to export goods, while simple and effective local security measures are not introduced.

"As food passes over extended periods of time through the food production, processing, storage and distribution chain, control has become difficult, increasing the risks of exposing food to intentional, undetected or involuntary contamination or adulteration. The use of pesticides and fertilizers, the use of hormones in meat production, large-scale livestock farming, and the use of various additives by food processing industries are among the food safety concerns that are associated with the globalized food system (GFS). In developing countries, GFS safety concerns are compounded by rampant poverty negatively influencing policy compliance and poor infrastructure for enforcement of food control systems." (Global, p. 111)

Pesticide application in the Dominican Republic

Agriculture – a dangerous sector

Agriculture, just like mining and construction, is one of the most hazardous sectors to work in. Millions of work-related accidents occur in agriculture each year, with at least 170,000 agricultural workers dying annually. The main causes of accidents are farming machinery and poisoning by pesticides or other agrochemicals: however, physical overload, noise, dust, allergies and infectious diseases transmitted between animals and humans also need to be taken into account. A major problem is so-called "highly hazardous pesticides", which may be no longer permitted in industrialized countries, yet they often remain widely available in developing countries. Small-scale farmers in particular often do not have, or use, the necessary protective gear. Children are especially vulnerable to these dangers. The International Labour Organization estimates that 59 percent of all child laborers work in agriculture, amounting to over 98 million girls and boys worldwide. The number of unreported cases is very high in this sector.

Infectious diseases transmitted between animals and humans rank among the most serious health risks in agriculture. Certain methods of cultivation favor outbreaks of these zoonotic diseases. Irrigation methods, for example, play a substantial role in the spread of malaria or other insect-borne diseases. Most victims of these diseases are women and children in rural areas, who do not have the means to prevent or treat such diseases. Both private and public research frequently focuses on those illnesses that primarily affect wealthier populations in cities and industrialized countries.

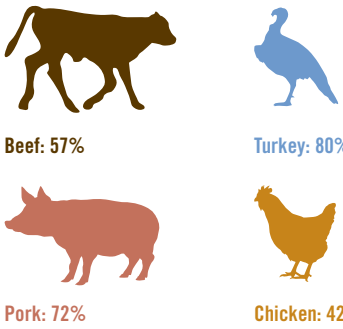
"There are currently 204 infectious diseases known to be spreading in both high- and low-income countries. 75% of these are zoonotic, meaning they are transmitted between animals and humans. These diseases are directly threatening human health and posing an indirect threat to rural incomes and livelihoods due to resultant trade restrictions." (Global, p. 198)

An additional danger to human health is the increasing antimicrobial resistance, which is accelerated by the misuse of antibiotics in humans but also in industrialized farming systems. As early as 1997, the WHO warned against the sub-therapeutic use of antibiotics in livestock farming, reiterating this warning in a new report in 2012. The development of resistant strains of bacteria is rising to alarming levels across the globe, with a growing list of infections such as pneumonia, tuberculosis or blood poisoning becoming harder and impossible to treat as antibiotics become less effective. In 2014, there were about 480,000 new cases of multidrug-resistant tuberculosis.

The IAASTD contends that agriculture and nutrition are the foundations of human health. At the same time, they are a major cause of disease in both rich and poor countries. Healthy and sustainable diets, safe methods of food production and sustainable agriculture could prevent suffering and premature death for millions of people. These are also decisive factors for a solid economic upturn in developing countries and an effective way for industrialized countries to reduce escalating costs in their healthcare systems. One of the key IAASTD messages is that sustainable and healthy diets can only be achieved where consumption (demand) and production are developed together instead of separately. This message is no longer a contentious issue from a scientific point of view, but putting it into practice is often inhibited by powerful economic interests.

Antibiotic-resistant bacteria in the US

Percent of meat samples containing antibiotic-resistant Enterococcus faecalis bacteria tested in US supermarkets in 2012



Source: FDA (2014)

"Agricultural knowledge, science and technology has focused on adding financial value to basic foodstuffs (e.g., using potatoes to produce a wide range of snack foods). This has resulted in cheap, processed food products with low nutrient density (high in fat, refined sugars and salt), and that have a long shelf life. Increased consumption of these food products that are replacing more varied, traditional diets, is contributing to increased rates of obesity and diet-related chronic disease worldwide." (Synthesis, p. 54)

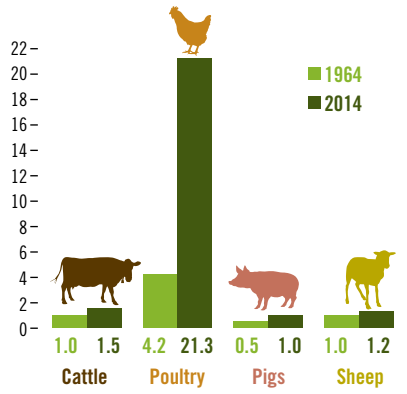
Bhutan – from "Gross National Happiness" to a fully organic nation

Legend has it that in 1972, when the World Bank pointed out to the then 17-year-old Fourth King of Bhutan that the majority of his people had to live from less than a dollar per day, the king responded that the happiness of its population was more important than the gross national product of a country. The concept of measuring "Gross National Happiness", which was then developed by Buddhist and western scientists, has gone on to earn international fame and recognition. 124 variables are used to measure if the psychological, material, spiritual, ecological, social, and health conditions are sufficient for both personal and collective well-being. Not all variables need to be present for a person to be happy: According to the latest happiness survey in 2015, only 8.8 percent of the roughly 775,000 Bhutanese considered themselves unhappy, having achieved sufficiency in less than half of the variables, while a total of 47.9 percent are 'narrowly happy', 35 percent are 'extensively happy' and 8.4 percent of the population are identified as 'deeply happy', enjoying sufficiency in 77 percent or more of the weighted indicators. Despite the country's poverty, Bhutan holds a top position for happiness in the international ranking. In 2008, Bhutan's first freely elected government signed the IAASTD and drew its own conclusions from the report. In 2012, Bhutan's then Minister of Agriculture and Forests, Pema Gyamtsho, himself a farmer like two-thirds of the population, announced his plan to make the country the first fully organic nation worldwide. Outlining the steps to be taken in a strategy, he stated that initially all farmers would receive knowledge, advice and training. Apart from protecting the environment and the independence of farmers from international agribusiness, Bhutan would aim to promote the export of high quality organic products to neighboring countries to offer better economic perspectives and prevent young people from leaving rural areas. The small Himalayan kingdom nestled between China and India is largely self-sufficient (apart from rice) despite the fact that farming is only possible in the fertile valleys on three percent of the land area. 80 percent of the territory is covered with forests, with the constitution stipulating that this must remain the case in order to protect nature. In 2012 at the UN Conference on Sustainable Development Rio+20, Bhutan's then Prime Minister Jigmi Thinley declared: "I think one of the world's biggest myths is that going organic is a choice. From the perspective of food security, there is no choice. Simple survival demands and requires it." **bit.ly/GrossNH bit.ly/SpeechRio**

Meat and Animal Feed

Cattle, poultry, pigs and sheep worldwide

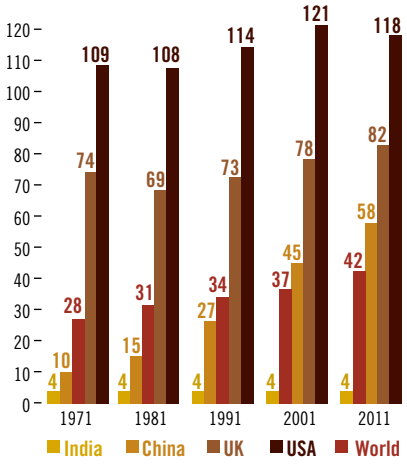
Increase in the global number of farm animals in billions between 1964 and 2014



Source: FAOSTAT

Hunger for meat over the past decades

Annual meat consumption in kilograms per capita in some countries and global average



Source: FAOSTAT

Over the past five decades, global meat production has almost quadrupled from 84 million tons in 1965 to more than 319 million tons in 2015. The IAASTD predicts that this trend will continue, especially because the growing urban middle classes in China and other emerging economies will adapt to the so-called western diet of people in North America and Europe with its taste for burgers and steaks. The FAO estimates that by 2050 global meat production will increase to 455 million tons.

On average, every person on Earth currently consumes 43 kilograms of meat per year. This figure includes babies and adults, meat eaters and vegetarians alike. The global averages masks differences between regions and countries. Annual meat consumption in 2011 was 82 kilograms in the EU compared to 14 kilos in the world's least developed countries; US citizens consumed 118 kilograms per year, while people in India only ate four kilos. In general, men eat more meat than women. In the EU, meat consumption has stagnated recently with a growing number of people switching to vegetarian or vegan diets. Moreover, beef has lost in popularity whereas the consumption of chicken has increased remarkably. The favorite meat of Europeans is pork. The Chinese also share this appetite for pork. Per capita meat consumption in China has increased six-fold over the past 40 years. Since the population almost doubled to 1.4 billion people over the same period, global demand for meat and animal feed has exploded.

Meat consumption in most high-income countries is higher than considered healthy. The British Nutrition Foundation recommends a varied diet based on starchy foods, fruit and vegetables, and only moderate amounts of meat, with no more than 500 grams of red and processed meats per week (26 kilograms per year). In China's neighboring country, India, where the population and economy has seen a similar development, meat consumption has remained at a very low level. This shows that eating more meat with rising incomes is not a question of human nature but rather is connected to culture.

Plate or feed trough?

The production of meat, milk and eggs leads to an enormous loss of calories if animals are fed on cereals and oil seeds that have to be grown on fields. The United Nations Environment Programme estimates that the calories that are lost by using cereals as animal feed instead of using them directly as human food, could theoretically feed an extra 3.5 billion people. Conversion rates from plant-based into animal-based calories vary. According to conservative estimates cited by the IAASTD, it takes two kilograms of grain to produce one kilo of chicken, four kilos for pork and seven kilos for beef.

By their nature, cattle and sheep eat grass. More than two-thirds of the global agricultural area are permanent meadows and pastures. If livestock eat grass and other plants that are not suitable for direct human consumption, they do not compete for cereals but increase food supply and add significantly to agricultural production. They produce manure, contribute to soil cultivation, serve as draught and pack animals, recycle waste and stabilize the food security of their owners. Large parts of the grasslands used today, especially in arid regions, are not suitable for any other agricultural use except extensive grassland management. However, it is no longer possible to substantially increase its production capacity. In some world regions, overexploitation of grasslands, also through traditional livestock husbandry, has become a serious problem.

"Worldwide, livestock have traditionally been part of farming systems for millennia. Integrated systems provide synergy between crops and livestock, with animals producing manure for use as fertilizer and improvement of soil structure (as well as a source of fuel), while crop by-products are a useful source of animal and fish food." (Global, p. 176)

Chickens, pigs and other small animals, traditionally kept to make use of waste and other by-products or to eat worms and acorns, can complement food production and optimize the use of resources. Today, however, most fattened livestock are kept in increasingly bigger factory farms. They are mainly fed with concentrated feed based on soybean, rapeseed, maize, wheat or other grains grown on arable land. This results in the loss of land that is typically used in direct food production.

"The increase in consumption of animal products is, next to population growth, one of the major causes of the increase of global fertilizer use. World meat consumption (and production) is expected to grow by 70% in the period 2000-2030 and 120% in the period 2000-2050. The production and consumption of pig and poultry meat is expected to grow at a much higher speed than of bovine and ovine meat. Over the last years there has been a major expansion in large scale, vertically integrated industrial livestock systems, and this development is expected to continue over the coming decades. These systems can lead to concentration of manure; although manure is a valuable source of nutrients, concentrated spreading of manure leads to significant emissions, to air, soil and water." (Global, p. 281)

Importing land: the appetite for meat is consuming the Amazon

The huge demand for animal feed is especially becoming a problem if the production and the associated impacts are "outsourced" to other countries or regions. The EU has a 70 percent deficit in protein-rich crops that is met primarily by soy imports. In 2014, the 28 member states imported 18.5 million tons of soymeal and 13.5 million tons of soybeans, mostly from Brazil, Argentina, Paraguay and the United States. The area used there for the production of such export crops is equivalent to almost one fifth of the EU's total arable land area. Rainforests are cut down and large pasture areas are converted into cropland for the cultivation of soy. This is not only a catastrophe for global biodiversity and climate protection, it also reduces soil fertility due to large monocultures that dominate soy production. China, on the other side of the Pacific, is the major soy importer worldwide, importing 74.5 million tons in 2014. The cheap imports also cause many problems for local soy farmers. In its country of origin, where the soybean is also called "meat of the soil", the area of cultivation decreased by almost one-third between 2004 and 2014.

"At the global scale, soybean is one of the fastest expanding crops. (...) Deforestation for soybean expansion has been identified as a major environmental threat in Argentina, Brazil, Bolivia and Paraguay. In part, area expansion has occurred in locations previously used for other agricultural or grazing activities, but additional transformation of native vegetation plays a major role." (Global, p. 284)

Legumes can fix nitrogen from the air in symbiosis with bacteria at their roots.

Leguminous plants can offer many advantages. To raise awareness of their benefits the UN declared 2016 the International Year of Pulses. Legumes can fix nitrogen from the air in symbiosis with bacteria at their roots, thus reducing the need for mineral fertilizers or animal manure. They could make an essential contribution to climate protection and soil fertility. In Europe, however, the cultivation of soy and other domestic protein crops such as broad beans, field peas and lupines, has not been competitive for decades. Although the EU has recognized the need to reduce its dependency on imported protein crops, a clear strategy to close the gap is still missing. During the last reform of the Common Agricultural Policy, the EU did not manage to establish mandatory crop rotation with legumes as a condition for receiving direct payments.

Industrial livestock farming turns up the heat

The industrial production of meat, milk and eggs, which is no longer tied to pastures, requires the cultivation of cereals and oilseeds for the use as animal feed. These crops are mainly cultivated in highly energy-intensive monocultures. In addition, ruminants emit the dangerous greenhouse gas methane and livestock causes ammonia emissions from manure and dung. The industrial livestock sector therefore makes up large part of agriculture's contribution to climate change. The negative impact of meat and dairy production on the climate could partly be mitigated by improving the composition of animal feed in order to reduce methane emissions. Additional sources of feed, for example from organic waste and unused bycatch in fishery, could also enhance efficiency in this area. A better distribution of meat production facilities would help to reduce transport distances and allow for the use of animal dung in those places where nutrients were removed from the soil.

"The livestock sector has enormous impacts on the environment: it is responsible for 18% of greenhouse gas emissions measured in CO_2 equivalents, and 9% of anthropogenic CO_2 emissions, including the combustion of fossil fuels to make the additional inputs. Globally, it accounts for about 8% of human water use, mostly for the irrigation of feed crops. It is estimated that 1 kg of edible beef results in an overall requirement of 20 to 43 tonnes water per kg of meat (...). In the US, livestock are responsible for 55% of soil erosion and sediment, 37% of pesticide use, 50% of antibiotic use and a third of the loads of nitrogen and phosphorus into freshwater resources." (Global, p. 518, 520)

Need for changes in consumer habits

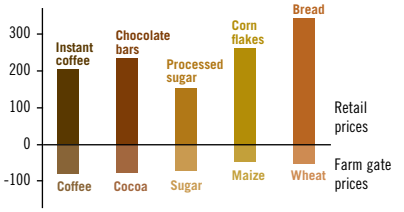
Although the IAASTD does not provide recommendations with respect to consumer habits, the results of the report can only lead to a single conclusion: The consumption of meat and dairy products in industrialized countries has to be reduced and consumption in emerging countries should be limited to an acceptable level. These are the most urgent and most effective steps in achieving food security and for protecting natural resources and the climate. Considering the disastrous consequences of meat consumption, would it really be so radical to follow our grandparents' tradition of a Sunday roast rather than eating meat every day? This would not only be good for our health, but in turn for food safety and the environment as well. The respectful treatment of farm animals would be beneficial to their well-being and to our self-respect. When buying meat at the supermarket, people wouldn't feel compelled to suppress their own thoughts of the unbearable conditions in modern meat factories, nor of the loss of forests, animal and plant varieties, or of global warming – all of which are closely related to this form of production, along with the decay of rural areas and small-scale farmers' livelihoods.

Trade and Markets

"One can now speak of a 'global treadmill' that allows farmers in developed economies to export their (sometimes subsidized) products to developing countries and compete with local small-scale farmers. Value added per agricultural worker in 2003 (constant 2000 US$) in developed market economies was 23,081 with a growth over 1992-2003 of 4.4%. For sub-Saharan Africa the figures are 327 and 1.4%, respectively. As long as the global treadmill is operating, even with all OECD subsidies removed, efforts to uplift rural poverty will remain severely handicapped. (...) The rural poor are not on the global treadmill; instead the global treadmill prevents them from development. Required are institutional framework conditions that provide realistic opportunities to subsistence farmers to become small-scale commercial farmers." (Global, p. 481-482)

Development of producer and retail prices

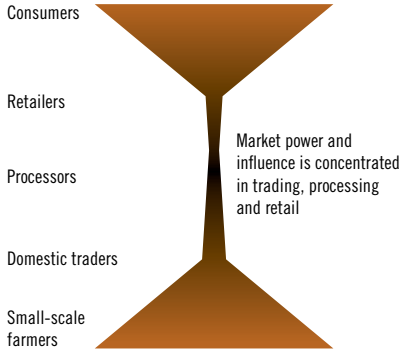
Price changes of retail foodstuffs and farm gate prices between 1980 and 2000 in percent



While nominal farm gate prices for coffee, cocoa, raw sugar, maize and wheat fell, retail prices for the corresponding processed products increased remarkably over the same period.

Source: Global, p. 458

Market concentration



From farmer to consumer, world trade has become a bottleneck. There has been a rapid concentration of market power away from producers into the hands of a limited number of traders, processors and retail companies who are making the biggest profit.

Source: Synthesis, p. 67

"Agricultural trade is increasingly organized in global chains, dominated by a few large transnational buyers (trading companies, agrifood processors and companies involved in production of commodities). In these globalized chains primary producers often capture only a fraction of the international price of a trade commodity, so the poverty reduction and rural development effects of integration in global supply chains have been far less than optimal." (Synthesis, p. 65-66)

The misery of millions of small-scale farmers is often the result of unfair competition between large, world market-oriented agricultural companies and small family farms. Millions of smallholders worldwide produce just enough for their families to survive. However, harvests are often not sufficient for the whole year and small-scale farmers are frequently affected by hunger. Only those farmers who are able to sell their products at an adequate price will produce more than their families consume, and only in this case can they contribute to feeding other people and make provisions for hard times. Preconditions for this are access to markets as well as the possibility to invest and handle the risks associated with the investment. Millions of farmers, especially women, fail to comply with these basic prerequisites. Local, regional and national markets remain closed to them; the necessary infrastructure, incentives, information, protection from competition and systematic development are all absent. It is often easier for cheap finished products from industrialized countries to gain access to the markets in the cities of the Global South than it is for products from the region itself.

Unequal partners

The international conditions of global agricultural trade emerged in the colonial era of the 19th century. Today they are regulated by the World Trade Organization and a large number of bilateral and multilateral trade agreements. Their objective is to expand and liberalize international trade through the elimination of tariffs and trade restrictions. In theory, free markets and worldwide competition reduce the global costs of production, thus increasing prosperity. However, it is frequently doubted that this can hold true for agricultural production and, at the same time, for the management of our limited natural resources, as long as the local ecological and social conditions differ completely. It is undisputed that the current conditions prevailing on the world market for agricultural commodities do not provide basic food for everyone through sustainable production. According to the IAASTD, the conditions of global agricultural trade would have to be radically changed in order to achieve this aim.

Producer prices for agricultural commodities fell steadily since the Second World War and continued to do so roughly until the turn of the millennium. Correspondingly, the income of the majority of farmers worldwide has also decreased. In industrialized nations, the number of farmers declined, while the average farm size increased. At the same time, the operating costs for farm machinery, pesticides, energy, seeds and other inputs increased with the industrialization of agriculture. However, farmers' share in retail prices has decreased dramatically for the benefit of retailers and food processors.

Global market concentration

Within all upstream and downstream industries to agriculture, an increasing global and national concentration is taking place in the hands of just a few companies that dominate the market. This is exacerbated by a growing vertical integration along the value chains – chemical companies are controlling the global seed market; raw material traders are controlling transport routes, mills and refineries; supermarket chains are dominating wholesale trade and processors their contract farmers. This process is reinforcing the economic marginalization of small-scale and subsistence farmers who are of no interest to the global industry, neither as customers nor as suppliers.

Even though the percentage of agricultural production traded internationally is relatively small (around 15 percent in the case of cereal production), world market prices have an enormous leverage effect. They also determine domestic prices, particularly in smaller countries with unprotected markets. If local producers charge higher prices, they are immediately pushed out of urban markets.

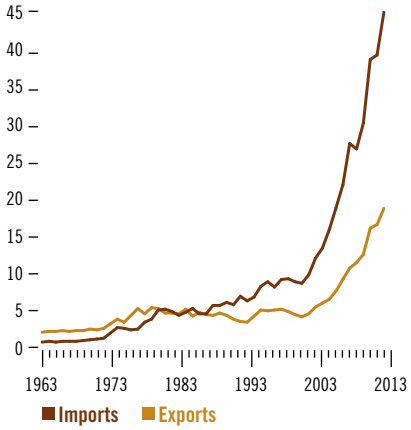
Enhancing opportunities in domestic and regional markets

World trade has an enormous impact on agricultural policies in many developing countries. Rather than providing the population with food, or promoting the development of domestic markets and rural areas, governments and local elites frequently pursue the primary goal of generating foreign currency and tax revenue from agricultural exports. Although large parts of their populations are suffering from hunger, especially in rural areas, many countries still choose to supply cheap raw materials for the animal feed, fiber, (bio)fuel and luxury food industries in the North, with devastating ecological and social costs. As net-importers of food, these countries become dependent on world market prices over which they have no influence. The IAASTD identifies the least developed countries and the poor in rural areas as the losers of global trade and its ongoing liberalization.

The report warns against an opening of markets in regions where cheap imports and exports would hinder rural and agricultural development, and threaten food security and incomes of the population. The IAASTD also points to the fact that import tariffs make up one quarter of state revenues in some poor countries and are relatively easy and reliable to collect. The loss of these revenues could therefore reduce the potential of public social and structural policies, and the already weak capacity of public institutions to act. Industrialized nations themselves frequently make use of tariff escalation for imported goods, with import tariffs increasingly depending on the degree of processing that has occurred. This allows industrialized countries, in which agriculture is rarely an important economic sector, to import cheap raw materials while setting higher tariffs for processed goods to protect their own processors. This prevents many countries in the South from developing their own processing industries and creating jobs.

The world trade divide

Agricultural exports and imports of the world's least developed countries in billion US dollars



Apart from minerals, the 48 poorest countries of the world (LDCs) have hardly any other export products than agricultural commodities. Neglecting domestic food production in favor of the cultivation of cash crops has caused high import bills for them.

Source: FAOSTAT, Trade

Fair prices for sustainable production

The IAASTD calls for a radical change of course in current policies: Farmers, particularly those in developing countries, must be paid an adequate price for their environmental services they provide during production (such as soil and biodiversity conservation, water management and the reduction of carbon emissions). This could include climate or environmental charges, whose collection is organized by states and that are distributed purposefully and fairly from a global perspective. The IAASTD describes the EU subsidies for agri-environmental measures as a step into the right direction. In developing countries, such programs could boost rural development and ensure that ecological sustainability can be financed.

"The sub-Global IAASTD reports identify many policy challenges:
1. Crafting trade rules that allow developing countries needed flexibility to pursue development, poverty reduction and food security agendas, and that address the distributional impacts of welfare benefits and losses from trade liberalization;
2. Achieving remunerative prices for small-scale farmers;
3. Increasing the value captured by small-scale producers in vertically integrated agrifood chains;
4. Addressing the increased regulatory responsibilities required by trade agreements with limited tax revenues, which can be diminished by tariff reductions." (Global, p. 453)

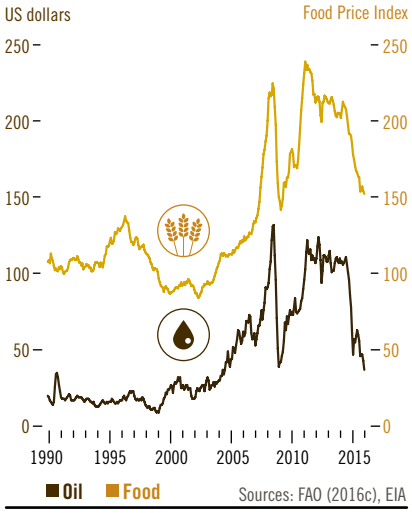
Private sector approaches could also make an important contribution. Fair trade initiatives and trade with organic products allow consumers, both in the North and the South, to actively support sustainable forms of agriculture through informed purchase decisions. These initiatives, introduced to offer alternative trading channels to mainstream commodity markets, have proved to be an effective way to reduce poverty. Apart from direct economic effects, decisions only to buy products that provide more favorable and stable returns to farmers can serve to exert a healthy dose of pressure on the rest of the market.

"Fair Trade and environmentally linked production systems, such as organic and eco-friendly production, were introduced as alternatives to the mainstream commodity markets. While these models offer small-scale producers better terms of trade, the market share for these trading systems has been slow to grow and still only occupies a small percentage of global trade. Nevertheless, the principles were proven and a new generation of business models needs to be designed that can provide windows for the less endowed producers to enter mainstream markets through trading platforms that promote greater stability of demand." (Global, p. 460)

"IAASTD projections of the global food system indicate a tightening of world food markets, with increasing market concentration in a few hands and rapid growth of global retail chains in all developing countries, natural and physical resource scarcity, and adverse implications for food security. Real world prices of most cereals and meats are projected to increase in the coming decades, dramatically reversing past trends." (Synthesis, p. 22)

Prices for food and crude oil

Price increases for one barrel of crude oil Brent (in US dollars) and for food commodities (Food Price Index in points) since 1990



Food speculation

Shortly after the publication of the IAASTD, an internal World Bank report cited the speculation with agricultural commodities on the commodity futures exchanges, as well as the production of biofuels, as the main reason for the food price spikes in 2008. This sparked fierce controversy among scientists over the impacts of speculation with food.

On the commodity futures exchanges, contracts have always been concluded on future deliveries of agricultural commodities at a prior agreed-upon price. This safeguarded both sellers and buyers against any excessive price jumps, for example those caused by the vagaries of the weather. If the fixed price was higher than the current price at the settled date, the seller benefited – if the fixed price was lower than prices are at the time the contract is settled, the buyer made a profit. Both parties were able to already calculate with the price at the time a contract was closed. Over the past years, however, this has turned into a real casino for investors and speculators, who are not interested in the soy, wheat, maize or rice they speculate with. It is only important to them that the prices do not follow the same logic as the share prices on the DAX or NASDAQ, on which they speculate at the same time in order to spread their risk.

Since the 1990s, the deregulation of commodity futures trading in the United States made it possible for institutional investors to enter this market on a large scale. Subsequently, the percentage of commercial traders has decreased remarkably while the number of speculative traders has exploded on the world's most important futures exchange CBOT in Chicago. In 2002, eleven times the actual amount of wheat available was traded on the CBOT; in 2011, 73 times the actual US wheat harvest was traded. Although these speculative deals with food commodities are generally oriented towards the real situation of supply and demand, the psychology of the stock exchange and the algorithms of the computers that control the trade have led to increasingly nervous fluctuations. While there are many factors influencing global food prices, such as the oil price, supply and demand or extreme weather events, many analysts agree that investors who bet on long-term increases in food prices are having a price-driving effect.

SDG 2, target 2c:
Adopt measures to ensure the proper functioning of food commodity markets and their derivatives and facilitate timely access to market information, including on food reserves, in order to help limit extreme food price volatility

Betting on hunger

It is a fact that speculators get rich when rising cereal prices lead to poverty and hunger for millions of families. Hedge funds, pension funds and investment banks such as Goldman Sachs and Morgan Stanley now dominate the food commodities markets. In 2013, several European banks pulled back from speculative trading in agricultural commodities in response to public campaigns by many non-governmental organizations. Barclays – the United Kingdom's biggest player in food speculation – announced it would no longer trade in agricultural commodities for speculative purposes. In Germany, most financial institutions have given up making direct speculations with agricultural commodities with the exception of Allianz and Deutsche Bank, the latter of which still ranks among the leading speculators. In early 2014, the European Union introduced new regulations that place a limit on the number of food contracts that banks and other finance companies can hold. While this was welcomed as an important first step, there are still several loopholes in the regulation. This is also the case in the US, where regulation of food speculation was included in the Dodd-Frank Act in 2010. In the theoretical discussion about the impact of speculation on food prices, which is strongly influenced by interested circles, no agreement has been reached. Hope remains that price jumps in the global markets such as those in 2008 and 2011 will not occur again, together with their fatal consequences for the people affected.

Food Sovereignty

The IAASTD with its 58 signatory states was the first intergovernmental, UN-led process to introduce the term of *food sovereignty* into the debate and to clearly define it. The concept was developed by the international peasants' movement La Via Campesina. At the World Food Summit 1996 in Rome, the organization presented food sovereignty as an anti-colonial critique of the foreign domination of states by the international trade rules of the World Trade Organization as well as the neoliberal credit conditions imposed by the World Bank and the International Monetary Fund. The basis of food sovereignty is self-determined food production. The concept therefore focuses in the first place on food producers and then on consumers.

"Food sovereignty is defined as the right of peoples and sovereign states to democratically determine their own agricultural and food policies." (Global, p. 10)

On the other hand, f*ood security*, as defined by the World Food Summit, is a passive state of food supply, which exists "when all people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life." The *right to food*, enshrined in the UN International Covenant on Economic, Social and Cultural Rights, is a human right, defined as "the fundamental right to freedom from hunger." The 164 states parties are obliged to ensure the access of their populations to adequate food.

"Assumptions that national average food production figures can indicate food security are belied by internal distribution constraints, political limitations on access, inabilities to purchase available food, overconsumption in segments of a population, policies which encourage farmers to shift from family food production to cash crops, crop failure, storage losses, and a range of other factors." (Global, p. 10)

Food sovereignty does not describe a universal silver bullet solution. It is a concept for the democratization of food production, which can be further developed and adapted to different conditions. Important principles of food sovereignty are the right to food, democratic food production systems, the strengthening of local markets, fair trade relations and the formation of fair prices, decent living wages, debt relief for states, freedom of association and education. Other principles include access to fertile land, pastures, fishing grounds, forests, water and seeds. This access has to be ensured where necessary through agrarian and land reforms, as well as through the agroecological management and the common conservation of natural resources. Food sovereignty calls for the development of local and regional self-sufficiency and if possible close links between producers and consumers. However, it has nothing to do with autarchy (self-sufficiency) in the sense of a political doctrine.

"Food sovereignty has a broader dimension, since it incorporates issues such as agrarian reform, territorial control, local markets, biodiversity, autonomy, cooperation, debt and health, all of which have to do with local food production. (...) For civil society, food sovereignty, as a different paradigm, is needed to ensure that the developing countries can attain food security, rural employment and the goals of sustainable development. For the developing countries, food sovereignty encompasses the demand that the World Trade Organization (WTO) put an end to its control over food and agriculture. Food sovereignty basically recognizes that small farmers and landless peasants will never be able to compete in the entrepreneurial agricultural paradigm." (Latin America and the Caribbean, p. 20)

When the IAASTD promoted and integrated the 'unscientific' concept of food sovereignty in 2008 because it goes beyond conventional concepts of food security, it received a lot of criticism. Since then, the term was gradually acknowledged at official level. In 2013, the Food and Agriculture Organization signed a cooperation agreement with La Via Campesina to join forces in strengthening agro-ecological small-scale farming. The concept and definitions of food sovereignty are continually being developed and deepened. The food sovereignty movement is gaining momentum, in the urban North as well as in the Global South, with individuals, farmers and social movements working to make food sovereignty a reality.

Food sovereignty as a symbol

Food sovereignty has become a concept of self-determination, both in industrialized nations and in the cities. In this context, it is also a matter of "decolonization" and of actively changing the relationship with the concentrated economic and communicative power of food corporations and retail chains.

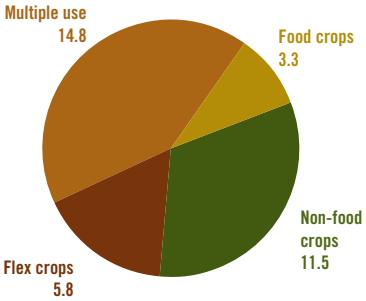
For many people in the cities, especially the young generation, cooking itself has become an act of emancipation. Vegan or vegetarian diets; fair, local or organic food, as well as the use of edible products destined for waste have turned into a symbol. There are many diverse forms of expression in the search for food sovereignty. City dwellers take the cultivation of vegetables into their own hands again, in community, school and neighborhood gardens or intercultural gardening projects. Urban apiculture is on the rise, food cooperatives have been formed and Community Supported Agriculture (CSA) allows consumers to directly support the production of food with their own money as well as their active work. This is all about self-fulfillment and overcoming a sense of alienation from food production, but it is also related to the old wisdom that eating is always a political act.

Land Grabbing

"Large inequities in the tenure and access to land and water have exacerbated economic inequalities that still characterized many world regions in the world. Land reform, including improved tenure systems and equitable access to water are suggestive means to support sustainable management and simultaneously respond to social inequalities that inhibit economic development." (Synthesis, p. 32)

Cash or food crops?

Agricultural land acquisitions for crops in million hectares according to destination of use (total area as of May 2016: 35 million hectares)



Only a small part of the areas acquired by agricultural companies or speculators across the globe are intended to be used for food production. The lion's share is destined for other uses. Ideal for investors are so-called flex crops that can be used for biofuels, animal feed or food depending on the market situation. Of the concluded projects intended for agricultural use that were captured by the *Land Matrix* as of May 2016, only 10 percent of the area was exclusively destined for food production.

Source: www.landmatrix.org (2016)

SDG 1, target 4:
By 2030, ensure that all men and women, in particular the poor and the vulnerable, have equal rights to economic resources, as well as access to basic services, ownership and control over land and other forms of property, inheritance [and] … natural resources

Forest that was once used by the population is now in the hands of a palm oil company.

Since 2008, the term "land grabbing" gained notoriety around the globe. It refers to large-scale land acquisitions mainly by private investors but also by public investors and agribusiness that buy farmland or lease it on a long-term basis to produce agricultural commodities. These international investors, as well as the public, semi-public or private sellers, often operate in legal grey areas and in a no man's land between traditional land rights and modern forms of property. In many cases of land grabbing, one could speak of a land reform from above, or of the establishment of new colonial relationships imposed by the private sector.

The IAASTD covers the problem of unfair distribution of land, which has existed for many centuries, as well as approaches to agrarian reforms and communal land use. Its key message is simple: Secure land tenure, property rights and other forms of common ownership, including access to water, are an essential prerequisite for family farms to invest in their own future. They provide the basis for all forms of sustainable development and land cultivation.

There is hardly any other economic sector with so little transparency as in the area of land ownership. Even in times of *Google Maps*, a global land register is still a long way off. History often plays a key role: Past social and economic systems, ideologies, tribal rights and gender privileges, as well as scars of war and displacement, remain visible. The power over land registers is still today not granted by courts in all parts of the world but often seized violently by both private and public actors. According to recent estimates by Oxfam and others, up to 2.5 billion people depend on indigenous and community lands which make up over half of the earth's land. However, these communities legally own just one fifth of this land, making them highly vulnerable to land grabs from more powerful entities like governments and corporations.

Global land rush in countries with weak governance

Since 2009, the *Land Matrix*, a joint independent land-monitoring initiative of civil society, intergovernmental organizations and research institutes, has collected key information regarding land grabbing. For example, it shows that almost nine percent of Africa's total area of arable land has changed owners since 2000. The largest land acquisitions are concentrated in countries with weak governance structures. In these countries, the proportion of hunger and malnutrition in the population is also very high, for example the Democratic Republic of the Congo, Sudan, Mozambique, Ethiopia and Sierra Leone. Only 10 percent of the agricultural projects listed by the *Land Matrix* are exclusively destined for food production. The more common objective of land acquisition is the cultivation of biofuels or energy crops for export, fibers, animal feed or traditional cash crops such as coffee, tea and tobacco. A large proportion of land is used to cultivate so-called "flex crops", which can be used either for food or other purposes, particularly for biofuels.

Large-scale land acquisitions mainly target readily accessible, fertile land, in densely populated areas, cultivated by small-scale farmers. In many cases of land grabbing, securing access to water also plays an important role. Those affected by these land deals commonly receive insufficient compensation and are not consulted or involved in the process. It is also worth noting that large parts of the land acquired are often not used immediately and that the rate of abandoned projects is quite high. The *Land Matrix* therefore differentiates between concluded, intended and failed deals.

Can voluntary guidelines help?

In May 2012, the Committee on World Food Security (CFS) of the United Nations officially endorsed the "Voluntary Guidelines on the Responsible Governance of Tenure of Land, Fisheries and Forests in the Context of National Food Security". They are intended to provide governments, investors and civil society with rules on how to protect, document and administer legitimate rights; how to organize a change of land ownership; how to define public priorities and goals for land use; and how to deal with conflicts. The guidelines define access to land in the context of human rights, demanding gender equality and transparency, the rule of law, respect for different tenure systems and values, early consultation of all people who are likely to be affected and peaceful conflict resolution, as well as both public and private responsibility for

sustainability, food production and employment. Most paragraphs start with the words "States should". The guidelines are a collection of democratic conditions founded on the rule of law, something that is often not prevailing in the countries ranking high on the list of popular land grabbing destinations. In practice, this collection of principles, suggestions and intentions are only likely to become relevant if the governments that promote or tolerate land grabbing in their countries face consequences if they are not observed, for example loss of development aid or the suspension of cooperation agreements. They could also become an effective tool if companies that violate the guidelines become subject to sanctions imposed by trading partners, but also by the companies' countries of origin. Four years after the adoption of the guidelines, examples of such an effective implementation are still missing.

"The complex social and political contradictions of colonial and post-independence land policies have increasingly derogated the land rights of the poor, fuelling popular demands for land reforms." (Sub-Saharan Africa, p.17)

Trade in agricultural commodities creates a global land market

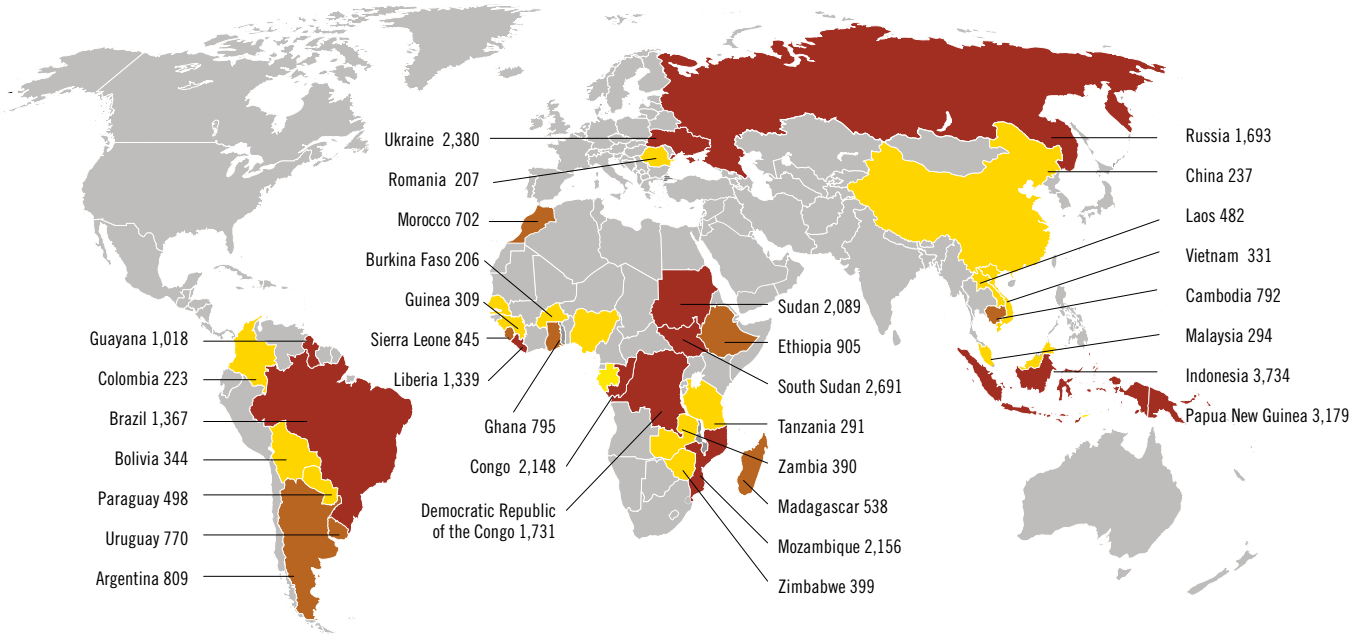
There are several reasons behind the growing interest of international investors in large-scale land deals. Firstly, there is an expanding market for agricultural commodities that can be traded globally and are thus not dependent on the purchasing power of local populations. Secondly, the increasing scarcity of fertile soil is a trend that has not gone unnoticed by investors. Thirdly, most analysts agree that although food prices have once again decreased following the spikes in 2007-2008 and 2010-2011, they will remain above pre-2007 levels. The effects of climate change and weather shocks may increase the level and volatility of food prices. For capital investors in search of investment possibilities, arable land therefore is an attractive choice due to a predicted future value increase, even in areas where yields are not ideal in the short term. In Europe, large-scale land acquisitions in countries such as the Ukraine and Romania are considered safe business. This frequently leads to the displacement of family farmers and drives up prices for farmland, making it hard for small-scale and young farmers to obtain land. According to a recent study published by the non-profit organization GRAIN, growth in farmland deals has slowed since 2012 as many projects which appeared in the investment frenzy after 2008 have failed. However, the last few years have seen a spectacular rise in long-term farmland investments by institutional investors, such as pension funds. The researchers warn that gaining access to farmland is increasingly becoming part of a broader corporate strategy to profit from carbon markets, mineral resources, water resources, seeds, soil and environmental services.

"Better than gold"

"Buy land, they are not making it anymore," said Mark Twain already 150 years ago. In 2012, his compatriot Warren Buffett expressed it this way: "I will guarantee you that farmland, over a hundred years, is going to be gold." On the TV channel CNBC, the financial guru, who is investing millions of dollars in agriculture in Africa together with Bill Gates, explained the reasons: "If you buy an ounce of gold today and you hold it 100 years, you can go to it every day and you could – you could coo to it and you can caress it and you can fondle it and 100 years from now you'll have one ounce of gold and it won't have done anything for you in between. If you buy 100 acres of farmland, it will produce for you every year. You can use that money to buy more farmland; you can do all kinds of things. For 100 years it'll produce things for you and you still have 100 acres of farmland." Then, Mr Buffett gave another safe bet: "With land you can get somebody else to do all the work, give them a percentage of the crop and you can sit back there for a hundred years."

Source: CNBC

The map of global land deals



Reported area over 1 million hectares
Reported area between 500,000 and 1 million hectares
Reported area under 500,000 hectares

Large-scale land acquisitions (in 1,000 hectares)

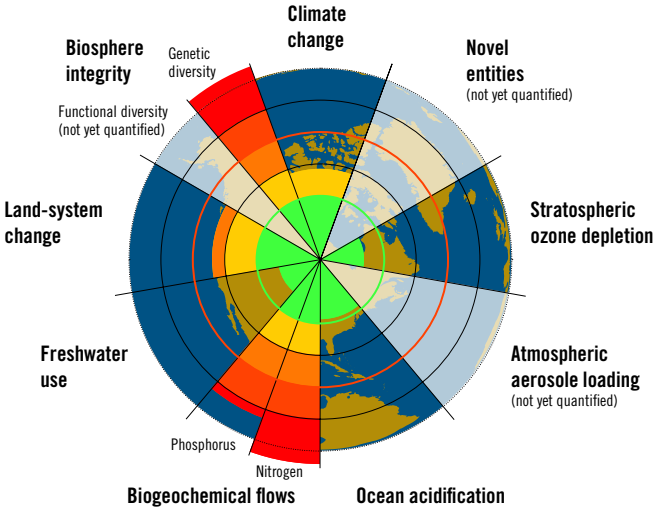
The land grabbing deals captured by the *Land Matrix* as of May 2016 cover a total area of 70 million hectares. The land is not only used for agricultural purposes, but also for forests (wood), energy and industry. The dataset lists both concluded deals (43 million hectares) and intended transactions (20 million hectares) for which information was publicly available. Intended acquisitions often fail (the *Land Matrix* lists almost 7 million hectares). The map presents a snapshot of the situation in 2016. It illustrates concluded deals in the main target countries, documenting the current regional focus for international investors and the dimensions of the land grabbing phenomenon to date.

Source: www.landmatrix.org (2016)

Multifunctionality

"Last but by no means least, agriculture ensures the delivery of a range of ecosystem services. In view of a globally sustainable form of development, the importance of this role may increase and become central for human survival on this planet." (Global, p. 15-16)

A safe operating space for humanity



The inner green shading represents the safe operating space for nine planetary systems. The red wedges show whether humanity is still living within these safe boundaries or, as in the case of four systems, has already exceeded them.

Source: Steffen, Rockström et al. (2015)

Agriculture produces more than just food and commodities. Since agriculture and forestry use more than 60 percent of the Earth's land surface, these economic sectors are crucial to the functioning of our ecosystems.

In 2009, a group of 29 scientists published a groundbreaking article in the journal Nature titled "A safe operating space for humanity" that was updated in 2015. The article tries to define the planetary boundaries for nine critical biophysical systems of the earth. According to the scientists, if humanity exceeds these safe thresholds, there will be a threat of abrupt or irreversible environmental changes. Just how much exactly the Earth system can endure before it collapses can be extensively discussed. However, the scientists argue that the safe operating space for four of the nine systems has already been clearly exceeded, namely in the area of climate change, land-system change, human interference with the biogeochemical cycles (phosphorus and nitrogen) and, in particular, the loss of biosphere integrity (biodiversity loss and species extinctions). The way we farm and produce our food is the decisive factor for these four boundaries as well as the rest of the nine crucial systems. According to the authors, "the relatively stable environment of the Holocene, the current interglacial period that began about 10,000 years ago, induced humans, for the first time, to invest in a major way in their natural environment rather than merely exploit it", namely to engage in farming and forestry. However, a new era has arisen since the beginning of the Industrial Revolution, the Anthropocene, in which human activities, a growing reliance on fossil fuels and industrialized forms of agriculture have become the main driver of global environmental change.

The IAASTD underlines the enormous environmental responsibility of agriculture reflecting the fact that over the past 50 years, we have been one-sidedly fixated with the aim of increasing efficiency and productivity. By doing so, we have lost sight of the fact that agricultural overproduction is seriously threatening the basis of our food supplies. Agriculture is the source of livelihoods for one third of the world's population and creates the social structure of rural areas. Not only are jobs closely linked to agriculture; the social cohesion of communities, their level of self-sufficiency and their resilience in times of crisis and disaster also depend largely on agriculture. After all, agriculture often produces a feeling of belonging and being at home. The beauty, peculiarity, flavor, history and tradition of regions and cultural landscapes form our identity and even our spiritual values. Hardly any civilization is conceivable without its particular farming and food culture. This enormous wealth of natural diversity, as well as land use and agriculture, contribute more than just food and agricultural products to the prosperity of society – or, in the case of negative changes, its impoverishment.

"Agriculture is multifunctional and goes far beyond food production. Other important functions for sustainable development include provision of nonfood products; provision of ecological services and environmental protection; advancement of livelihoods; economic development; creation of employment opportunities; food safety and nutritional quality; social stability; maintenance of culture and tradition and identity." (Global, p. 146)

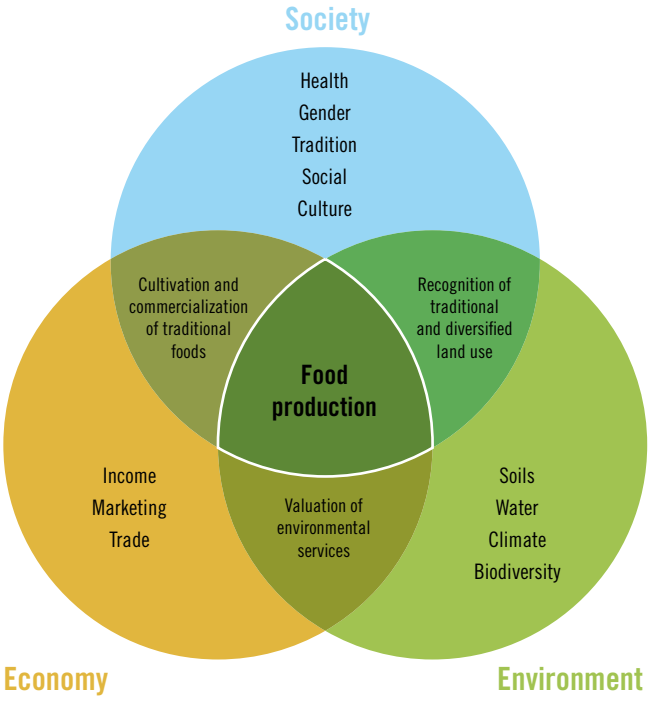
Agriculture: vital but "valueless"

According to the authors of the IAASTD, over the past decades, the multifunctionality of agriculture has frequently been ignored and neglected by politics, economics and science, but also by agricultural companies and farmers themselves. The only factors that seemed to count in agriculture were yield, price and economic efficiency of products. Development and agricultural policies, as well as research and technology, were exclusively determined by these criteria.

Beyond agricultural production, there are many vital services and goods that agriculture provides and maintains – or which agriculture neglects and destroys. These goods and services are of high value to communities, from the local level to the global community. Since they are not traded as a product, or at least only indirectly (e.g. tourism and health), the market does not determine a price defining their value.

Something that does not fetch a price is seen as not worth being produced or preserved. Things that are considered free are often recklessly used, and have little value attached to them. As these services are apparently free of charge, some of the most valuable services of agriculture are threatened by purely market-based logic of cost considerations. If the destruction of the environment, as well as of landscapes and rural communities, is made more difficult, and thus becomes a cost factor, companies often relocate production and jobs. Environmental and social dumping can therefore become a competitive advantage on the world market.

The multifunctionality of agriculture



Source: Synthesis, p. 19

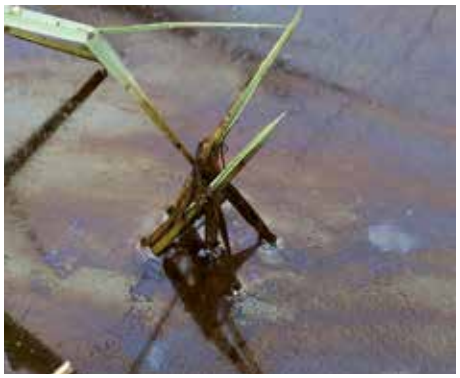
Public money for public goods

In recent times, however, science and politics have begun to recognize the multifunctionality of agriculture, especially from an ecological point of view. The EU Member States and other industrialized countries are starting to take the diverse role of agriculture more into account, particularly in areas such as law, the granting of subsidies and research. During the last EU agricultural reform, civil society organizations campaigned for a greener and fairer agricultural policy under the slogan "Public money for public goods". The use of the term multifunctionality has however been controversial and contested within the World Trade Organization (WTO). Governments of the export-oriented countries in North and South America suspect it could lead to "market-distortion". Companies and proponents of free-market theories largely oppose interventions on behalf of the protection of public goods and interests.

"Ecosystem services remain largely unpriced by the market. These services include climate regulation, water provision, waste treatment capacity, nutrient management, watershed functions and others. Payments for environmental services (PES) reward the ecosystem services provided by sustainable agriculture practices. PES is a policy approach that recognizes the multifunctionality of agriculture and creates mechanisms to value and pay for these benefits." (Global, p. 462)

In many developing countries, as well as in industrial countries, short-term economic constraints and long-term sustainability goals seem often incompatible with one another. This applies to particular businesses, individual households and communities, as well as to macroeconomic decisions. Hardship, the

"While many households are aware that their decision-making is short term, the severe cost of hunger makes long-term considerations of benefits of natural resources irrelevant to them." (Global, p. 36)



SDG 15, target 9, a and b:
By 2020, integrate ecosystem and biodiversity values into national and local planning, development processes, poverty reduction strategies and accounts
Mobilize and significantly increase financial resources from all sources to conserve and sustainably use biodiversity and ecosystems
Mobilize significant resources from all sources and at all levels to finance sustainable forest management and provide adequate incentives to developing countries to advance such management

fear of losing one's livelihood or pressure of competition frequently lead to ecologically and socially destructive decisions and behavior. The environmental and social services of agriculture could be promoted by giving them a market price and by paying for them. In addition, legal provisions and prohibitions at state and municipal level could help. The IAASTD gives examples for both options. They can perfectly complement each other but have to be assessed with regard to their effectiveness.

Multifunctionality as an opportunity

For highly specialized scientists, the concept of economic, ecological, social and cultural multifunctionality is an unusual challenge. Farmers and their communities could offer them guidance making use of their local and traditional knowledge, and their wealth of experience. For generations, it has been farmers' core business to think and decide in a multifunctional way and to compare, in a pinch, also apples and oranges.
Human history contains many successful examples of how civilizations have sustainably shaped multifunctionality in exchange with nature – as well as examples of how they collapsed through failure to do so. Today, our globally interconnected society possesses a larger wealth of experience and knowledge than any other civilization before in order to meet the challenges ahead. However, it is also the first time that a real risk of global failure exists. To effectively face this risk, we must adapt our modes of behavior timely, diversely and simultaneously in as many places as possible. The multifunctionality of agriculture and food cannot be reduced to single aspects such as justice, hunger, health, resource conservation, or the protection of climate and species. Multifunctionality requires the high art of balancing all of these aspects in a constant exchange with all stakeholders.

"Successfully meeting development and sustainability goals and responding to new priorities and changing circumstances would require a fundamental shift in science, technology, policies, institutions, capacity development and investment. Such a shift would recognize and give increased importance to the multifunctionality of agriculture, accounting for the complexity of agricultural systems within diverse social and ecological contexts. (…) It would also recognize farming communities, farm households, and farmers as producers and managers of ecosystems. This shift may call for changing the incentive systems for all actors along the value chain to internalize as many externalities as possible." (Synthesis, p. 4)

Managing land and water use together: nomadic herdsmen and farmers in Niger


Meeting of members of a well committee

In the Sahelian country of Niger, the rural population comprises of sedentary farmers and nomadic herdsmen. During the dry season, the nomads used to travel several hundred kilometers with their herds from the northern region to the farming areas in the south, where their cattle could graze on the harvested fields. With the onset of the rainy season, the herdsmen would then head back so that the farmers could cultivate their land again. However, recurrent droughts and a rapidly growing population have caused these once complementary systems to increasingly come into conflict. Due to the mounting pressure on natural resources, farmers no longer keep cattle routes clear and have started using land that was previously reserved as a grazing area for the livestock. As a result, the herdsmen feel compelled to drive their cattle over the arable land.
In 1993, the government of Niger passed the *Rural Code* to prevent land conflicts between the different groups. It is a framework law that regulates land use rights for the local rural population and, at the same time, secures space for livestock farming. In the beginning, implementation was slow but in recent years it has gained momentum: The establishment of land commissions at all administrative levels, an essential element of the law, has today become an important instrument for jointly managing and administering land and water use by involving all parties concerned. The commissions, which are comprised of representatives from government as well as the different user groups, certify land use rights, control the legitimate use of resources and mediate in the case of land conflicts. This has ensured legal certainty for the rural population.
A successful approach to settling conflicts is the establishment of clearly marked cattle corridors. In the department of Mayayi in the south of the country, for example, about 450 kilometers of corridors for the cattle herds were established and secured step by step between 2011 and 2015. These corridors are defined in a broad participatory consultation process and are demarcated with boundary posts and live hedges.
Access to water also leads to repeated conflicts between sedentary farmers and nomadic herdsmen. To ease the situation, wells were built along the corridors and are managed by competent committees consisting of all relevant actors. **bit.ly/HEKSNiger**

"Conflicts between nomadic herdsmen and sedentary farmers have occurred for thousands of years. (...) The development of living fences/hedges to protect valuable food crops and regenerating trees has the potential to enhance production for the sedentary farmers, however if the nomads' need for continued access to wells, watering holes and dry season fodder is not managed at a regional scale, it may lead to worsened conflict. In this situation, effective integration of crop and livestock systems has to make provision for alternative sources of dry season fodder (e.g., fodder banks), and corridors to watering holes and grazing lands. Participatory approaches to decision making can avoid such conflicts between sedentary and nomadic herdsmen." (Global, p. 177).

Industrial Agriculture and Small-scale Farming

"Industrial Agriculture: Form of agriculture that is capital-intensive, substituting machinery and purchased inputs for human and animal labor." (Global, p. 563-564)

Even today, agriculture is an important source of income and the world's largest business. One-third of the economically active population obtains its livelihood from agriculture. In Asia and Africa, millions of small-scale and subsistence farmers, pastoralists, fishermen and indigenous peoples produce most of the food consumed worldwide, in most cases on very small plots of land.

Over the past decades, agricultural policy and international institutions, as well as private and public agricultural research have often considered small-scale and subsistence farmers as backward "phase-out models" of a pre-industrial form of production. For more than 50 years, "grow or die" has been both the capitalist and socialist principle for progress, with just a few exceptions. The widely held belief was that only large economic units were capable of achieving increases in productivity on a competitive basis through modern and rationalized cultivation methods, mainly with chemical inputs and the use of machinery. A global increase in productivity was considered necessary to feed a rapidly growing world population.

The agricultural treadmill

"Agricultural treadmill: (...) Farmers who adopt early use of a technology that is more productive or less costly than the prevailing state-of-the-art technology, i.e., when prices have not as yet decreased as a result of increased efficiency, capture a windfall profit. When others begin to use the new technology, total production increases and prices start to fall. Farmers who have not yet adopted the technology or practice experience a price squeeze: their incomes decrease even if they work as hard as before." (Global, p. 73)

The IAASTD describes this development model of industrialized nations as the "agricultural treadmill". It is based on technological advances achieved through mechanization, plant breeding for high-yielding varieties, the use of agrochemicals and genetic engineering, etc. With increasing external inputs, the unit costs of production are declining and the productivity per worker is increasing. Production is growing and producer prices are falling. The only businesses that can survive on the market are those that remain one step ahead of their competitors by investing in rationalization and expansion, or those with locational advantages. If others catch up with them, another round begins. An end to this treadmill is not in sight: The more global the market, the higher the speed and the more incalculable the game becomes for each participant.

The IAASTD calls into question the idea that this universal principle of technological progress in a free-market economy is the ideal concept for sustainable food production and agriculture. Firstly, fertile soils – the most important basis of agriculture and a resource that can rarely be multiplied – are seldom distributed fairly. Almost nowhere in the world does access to land follow classical market rules of supply and demand. The distribution of soils is shaped by the historical legacy of feudalism, colonialism and patriarchal inheritance rights and has always been the result of very particular machinations and struggles for power that are rarely transparent, fair and non-violent. Secondly, agriculture in many regions of the world depends on massive public interventions and subsidies that frequently pursue short-term macroeconomic goals, such as low food prices, as well as geostrategic interests. A particular country's capability of supplying its own population with food in the event of war and conflict, but also the threat of putting a halt to food exports, is still part and parcel of the classical arsenal of many countries' power politics globally.

SDG 2, target 3:
By 2030, double the agricultural productivity and incomes of small-scale food producers, in particular women, indigenous peoples, family farmers, pastoralists and fishers, including through secure and equal access to land, other productive resources and inputs, knowledge, financial services, markets and opportunities for value addition and non-farm employment

Subsidies for certain agricultural commodities, producers, forms of production and exports are mainly paid in industrialized countries. It is predominantly large agricultural corporations and big trade and processing companies that profit from these subsidies. Worldwide, direct and indirect subsidies have a profound influence on production costs and prices of agricultural commodities. The Organization for Economic Co-operation and Development (OECD) estimates that in 2014, public agricultural subsidies in OECD countries amounted to 332 billion dollars.

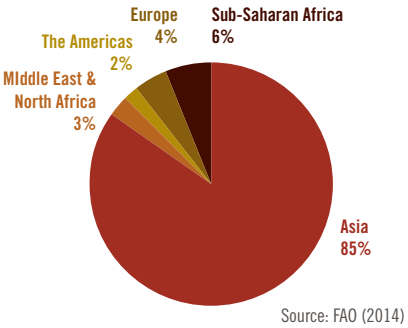
"Small-scale diversified farming is responsible for the lion's share of agriculture globally. While productivity increases may be achieved faster in high input, large scale, specialized farming systems, greatest scope for improving livelihood and equity exist in small-scale, diversified production systems in developing countries. This small-scale farming sector is highly dynamic, and has been responding readily to changes in natural and socioeconomic circumstances through shifts in their production portfolio, and specifically to increased demand by increasing aggregate farm output." (Global, p. 379)

The end of industrial productivism

In general, the large-scale industrialization of agriculture in North and South America, Australia and Europe and the "Green Revolution" in Asia have led to impressive successes in increasing productivity and rationalization over the past fifty years. The increase in global agricultural production has outstripped population growth. According to different estimates, the current production could feed 10 to 14 billion people if it was used exclusively and as efficiently as possible as food.

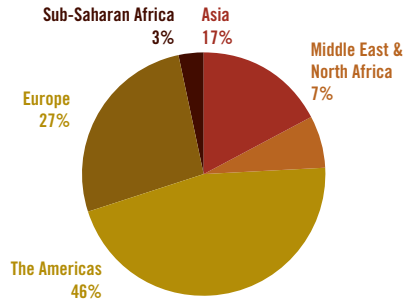
However, the one-sided focus on productivity of industrial agriculture exploits the available natural resources of our planet to an untenable and unsustainable extent. The basic strategy to replace human labor with farm machinery, agrochemicals and fossil energy is a dead end in times of climate change, dwindling oil reserves and overexploited natural resources. We have exaggerated the problem with the concept of producing huge amounts of meat and agricultural commodities in highly rationalized monocultures and from just a few standardized high-yielding crop varieties that then are processed into the apparent product variety we are used to seeing in our supermarkets. Industrial agriculture consumes large amounts of pesticides, mineral fertilizers, energy and freshwater resources and produces large volumes of greenhouse gas emissions. The ecological costs of these advances include depleted and salt-affected soils, deforestation and the contamination of entire bodies of water, as well as an unprecedented loss of biodiversity. This especially affects those whose livelihoods depend on natural resources. Despite its overproduction, the industrial model of globalized agriculture is incapable of satisfying the basic needs of currently seven billion people for sufficient and nutritious food. At the same time, it has substantially contributed to modern forms of obesity and malnutrition. It promotes a flourishing industrial production of so-called cash crops. Instead of growing food for the malnourished and impoverished local population, these cash crops are grown for the world market. Among the social costs of globalized agricultural production are hunger, malnutrition and water scarcity, together with growing inequality, violent conflicts over land and other scarce resources, the economic and cultural erosion of rural communities and entire regions, as well as displacement of people and rural exodus.

Global distribution of farms below 10 hectares



Source: FAO (2014)

Global distribution of farms over 10 hectares

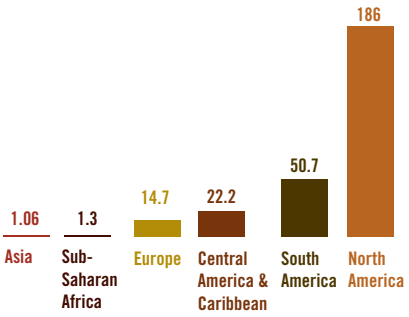


Source: FAO (2014)

Challenges of post-industrial agriculture

The IAASTD clearly debunks the myth that industrial agriculture is superior to small-scale farming in economic, social and ecological terms. The report argues for a new paradigm for agriculture in the 21st century that recognizes the pivotal role small-scale farmers play in feeding the world population. Small-scale, labor-intensive structures that focus on diversity can guarantee a form of food supply that is socially, economically and environmentally sustainable and that is based on resilient cultivation and distribution systems.

Average farm size in hectares



Source: IFAD (2010)

Approximately 2.5 billion people, almost 34 percent of the world's population, depend on agriculture for their livelihood. Almost 46 percent of the world population lives in rural areas. Of the 570 million farms worldwide, 83 percent are smallholders who cultivate plots of land no bigger than 2 hectares and 97 percent farm less than 10 hectares. It is these small farms however that produce the largest amounts of food (in Asia and Africa around 80 percent) and cultivate around 60 percent of the arable land worldwide – often soils that are less fertile and insufficiently irrigated. Although the percentage of small farmers relative to the world population is getting smaller, their absolute number is increasing in Asia. The average farm size in Asia and Africa is decreasing, whereas farms are getting bigger in Europe and North America.

In Latin America, the average numbers disguise the extremely sharp contrast between a few huge operations that are engaged in one of the most industrialized forms of agriculture worldwide, and a large number of small-scale farmers with less than two hectares of land. In Argentina, for example, the average farm size is 582 hectares; in Guatemala, the average size is 4.5 hectares. In North America and Europe, these calculations also disguise small farms whose owners can no longer make a living from agriculture.

However, the IAASTD is far from romanticizing the current form of small-scale and traditional agriculture, or calling for a return to pre-industrial conditions. It offers a clear and detailed description of the problems small-scale farmers frequently face in terms of productivity and efficiency, as well as the practices they use which are hazardous to human health and the environment. Both loss of traditional knowledge and lack of up-to-date knowledge are contributing to the misery of many smallholder families and subsistence farmers. Many traditional methods of production no longer offer a sustainable perspective. The challenges of the future can only be met with enormous boosts in innovation and with qualified farmers.

Food efficiency instead of increased surplus value

For this reason, the IAASTD considers investment in smallholder production the most urgent, and a secure and promising means of combating hunger and malnutrition, while at the same time minimizing the ecological impact of agricultural practices. Improved methods of cultivation, mostly simple technologies and basic knowledge, more adequate seeds and a large number of agroecological strategies all provide huge potential for boosting productivity in a sustainable way. They are more likely to make sure that the additional amounts of food produced are actually available where they are needed most.

If small-scale farmers have sufficient access to land, water, credit and equipment, the productivity per hectare and per unit of energy use is much higher than in large intensive farming systems. In general, smallholder production requires considerably fewer external inputs and causes minor damages to the environment. Small farms are more flexible and better at adapting to local and changing conditions. As small-scale farming is more labor-intensive, it also enables more people in rural areas to make a living.

"Though the productivity per unit of land and per unit of energy use is much higher in these small and diversified farms than the large intensive farming systems in irrigated areas, they continue to be neglected by formal Agricultural Knowledge, Science and Technology." (Synthesis, p. 22)

The preconditions for this are comprised of a minimum of legal certainty, sufficient income and an infrastructure that is tailored to their needs: wells, streets, public health care, access to education and agricultural extension, as well as means of communication. Moreover, in areas where small-scale farmers could produce more, this often does not happen due to a lack of basic storage and transport facilities, as well as access to local and regional markets that would make such efforts rewarding. Fair credit conditions for basic investment and insurances when crops fail could contribute to make their risks more manageable.

However, public investment in rural development in many developing countries, especially Africa and the least industrialized regions of Asia, has been severely neglected over the past 30 years. Private investment has been made in just a few export-oriented areas, which are often also the focus of national and international support programs. The IAASTD describes this as a fatal global trend towards a decapitalization of small-scale farmers, which must be urgently reversed.

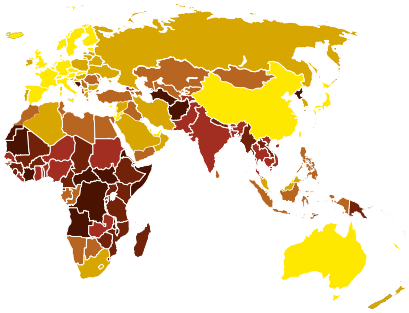
"Grow or die" is no longer modern

The IAASTD made the case for supporting small-scale farmers, questioning for the first time the agricultural paradigm "grow or die" of past decades. In recent years, many national and international development organizations and agencies have taken up this plea to invest in smallholders, at least in their publications and declarations of intent. The United Nations even declared 2014 the International Year of Family Farming. With Sustainable Development Goal 2, UN nations committed themselves to doubling the agricultural productivity and incomes of small-scale food producers by 2030, including through secure and equal access to land, other productive resources and inputs.

In practice, however, small-scale farmers are "difficult customers" for global players; efforts and expenses are higher for investing in smaller units of production. It does not always prove effective to delegate the administration of programs and funds to national or regional authorities since the disregard for small-scale farmers is often deeply rooted, especially in the cities. Ministries of agriculture in the EU and other industrialized countries also seem to consider the IAASTD's message as purely related to development policy. According to their reading, small-scale farming structures may be an effective means for fighting hunger in the poor countries of the Global South. The modern, "knowledge-based bio-economies" of industrialized nations, on the other hand, requires the continued "structural adjustment". Between 2003 and 2013, more than one-fourth of all farmers in the EU simply gave up. The most recent reform of EU agricultural policy for the period 2014 to 2020 is only likely to further reinforce this trend.

Employment in agriculture

Agricultural employment as share of total employment in percent 2011-2015



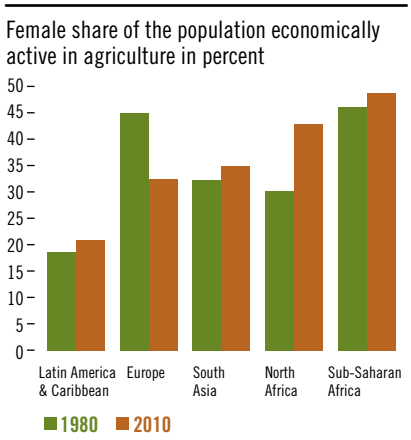
The regions where most of the world's people live correspond to the areas where the majority of the population is employed in agriculture. In North America, the map would be colored in a bright yellow, Latin America would in some parts be bright yellow and in others dark yellow. In Bolivia, for example, 32 percent of the employed population is working in agriculture while it is only one percent in Argentina. Self-employed work is covered differently in statistics, especially the unpaid work of women in agriculture. If this kind of work was properly considered in employment statistics everywhere, some of the countries colored in light red would become dark red.

Source: World Bank (2016)

The Female Face of Farming

"Most women in sub-Saharan Africa bear multiple responsibilities: producing food; weeding and harvesting on men's fields; post-harvest processing; providing fuelwood and water; and maintaining the household. The burden on rural women is increasing as population growth outpaces the evolution and adoption of agricultural technology and as growing numbers of men leave farms for urban jobs." (Sub-Saharan Africa, p. 52)

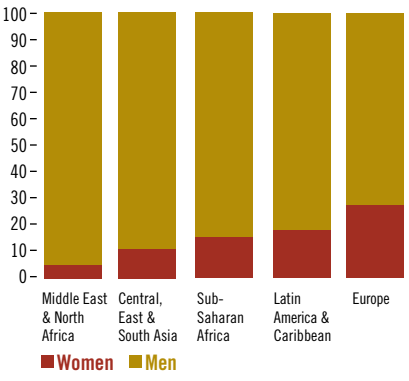
Female share of agricultural labor force



Source: FAO (2011)

The share of women in the agricultural labor force is on the rise except in Europe. However, the share of female land owners is very low at global level. Average figures for regions often disguise large differences between countries.

Share of female agricultural holders



Source: FAO (2015b)

Although the IAASTD firmly warns us against hoping for any kind of 'silver bullet' solutions, it leaves no doubt that respecting the basic rights of women, especially in rural areas in Asia and Africa, is by far the most effective means of fighting hunger and poverty sustainably. This ranges from the fundamental right to bodily integrity, to the freedom to choose when or if to marry and to have children. Whether women can exercise their right to learn to read and write, to own land, to have access to water, livestock and machinery; or whether they are allowed to open a bank account or take a loan can be a decisive factor in women's chances of being able to provide for themselves and their families. If women have the opportunity to self-organize and take part in decision-making, the whole community will benefit.

However, women and girls are still discriminated against. Women account for 70 percent of the world's hungry and are disproportionately affected by malnutrition and food insecurity. When food is scarce, female family members often get the smallest portions. Pregnant and lactating women are most vulnerable to malnutrition. The responsibility for their children's survival often requires additional sacrifices from them. In the labor market, women are often literally paid starvation wages.

In Africa and in many parts of Asia, women in rural areas not only have to take care of children and elderly, they also constitute the majority of the agricultural labor force in small-scale and subsistence farming. Female farmers are responsible for cultivating, plowing and harvesting more than 50 percent of the world's food. In sub-Saharan Africa and the Caribbean, they produce up to 80 percent of basic foodstuffs. Official statistics do not record unpaid work, be it in the garden, in the field or in the household, and thus insufficiently represent women's actual work load.

The feminization of agriculture

The number of female-headed households is increasing as a result of civil wars, AIDS and the migration of men to cities searching for paid work. The IAASTD describes this as 'the feminization of agriculture', which is having profound and far-reaching effects, both positive and negative in nature. Leading priorities of future development policies must therefore include offering qualification opportunities, extension services and agricultural training to women. In order to make this a reality, the number of women in agricultural extension and research needs to be increased, initially. Worldwide, only five percent of all extension resources are directed at women farmers, and only 15 percent of extension workers are female.

The industrialization of agriculture mainly falls within typically male areas of decision-making, including the economic risks involved. These areas include the competitive use of machinery, agrochemicals and high-yielding plant varieties; the cultivation of cash crops and the breeding of large livestock for supra-regional markets. Men's involvement in these often risky activities have in the past decades brought about ruin for many farmers, forcing them to migrate to the slums of the cities and causing many to commit suicide out of desperation. By contrast, women tend to be more cooperative and cautious, and try to minimize risks in food production, processing and supply, opting instead for social self-help and preventive health care. Men's forms of farming practices geared toward national and international markets therefore often undermine female domains and competences. Women frequently provide their families with food, from diversified cultivation of vegetables, fruits, tubers and herbs in their gardens, as well as from the rearing of small livestock. These kind of simplistic characterizations do no justice to the complex gender relationships that differ according to region, history and culture. However, they do show some basic lines of future development, in which the IAASTD recognizes maybe the biggest potential for innovation in order to achieve its goals of sustainability and development.

"The feminization of agriculture model in the region is determined by two major factors. First, women have much poorer access to and control over productive resources and they have inadequate access to public services, such as training, extension and credit. Technologies are often designed for irrigated land in favorable areas where male farmers predominate, with poor farmers, mainly women, lacking access to credit and appropriate technologies. Second, rural society structure makes it difficult for all members of the household to migrate, since cities have even more limited resources for masses of asset-poor (...). Women constitute the majority of this group and when men leave to become temporary laborers in cities, they are left behind to take care of the land, children and elderly. Thus, they have the compounded burden of productive and reproductive work." (East and South Asia and the Pacific, p. 180)

The chances of escaping hunger and misery disproportionately increase if women become empowered in small-scale agriculture and regional development systems oriented primarily towards local markets and supply, and where agricultural production of export and non-food crops is only a secondary possibility to achieve additional income. The FAO estimates that women comprise, on average, 43 percent of the agricultural labor force in developing countries. However, only 13 percent of agricultural land holders worldwide are female. If women had equal access to productive resources, they could increase yields on their farms by 20 to 30 percent. This could raise total agricultural output in developing countries by 2.5 to 4 percent, reducing the global number of undernourished people by as much as 150 million.

"Microfinance reaches over 10 million members of savings and credit groups in the region, nearly 90% of whom are women. (...) The rise of women's Self-Help Groups (SHGs) or women's microcredit and microfinance groups (...) has made women's income a permanent component of household income and weakened patriarchal gender relations. (...) In India, SHGs have gone beyond savings and individual loans to take up management of community-based projects, contracting to construct minor irrigation works or undertake soil conservation. Unlike men's groups doing the same tasks, they have saved considerable amounts of capital and used their savings to invest in tractors and other forms of mechanization." (East and South Asia and the Pacific, p. 181)

Everywhere, women are impressively demonstrating that they are willing and able to use their skills and growing self-determination in order to directly increase social prosperity and to preserve natural resources. Back in 2008, the clear IAASTD message that women can make the decisive difference was not a new insight. In contrast to other messages, however, it fell on fertile ground. The World Bank, the FAO and public and private development organizations, but also a growing number of governments and institutions, have today taken up the issue of gender mainstreaming in their programs and activities.

SDG 5, target 5a:
Undertake reforms to give women equal rights to economic resources, as well as access to ownership and control over land and other forms of property, financial services, inheritance and natural resources, in accordance with national laws

The UN Sustainable Development Goals also focus on ending all forms of discrimination against women and girls everywhere, giving women equal rights to economic resources and addressing their nutritional needs. Although successes in the fight against gender inequality are often being achieved at a snail's pace, they are observable in many parts of the world.

"Small-scale farmers, particularly women, play a key role in promoting sustainable methods of farming based on traditional knowledge and practices. Women often possess knowledge of the value and use of local plant and animal resources for nutrition, health and income in their roles as family caretakers, plant gatherers, home gardeners, herbalists, seed custodians and informal plant breeders. Moreover, women often experiment with and adapt indigenous species and thus become experts in plant genetic resources." (Synthesis, p. 78)

Training small-scale women farmers in Kenya: escaping poverty within four years


Growing food with little space: bag garden

In Kenya, 70 percent of the population make their living from agriculture, cultivating the commonly barren soils of the country. Most of them are small-scale farming families with two to three hectares of land. More than one fifth of the population is still undernourished. In 1993, with the aim of improving food security in rural areas, Kenyan agronomist Ngugi Mutura founded the NGO Sustainable Agriculture Development Program (SACDEP) and established a training program for small-scale women farmers. It combines organic farming, the breeding of locally adapted seeds and water management with small animal husbandry and the use of renewable energy, as well as self-managed microcredit systems.

The point of departure is always a comprehensive analysis which focuses on which resources are available in the different local farming communities and how these could best be used and increased without high investment costs. Self-help groups of 30 to 40 people, 80 percent of whom are women, receive four years of training in organic farming on their plots of land. The training covers techniques such as composting and the production of natural plant protection. To get started, each group is taught how to construct water tanks and how to finance this through saving and lending groups. The groups also receive milk goats and small livestock. Together the women decide who will first get animals; the offspring is then passed on to the next group members. "Open field days" encourage a regular exchange of know-how between the women farmers, with expert farmers opening their farms for visitors and sharing their experience. As a part of the SACDEP training, so-called "Practicing Skills Facilitators" (PSFs) are defined as contact persons who are available in the field for any questions regarding cultivation. These field days and the training through PSFs are recognized as a successful approach to knowledge dissemination.

In 2015, a scientific evaluation praised the success of the program in reducing poverty and achieving equal opportunities for women. Since 1993, SACDEP has reached 55,000 families in six regions of Kenya. Today, thanks to their diversified farms, the farmers are both food secure and independent. The families have sufficient quantities of their own seeds for up to three sowings per year, enough to survive if droughts destroy a harvest. Based on 20 years of experience, SACDEP has developed a training program for organic, small-scale farming, which will also be taught at the first college for organic farming in East Africa which is currently being built up in Thika, 40 kilometers north of Nairobi.

bit.ly/SACDEP


Women farmers meet at a congress

The Five IAASTD Regions

The IAASTD not only consists of the global report; it also comprises five regional reports accounting for the special characteristics of the different world regions.

North America and Europe
(including Russia) still dominate the global trade in agricultural commodities as well as in the scientific, economic and political debate. With the exception of some regions in southern and Eastern Europe, food production is characterized by highly rationalized systems of industrial agriculture. The consumer societies of North America and the European Union are destroying and depleting more resources per person than any other region in the world and have imposed their model on the rest of the world. Together, these two regions account for the largest share of the global area of arable land.

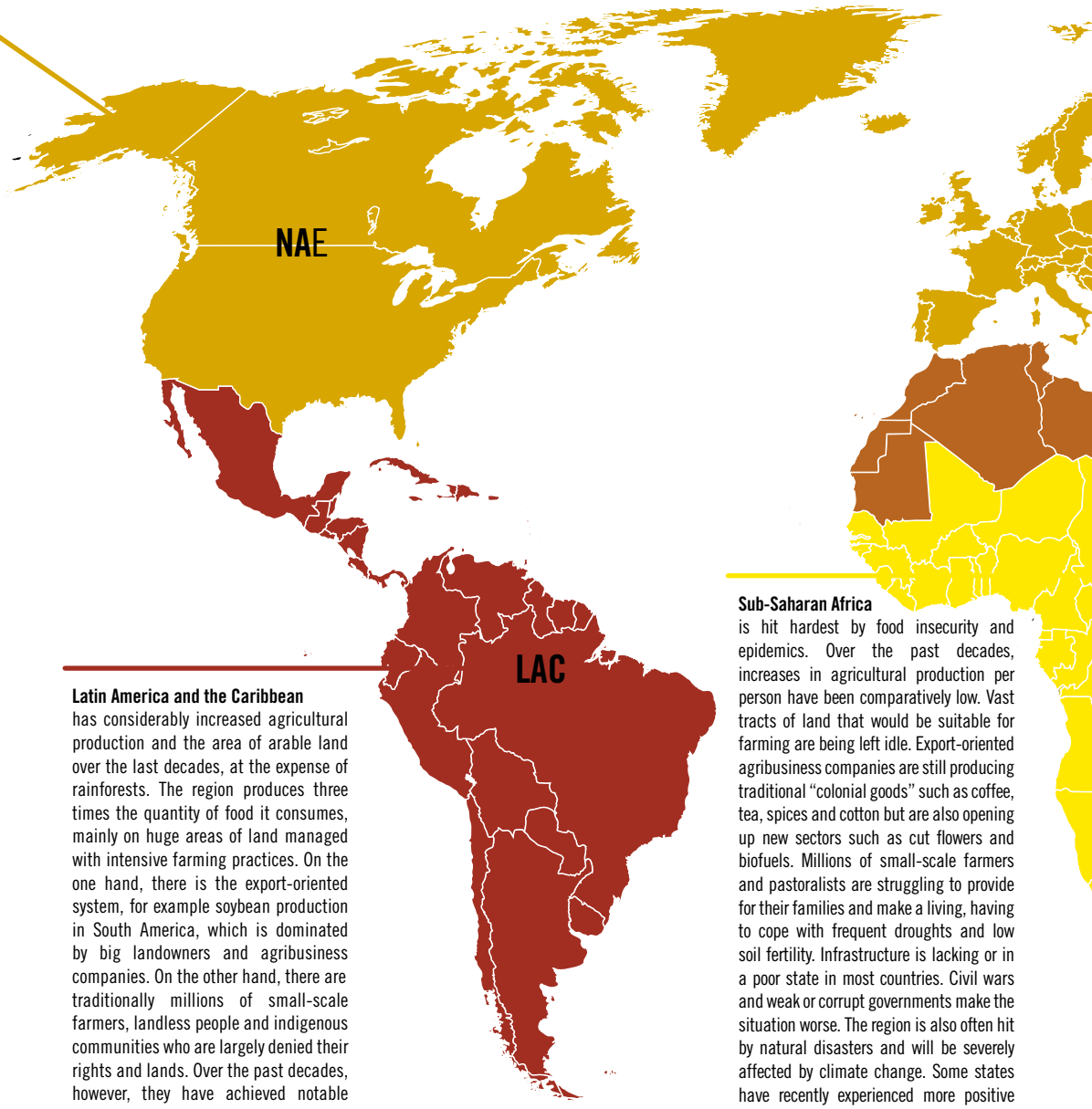
North America:

352 m / 4.9%

1.6%

500 m tons/1,419 kg per capita

471 m ha
42.0% 56.4% 1.6%



Latin America and the Caribbean
has considerably increased agricultural production and the area of arable land over the last decades, at the expense of rainforests. The region produces three times the quantity of food it consumes, mainly on huge areas of land managed with intensive farming practices. On the one hand, there is the export-oriented system, for example soybean production in South America, which is dominated by big landowners and agribusiness companies. On the other hand, there are traditionally millions of small-scale farmers, landless people and indigenous communities who are largely denied their rights and lands. Over the past decades, however, they have achieved notable political visibility in many countries by organizing themselves and defending their rights.

621 m / 8.7%

15.0%

218 m tons / 352 kg per capita

755 m ha
22.8% 74.5% 2.7%

Sub-Saharan Africa
is hit hardest by food insecurity and epidemics. Over the past decades, increases in agricultural production per person have been comparatively low. Vast tracts of land that would be suitable for farming are being left idle. Export-oriented agribusiness companies are still producing traditional "colonial goods" such as coffee, tea, spices and cotton but are also opening up new sectors such as cut flowers and biofuels. Millions of small-scale farmers and pastoralists are struggling to provide for their families and make a living, having to cope with frequent droughts and low soil fertility. Infrastructure is lacking or in a poor state in most countries. Civil wars and weak or corrupt governments make the situation worse. The region is also often hit by natural disasters and will be severely affected by climate change. Some states have recently experienced more positive political and economic developments, giving some rise to hope for change in the future.

884 m / 12.4%

54.5%

120 m tons / 136 kg per capita

843 m ha
22.5% 74.2% 3.3%

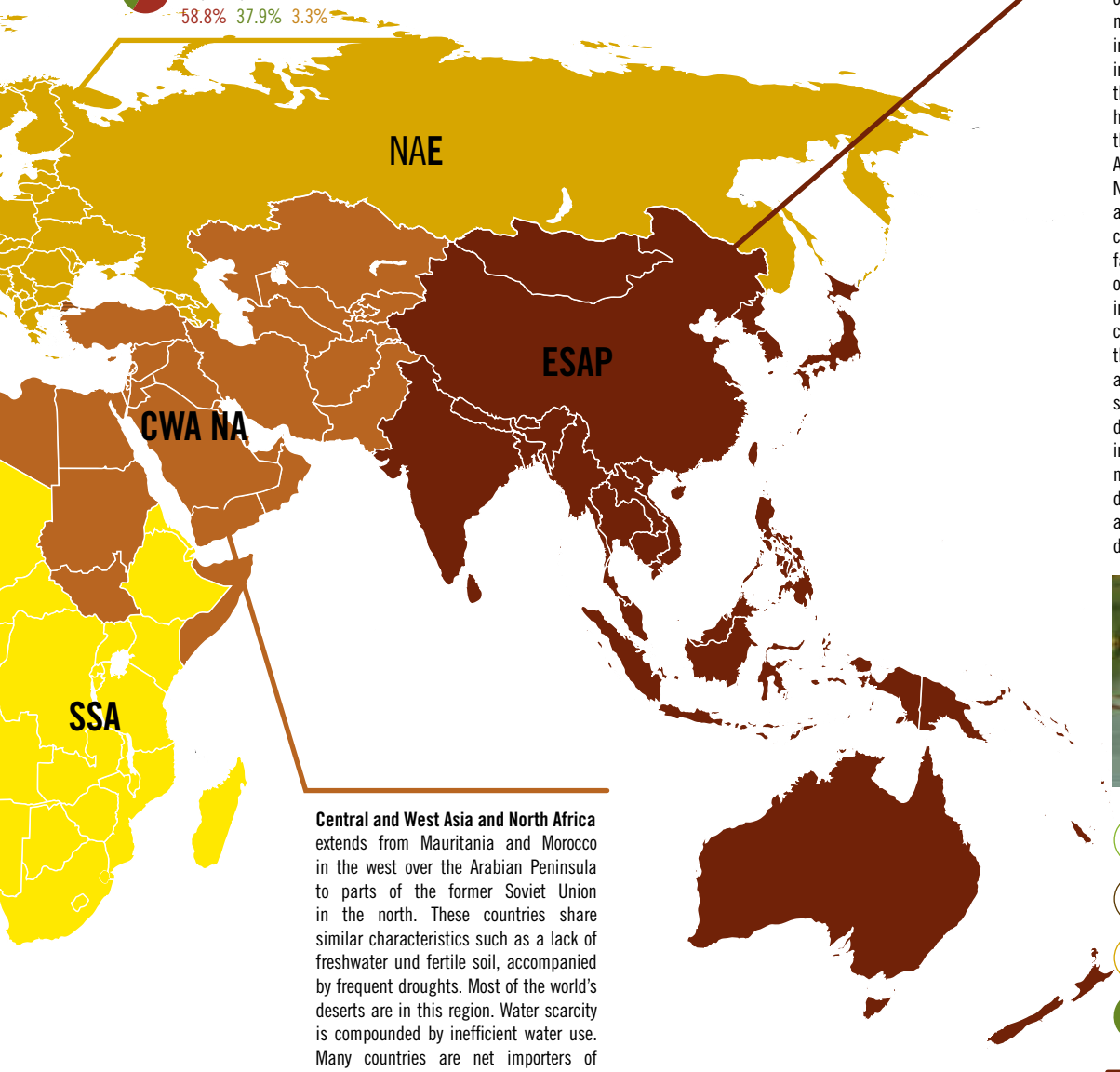
Europe:

750 m / 10.5%

5.5%

485 m tons / 647 kg per capita

473 m ha
58.8% 37.9% 3.3%



East and South Asia and the Pacific is the most densely populated region of the world. Over the past decades, many Asian countries have enormously increased agricultural production through intensification and irrigation. Although the share of the population suffering from hunger has decreased significantly, two thirds of the world's hungry still live in Asia. With the exception of Australia and New Zealand, small farms characterize agriculture in Asia and Pacific Island countries where 80 percent of the world's farmers live. The rapid industrial growth of the region over the past decades has influenced the world economy. Changes in consumer lifestyles, particularly among the rapidly growing urban population, are challenging some countries' self-sufficiency in food production. China's demand for animal feed for its livestock industry is transforming global commodity markets. Climate change could have devastating impacts and amplify the already existing high incidence of natural disasters.

3,709 m / 52.0%

48.6%

1,009 m tons / 272 kg per capita

1,374 m ha
29.1% 65.2% 5.7%

Central and West Asia and North Africa extends from Mauritania and Morocco in the west over the Arabian Peninsula to parts of the former Soviet Union in the north. These countries share similar characteristics such as a lack of freshwater und fertile soil, accompanied by frequent droughts. Most of the world's deserts are in this region. Water scarcity is compounded by inefficient water use. Many countries are net importers of food, especially cereals. The semi-arid zones are home to pastoral groups which depend on livestock for subsistence. The region holds some of the world's largest oil and gas reserves.

820 m / 11.5%

26.6%

173 m tons / 211 kg per capita

983 m ha
17.3% 81.1% 1.6%

Explanations:

Population in million people / Share of world population

Share of population whose livelihood depends on agriculture

Cereal production in million tons / Cereal production in kilograms per capita

Total agricultural area in million hectares
Arable Land Meadows and pastures
Permanent crops

All data refers to the year 2013

Source: FAOSTAT

Agroecology

"It is this continuing indigenous capacity for place-based innovation that has been almost entirely responsible for the initial bringing together of the science, knowledge and technology arrangements for what have become over time certified systems of agroecological farming such as organic farming (...) and variants such as permaculture. Systems such as these are knowledge-intensive, tend to use less or no externally supplied synthetic inputs and seek to generate healthy soils and crops through sustainable management of agroecological cycles within the farm or by exchange among neighboring farms. (...)
Recent comprehensive assessments conclude that although these systems have limitations, better use of local resources in small scale agriculture can improve productivity and generate worthwhile innovations and agroecological/organic farming can achieve high production efficiencies on a per area basis and high energy use efficiencies and that on both these criteria they may outperform conventional industrial farming. Despite having lower labor efficiencies than (highly mechanized) industrial farming and experiencing variable economic efficiency, latest calculations indicate a capability of producing enough food on a per capita basis to provide between 2,640 to 4,380 kilocalories/per person/per day (depending on the model used) to the current world population. Their higher labor demand compared to conventional farming can be considered an advantage where few alternative employment opportunities exist." (Global, p. 67)

Agroforestry in Indonesia

Since its origins 10,000 years ago, agriculture has always adapted to its respective environmental conditions. It is only in the past 100 years that the development and use of fossil energy sources allowed one part of the world's population to replace existing practices, which involved careful interaction with nature, with the use of machinery and modern chemicals. Over the past 60 years, this has led to an unprecedented global transformation and exploitation of natural habitats, along with regional agricultural and food systems. Today the consequences of this have become a central problem for humanity.

It may seem absurd to millions of farmers in developing countries that agroecology – the adaptation of agriculture to natural conditions and cycles, as well as to local needs – is treated like a new science, a social movement or even as a "romantic niche". These farmers' daily bread depends on whether they use the locally available resources optimally to be able to make a living. They measure the efficiency and sustainability of their cultivation systems in terms of the edible yield of their plots of land, as well as the ability to cope with natural disasters and crop failure. Since the 1980s, agroecology as a scientific discipline, practical skill and economic concept for success has received growing support worldwide. The IAASTD attributes a crucial role to agroecology in shaping the future of sustainable agriculture, demonstrating that it has now arrived at the heart of scientific and political debates.

Agroecological approaches

Agroecological concepts are primarily based on traditional and local knowledge and the corresponding cultures. Agroecology combines this knowledge with the findings and methods of modern science. The strength of agroecology lies in the combination of ecological, biological and agricultural sciences, along with medicine, nutritional and social sciences. Agroecology incorporates the knowledge of all stakeholders. Their practical contribution to solving complex problems with the help of locally available resources is crucial. Apart from water, soil and sun, other resources that are particularly important are the natural and cultivated diversity of plant species and varieties, along with the knowledge of people and communities on how these plants interact. The IAASTD documents a wealth of both new and old examples of successful agroecological adaptation, and describes the enormous potential of agroecology: It can contribute to directly increasing yields, protecting resources, reviving the local economy and improving health, prosperity and resilience (see also p. 52).

Organic farming as a model

Standardized and certified methods, in particular organic farming, are a small but important part of agroecological farming. Organic farming allows for the verification of criteria such as the non-use of synthetic pesticides and fertilizers. This makes it possible to market products internationally as well as develop a global network of producers and consumers for the exchange of information, education and scientific development. The IAASTD underscores the fact that certified organic farming can be an effective policy tool in promoting rural development and environmental protection states can favor over more energy-intensive agriculture. However, such attempts to standardize do not capture the diversity of agroecology. It is not a perfect system, nor is it a universal ideology. Agroecology is a continuous, never-ending approximation to the best possible solutions or compromises in the respective local, ecological, cultural and social context.

"The weight of the evidence points towards the need for:
- *more determined institutional and policy support for participatory ecologically-based decision making by farmers,*
- *agroenvironmental partnerships to foster social and environmental collaborative learning,*
- *stronger and more enforceable policy and regulatory frameworks,*
- *and investments by the public sector, donor and commercial agencies in sustainable and agroecological research, extension, education, product innovation and marketing." (Global, p. 107)*

Agroecology: lots of praise, little support

Agroecological farming systems are not good customers for agrochemicals, industrial seeds or heavy agricultural machinery. Moreover, the non-standardized products of agroecological farming are not suited to global commodity markets. As a result, agribusiness shows no interest in the expansion of agroecology. However at local and international level, a promising market is developing for goods that are sustainably and fairly produced. These so-called "ethical" and "ethnic" products are high in quality, from a certain region, can be traced back to their origin and have their own story.

Agroecological agricultural practices are knowledge-intensive, focus on details and follow a small-scale and long-term approach. This makes them unappealing for public or international large-scale development assistance projects intended to quickly achieve the "best" possible and easily measurable results with as little effort as possible. Shortly after the publication of the IAASTD, when the World Bank received additional billions of funding to be invested in the long-term fight against hunger, the lion's share of the funds went into large-scale projects, even including subsidies for agrochemicals.

Many scientists consider agroecology an unrewarding object of research: It implies too many parameters and levels of consideration, making agroecological systems difficult to dismantle and measure. This renders agroecological research unsuitable for prompt publications in the journals that are important for fundraising and careers in academia. For this reason, agroecology has only been systematically promoted in a few countries, such as Brazil or Thailand, and is often neglected by public funding, despite assertions to the contrary. Non-governmental and farmers' organizations, local initiatives and communities, as well as an increasing number of committed consumers, on the other hand, are playing a crucial role in the expansion of agroecology.

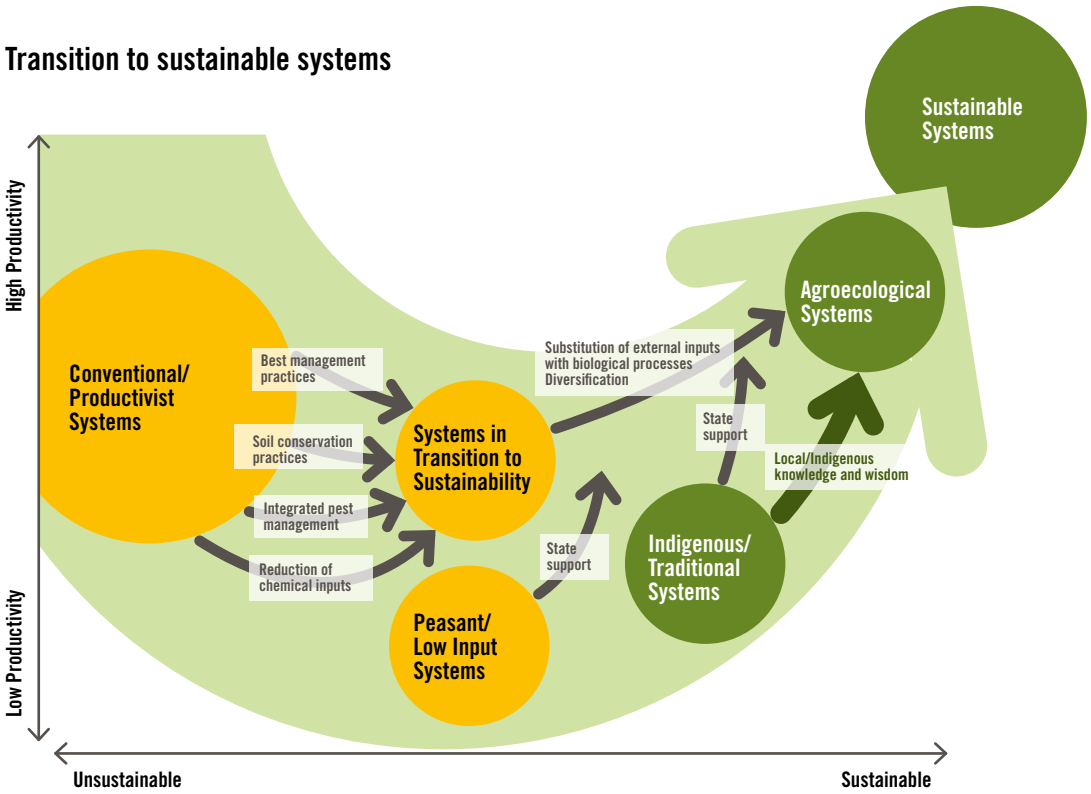
The IAASTD contributed substantially to making agroecology a globally recognized concept of ecological, climate-adapted and socially sustainable development. In 2011, the then UN Special Rapporteur on the Right to Food presented a report in which he identified agroecology as a mode of agricultural development which delivers fast progress in fighting hunger. The report stressed the need to scale up agroecology, arguing that the decisive factor is not how much is invested in agricultural development but how it is done. In 2014, the FAO hosted an international symposium on agroecology, "opening a window in what for 50 years has been the Cathedral of the Green Revolution", as FAO Director-General Graziano da Silva put it. The fact that some groups try to usurp the concept – albeit with quite different intentions, using terms such as "conservation agriculture" or "sustainable intensification" – is an unmistakable sign of the success of agroecology.

Agroforestry in Nepal: mango trees interspersed in a paddy field

Organic farming is one form of agroecology

"An increase and strengthening of AKST towards agroecological sciences will contribute to addressing environmental issues while maintaining and increasing productivity." (Global Summary for Decision Makers, p. 6)

Transition to sustainable systems



Source: Latin America and the Caribbean, Summary for Decision Makers, p. 9

Water

"In many water scarce areas current per capita water consumption is unsustainable. Globally, water is sufficient to produce food for a growing and wealthier population, but continuance with today's water management practices will lead to many acute water crises in many parts of the world." (Global, p. 279)

Water is becoming scarce – but what does this actually mean? After all, the planet never loses a single drop of H_2O. Although water is a finite resource, it will not be used up as long as we do not render it permanently unusable. However, it is important to integrate human and agricultural water usage into the natural hydrological cycle and to use the locally available water in an adequate, effective, sustainable and fair way.

Green and blue water

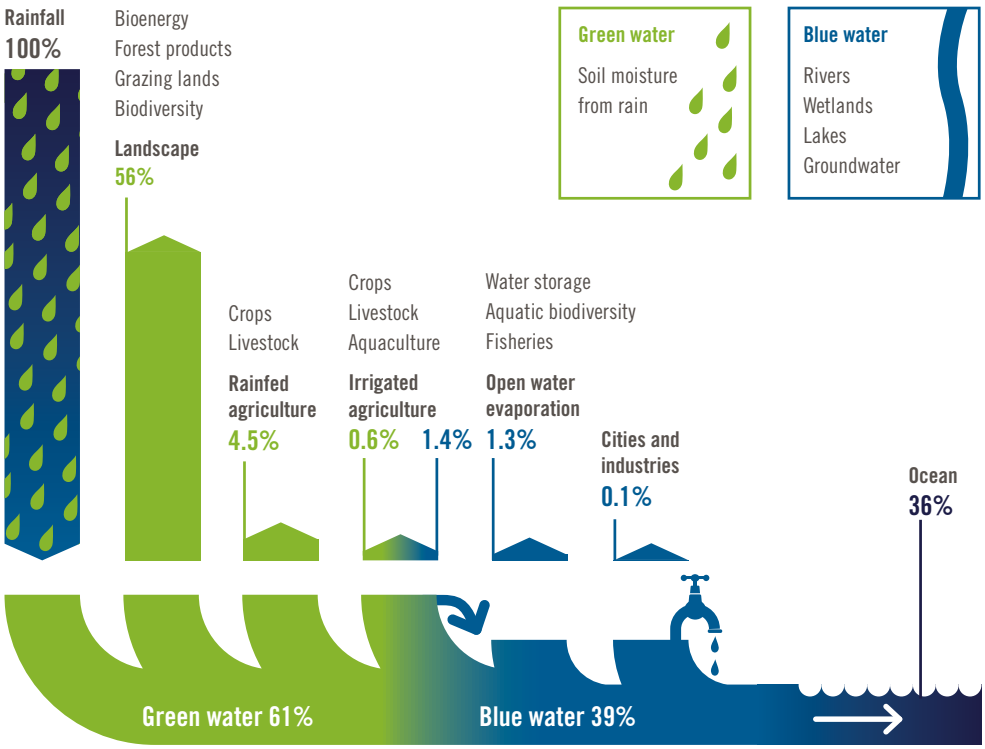
When it comes to freshwater most people think of water in rivers and lakes, groundwater and glaciers – so-called 'blue water'. Yet only small amount of the total rainfall feeds this freshwater supply. The majority of rainfall falls on the Earth's surface and either evaporates directly as 'non-productive evaporation' or, after being used by plants, as 'productive transpiration'. This second type of rainwater is termed 'green water'. The green water proportion of the total available freshwater supply varies between 55 and 80 percent, depending on the region of the world, as well as local wood density. The biggest opportunity and challenge for future water management is to store more green water in soil and plants, as well as storing it as blue water.

*"**First**, already more than a billion people live in river basins characterized by physical water scarcity. In these areas water availability is a major constraint to agriculture. (...) More areas will face seasonal or permanent shortages. **Second**, competition for water between sectors will intensify. (...) In most countries water for cities receives priority over water for agriculture by law or de facto, leaving less water for agriculture, particularly near large cities in water-short areas, such as Middle East and North Africa, Central Asia, India, Pakistan, Mexico, and northern China. Water for energy, i.e., hydropower and crop production for biofuels, will further add to the pressure on water resources. **Third**, signs of severe environmental degradation because of water scarcity, overabstraction and water pollution are apparent in a growing number of places with often severe consequences for the poor who depend heavily on ecosystems for their livelihoods." (Global, p. 341)*

Despite significant progress, there are still many people who do not have access to water and sanitation. In 2015, 663 million people, 87 percent of them living in Asia and sub-Saharan Africa, were without access to improved sources of drinking water. Every day, millions of women and children have to walk long and often dangerous distances in order to collect water and carry it home. As is the case for food and land, access to clean drinking water and water for agricultural use is unequally distributed. Sustainable Development Goal 6 therefore has the aim of achieving access to safe drinking water for all and making water use more sustainable.

SDG 6, targets 1, 3 and 6:
By 2030, achieve universal and equitable access to safe and affordable drinking water for all
By 2030, improve water quality by reducing pollution, eliminating dumping and minimizing release of hazardous chemicals and materials
By 2030, substantially increase water-use efficiency across all sectors and ensure sustainable withdrawals and supply of freshwater to address water scarcity

Global water use



Over 60 percent of the annual 110,000 km³ of rainwater evaporates above forests, savannah, agricultural and grazing land (green water). About 40 percent of rainwater (43,000 km³) contributes to rivers, lakes, groundwater and glaciers (blue water), which then flows back into the oceans. Human blue water withdrawals make up about 9 percent (or 3,900 km³) of total blue water sources, with 70 percent of this being used for irrigation (2,700 km³) and the remaining 1,200 km³ for industry and households. Only a very small part of this water cycle serves as drinking water.

Source: Aquastat (2014), IWMI

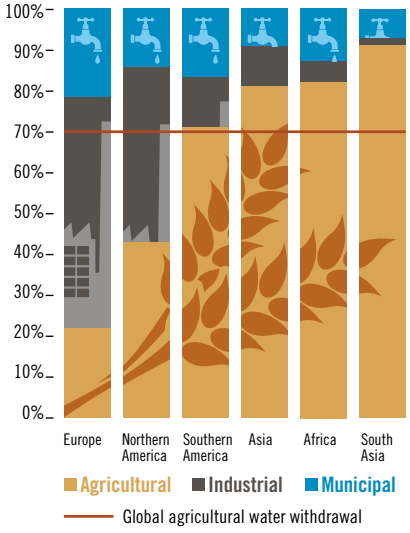
Competition for a scarce resource

Agriculture is by far the largest consumer of the Earth's available freshwater: 70 percent of blue water withdrawals from watercourses and groundwater are for use in agriculture, three times more than 50 years ago. By 2050, the global water demand of agriculture is estimated to increase by a further 19 percent due to irrigational needs. Irrigation provides around 40 percent of the world's food from just 20 percent of the cultivated area or 325 million hectares globally. Especially in the densely populated regions of South East Asia, the main factor for increasing yields were huge investments in additional irrigation systems between the 1960s and 1980s. It is disputed where the further expansion of irrigation, as well as additional water withdrawals from rivers and groundwater, will be possible in the future, how this can take place and whether it makes sense. Farming already competes with peoples' everyday use and environmental needs, particularly in the areas where irrigation is essential, thus threatening to literally dry up ecosystems. In addition, in the coming years, climate change will bring about enormous and partly unpredictable changes in the availability of water. By 2030, half of the world's population will be living in areas with high water stress.

In some regions of the world, water scarcity has already become an acute problem. The situation will deteriorate dramatically in the decades to come if we continue to overuse, waste and contaminate the resources available at local and regional levels. The IAASTD warns against bitter disputes within societies, but also between states, right up to violent conflicts and wars over water. Agriculture could reduce water problems by avoiding the cultivation of water-intensive crops such as maize and cotton in areas that are too dry for them, as well as by improving inefficient cultivation and irrigation systems that also cause soil salinization. Other practices that could be avoided include the clearance of water-storing forests, evaporation over land left lying fallow and the (in some parts of the world) dramatic overuse of groundwater sources.

Thirsty agriculture

Water withdrawal by sector in percent



Source: Aquastat (2014)

Pollution and over-fertilization

"Runoff and seepage of synthetic fertilizers and concentrated sources of livestock waste damage aquifers, rivers, lakes, and even oceans – with costly effects on drinking water quality, fish habitat, safety of aquatic food, and recreational amenities." (Global, p.10)

The pollution and contamination of entire watercourses is another grave problem. Water carries many substances: fertile soil that has been washed out, as well as nutrients which in high concentrations over-fertilize watercourses and deprive them of oxygen. Water can also contain pesticides, salts, heavy metals and sewage from households, as well as an enormous variety of chemical substances from factories. While some rivers and lakes in Europe are slowly recovering from direct pollution through industrial discharges, chemicals still jeopardize the health of freshwater ecosystems, an analysis of water quality data from 4,000 sites across Europe showed in 2014. Agriculture is responsible for the major part of chemical contamination. Water pollution is massively increasing in densely populated regions of Asia and other emerging economies. The use of water further downstream is becoming increasingly risky and expensive, sometimes impossible. Toxic substances in the groundwater can make this treasure unusable for entire generations. Agriculture is not only polluting water bodies with pesticides but also with huge amounts of nitrogen. The number and size of so-called "dead zones" in estuarial areas of large streams, where marine life is suffocating due to over-fertilization, is expanding.

Industrial irrigation

Responsible use and common distribution

The IAASTD recommends taking steps to irrigate agricultural areas more efficiently than today and intensifying the "water harvesting" of precipitation. The authors describe easy methods to avoid water evaporation directly from the soil, to increase the water storage capacity of soil and vegetation and to build local water reservoirs and irrigation systems. According to the IAASTD, in the world's most vulnerable regions there is hardly any other measure as effective for the stabilization of the hydrological cycle as the conservation and expansion of forests and trees. Water management systems that take all watershed users into account and provide them with the necessary rights and duties to maintain the common good, prove decisive for the sustainable use of water resources. The IAASTD does not rule out the fact that the water-scarce regions of Africa and Central Asia will have to import food from areas with abundant water resources in the future. Today, this export of "virtual water" already takes place on a large scale, although in the opposite direction. Water embedded in cash crops is imported from poorer countries, flowing mainly as animal feed into the meat production systems of industrialized countries.

Drip irrigation in Niamey, Niger

Soil Fertility and Erosion

"Soil is the source of nutrients required for plant growth and itself the result of organic processes of living organisms. It is therefore the primary environmental stock that supports agriculture. Soil condition varies widely but global estimates suggest that 23% of all used land is degraded to some degree, which is a cause of serious concern. The key soil degradation processes include: erosion, salinization and water logging, compaction and hard setting, acidification, loss of soil organic matter, soil nutrient depletion, biological degradation, and soil pollution. Agricultural activities influence all these processes." (Global, p. 39)

One handful of healthy soil contains more microorganisms than there are people living on earth. The thin layer of topsoil, that we walk on and through which plants send their roots, is the result of permanent, century-old processes of decomposition, transformation and build-up of soil organic matter through countless organisms. Most of these organisms are microscopic and at present we only know a fraction of them.

Since the transition from hunter-gathering lifestyles to settled agricultural societies, human civilizations have time and again learnt from painful experience that healthy soils are more fragile than they might appear. All forms of agriculture depend on the long-term fertility of a soil, its resilience and capacity to regenerate – a very sensitive base. Errors in soil management and care often only become apparent when it is too late. Some proven methods are no longer viable to meet the demand for fertile soil of a growing world population. These include slash and burn agriculture, which was traditionally used to convert forest areas into arable land for are restricted time, thereby adding nutrients to the soil, as well as the practice of leaving land fallow for several years to enable soils to regenerate. Globally, 10 to 20 percent of drylands and 24 percent of productive lands are degraded. Each year, an estimated 24 billion tons of fertile soil are lost due to erosion.

"Scientists estimate the global cost of soil erosion at more than US$400 billion per year. This includes the cost to farmers as well as indirect damage to waterways, infrastructure, and health." (Global, p. 518)

Some of the world's most vulnerable farmlands are tropical areas, where most of the organic matter is found on and above the surface, overlying a very thin topsoil layer, as well as the oldest soils in the world in the subtropical, dry plains of Africa. European soils, on the contrary, are deeper and richer in organic matter and for this reason more resilient.

Building up, maintaining and conserving the fertility of different soil types worldwide in the face of diverse climatic conditions is the biggest challenge to agriculture today.

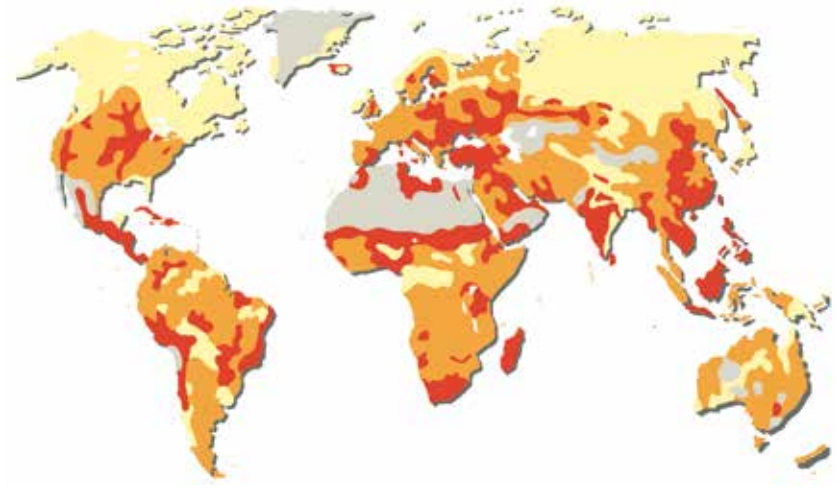
"Soil degradation in one form or another occurs in virtually all countries of the world. About 2,000 million hectares are affected by soil degradation. Water and wind erosion accounted for 84% of these damages, most of which were the result of inappropriate land management in various agricultural systems, both subsistence and mechanized." (Global, p. 24)

The key to soil fertility lies mostly in the humus content of soils. The wide variety of essential nutrients can only be available if soils contain a sufficient proportion of decomposed organic matter. And only then can these nutrients dissolve in water and be absorbed by the plant.

Generations of farmers and soil scientists from different cultural backgrounds have been researching and experimenting with tilth, the optimum soil condition for the cultivation of plants. Animal and human manure, nitrogen-fixing leguminous plants, mulching techniques, composting and adequate crop rotation can all play a decisive role.

Equally important factors for soil fertility are the preparation and protection of the soil structure, root penetration, aeration, water absorption and storage, wind protection, run-off prevention and terracing. To be truly healthy, soil also needs to be teeming with a wide variety of soil-dwelling organisms such as worms, spring tails, woodlice, as well as the right mix of soil microorganisms and fungi.

Soil degradation



Source: UNEP (1997)

Dependence on oil-based fertilizers

Over the past hundred years, the art of locally adapted soil conservation and land use has suffered, because these skills have increasingly been replaced by the standard use of synthetic mineral fertilizers. These fertilizers are easily applied, are seemingly inexhaustible and have replaced the long-term conservation and build-up of soil fertility. Each year, farmers use more than a 110 million tons of synthetic nitrogen fertilizer that is manufactured using the Haber-Bosch industrial process for making ammonia,

developed by German chemists Fritz Haber and Carl Bosch. Since the process only works at high temperatures and pressure it requires a lot of energy, making agriculture in general and soil fertility in particular dependent on the oil price. The boost in nutrients, provided by nitrogen fertilizers, made possible the steep increase in agricultural production over the past century and enabled the current overproduction.

"Innovative soil and crop management strategies can increase soil organic matter content, hence maintaining or enhancing crop performance. The organic matter content of the world's agricultural soils is typically 50-65% of pre-cultivation levels. Strategies to increase soil organic matter include the integration of crop and livestock production in small-scale mixed systems; no-till farming; cover crops, manuring and sludge application; improved grazing; water conservation and harvesting; efficient irrigation; and agroforestry." (Global, p. 175)

However, it has the same fatal effect on soils as a drug: the natural soil fertility and especially the humus formation are both affected. Soils are depleting and leaching faster; soil acidification is accelerating; or the soils need higher doses of mineral fertilizers. At the same time, mineral fertilizers tempt farmers to abandon the more time-consuming, knowledge-based and labor-intensive methods of conserving soil fertility or economic reasons compel them to do so. Without industrially produced mineral fertilizers farmers would not have been able to specialize in just a few crops, have monocultures or give up animal husbandry.

The IAASTD makes the case for an intensive relearning of soil knowledge for both industrial and small-scale agriculture, as well as its re-application in agricultural research. The report calls for refraining from all forms of agriculture and soil management that disregard the fundamental value of fertile soils. This includes over-fertilization, the overexploitation of sensitive soils, and exposure to water and wind erosion, which can be prevented for example with a stock of trees or hedges. Other harmful practices include the use of heavy machinery, which can lead to soil compaction, as can deep or unnecessary tillage with a plow. But soils are also threatened by the sealing of fertile land close to cities in industrial regions.

SDG 15, target 3:
By 2030, combat desertification, restore degraded land and soil, including land affected by desertification, drought and floods, and strive to achieve a land degradation-neutral world

SDG 2, target 4:
By 2030, ensure sustainable food production systems and implement resilient agricultural practices that (...) progressively improve land and soil quality

"Modern best practice guidelines for conventional production systems advise the full use of all indigenous fertility sources (composts, crop residues, and animal manures), with mineral fertilizers employed to bridge deficits between crop needs and indigenous supplies." (Global, p. 183)

More with less: boosting yields with the *System of Rice Intensification*


SRI rice plants have stronger roots

Rice is a staple food for over three billion people worldwide. By 2050, it is predicted that there could be another billion rice eaters in Asia. For this reason, scientists are working to breed new varieties, which promise higher yields. The traditional remedy in this area – greater output from higher inputs – was fundamentally questioned by a new method of cultivation developed in the early 1980s by French Jesuit priest and agronomist Henri de Laulanié. After many years of observation in field trials with small-scale farmers in Madagascar, he came up with the *System of Rice Intensification* (SRI); a system that requires less input but achieves greater output. SRI breaks with all established rules of wet rice cultivation. Firstly, the seedlings are transplanted at the two-leaf stage (between 8 and 12 days old) instead of waiting for one month. Secondly, the single seedlings are planted with an increased spacing of around 25 cm rather than planting them close together in bunches. With this method, seedlings do not compete for nutrients, space and sun, and develop stronger roots and more tillers. Thirdly, instead of continuously flooding fields to prevent weed growth, plants only receive the ideal amount of water and the soil is temporarily kept dry. This favors soil microbial development and reduces methane emissions. Since weed has to be controlled manually using a mechanical hand tool, the soil is well aerated, thereby improving plant growth. Finally, organic manure and compost is used for fertilization. Thanks to SRI, farmers in Madagascar were able to increase their yields from an average of two tons of rice per hectare to eight tons, with only one tenth of the amount of seeds required.

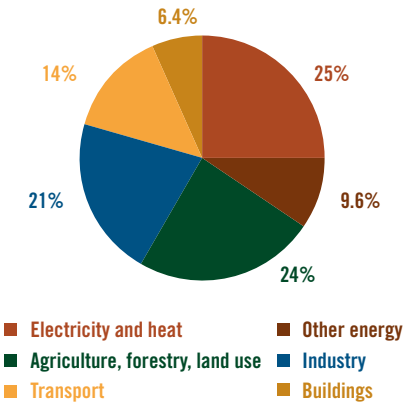
Since 1997, Norman Uphoff and other scientists at Cornell University who had observed the success of SRI in Madagascar have been committed to spreading and documenting the method. With the support of farmers' organizations and NGOs, farmers around the globe have adapted SRI principles to their climate zones and local conditions, and have often been rewarded with record yields. Switching to SRI requires a lot of courage, especially in areas where the survival of families depends on the harvest. The method requires a lot of work and knowledge, for example it is difficult for many small-scale farmers to irrigate the fields at the perfect moment. Nevertheless, 10 million small-scale farmers in over 55 countries in Asia, Africa and Latin America are now applying SRI. In China and India, authorities are already promoting the method. "I think that SRI is something unprecedented, as very few previous innovations have shown such a huge productivity windfall. And just as surprising is the fact that we have been able to proceed on such an international scale with so little support and so much opposition," says Uphoff. Scientists from the *International Rice Research Institute* in the Philippines argue the method is too labor-intensive and yield increases are not sufficiently verified. Seed and agrochemical companies are also not fond of a method that lures away clients by reducing the need for seeds, fertilizer and pesticides. But SRI is spreading rapidly: Hundreds of studies have been published and innovative farmers have extended the principles to other crops such as maize, finger millet, mustard and eggplant, achieving stronger plants and higher yields. **bit.ly/sri-cornell bit.ly/ileia**

Climate and Energy

"The highest emissions of greenhouse gases from agriculture are generally associated with the most intensive farming systems." (Synthesis, p. 47)

Sources of greenhouse gases

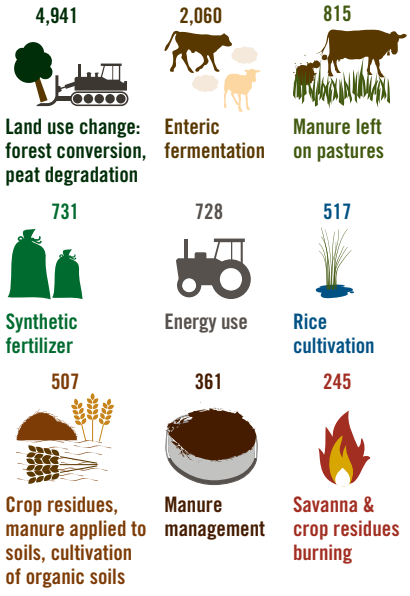
Greenhouse gas emissions by economic sector (Total in 2010: 49 Gt CO_2 equivalents)



Source: IPCC (2014)

Emissions from agriculture

Global emissions from agriculture, forestry and other land use in 2010 by sources (in million tons of CO_2 equivalents)



Source: FAOSTAT (2016)

Due to the capacity of plants to absorb the greenhouse gas CO_2 and soils to sequester carbon, agriculture could, in the long term, theoretically feed us in a climate neutral way and, in the short term, even sequester more CO_2 than it emits. Instead, the agricultural sector is one of the main sources of anthropogenic greenhouse gas emissions accounting for more than 10 gigatons of CO_2 equivalents. Almost half of these emissions result from land use changes due to the conversion of forests into arable or grazing land, as well as the drainage of peats and biomass fires. The other half stems from agriculture. Extremely potent greenhouse gases such as nitrous oxide result from the decomposition of mineral fertilizer, as well as methane from rice production and the digestive process of ruminants in livestock farming. Over the past 50 years, global emissions from agriculture have doubled.

The latest report from the Intergovernmental Panel on Climate Change (IPCC) attributes 24 percent of global emissions directly to agriculture and land use. This share – but not the total amount of emissions from agriculture – has decreased compared to the previous IPCC assessment the IAASTD drew upon mainly due to higher emissions in the energy sector. However, if the emissions the IPCC ascribes to other sectors are also included, for example from fertilizer production, energy used to power tractors and irrigation pumps, as well as emissions from the processing of food, its transport, storage, cooling and disposal, an enormous share of emissions depends on the way we farm and eat. Agriculture therefore plays a crucial role if the target of limiting global warming to well below 2°C above pre-industrial levels is to be achieved.

The climate footprints from different agricultural and food systems vary enormously. In general, labor-intensive small-scale farming is better for the climate than industrial monocultures. Food production for local markets and direct consumption has a lower climate impact than a system with complex transport, processing and cold chains.

Savings potentials and storage capacity

The IAASTD sees the greatest potential in a more climate-friendly form of soil management: Arable land must not lie fallow and a permanent vegetative soil cover should be maintained. Tillage and the depth of plowing have to be reduced to a minimum. The systematic build-up of organic matter will increase the carbon-storage and water holding capacity, as well as the fertility of the soil at the same time. For this purpose, crop residues should be tilled into the ground instead of leaving them for decomposition at the surface or burning them. The integration of trees into farming through agroforestry systems could also make an important contribution.

In the end, the capacity of different soils to sequester carbon is of course limited. The actual prevention of greenhouse gas emissions is inevitable. The most important measures to achieve this are reducing the use of mineral fertilizer and substituting chemical fertilizer with green manure and organic matter. Further saving potential lies in the optimization of cultivation methods, irrigation systems and the keeping and feeding of livestock as well as using natural pest control instead of chemical herbicides and insecticides. Deforestation must be stopped and under-utilized or degraded land should be reforested. The drainage of moors and peat soils, which sequester large amounts of carbon, must be avoided and reversed.

The IAASTD argues that reducing agriculture's dependence on fossil fuel energy must become a priority. Enormous potential lies also in the optimization and replacement of plant-based fuels, such as firewood, which in Africa is still the most widespread energy source for cooking. Many of these measures would not only reduce CO_2 emissions, but would also help agriculture to better adapt to future climate changes and to conserve natural resources and biodiversity. They could also bring economic benefits. Such win-win measures could help trigger a climate-friendly global shift in agriculture.

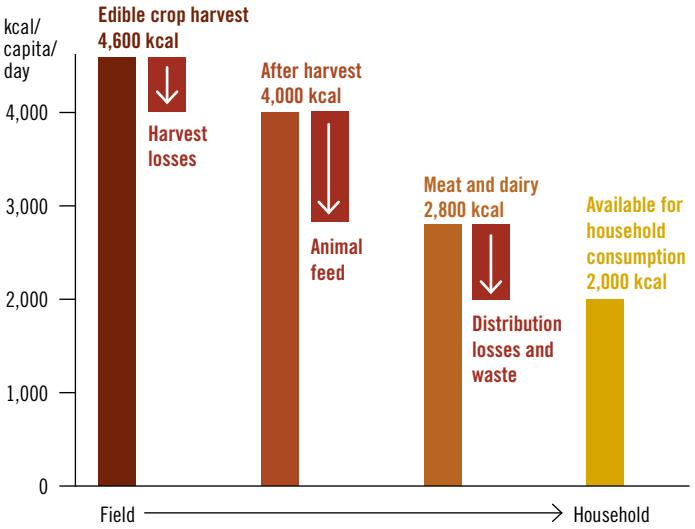
"Some 'win-win' mitigation opportunities have already been identified. These include land use approaches such as lower rates of agricultural expansion into natural habitats; afforestation, reforestation, increased efforts to avoid deforestation, agroforestry, agroecological systems, and restoration of underutilized or degraded lands and rangelands and land use options such as carbon sequestration in agricultural soils, reduction and more efficient use of nitrogenous inputs; effective manure management and use of feed that increases livestock digestive efficiency." (Synthesis, p. 9)

However, the IAASTD stresses that individual measures to cut CO_2 emissions must be adapted to the respective local conditions. The report clearly warns that they cannot be purely assessed according to climate aspects while disregarding contexts, indirect consequences as well as the impact on other ecological and social targets. According to the IAASTD, "silver bullet" or global solutions do not exist in this area. However, a secure way of increasing food energy

efficiency is to address the question of how many calories of fossil energy input are needed to produce one calorie of food that is actually consumed. A third of global food production is lost or wasted. In developing countries, over 40 percent of food losses occur after harvest and during processing, while in industrialized countries almost half of food waste occurs as food is being thrown away in factories, retail, restaurants and households. The carbon footprint of wasted food is 3.3 Gt CO_2 equivalents. Large efficiency gains could be achieved here. Public awareness of the problem has increased remarkably over the past years.

Although agriculture is key to the avoidance of emissions and the possible sequestration of carbon, it tends to be neglected in national and international climate strategies. In the Paris Agreement, which is to replace the Kyoto Protocol in 2020, agriculture is not even mentioned. The majority of the billions of agricultural subsidies paid by industrialized and emerging countries continue to promote cultivation and production methods, consumer habits and trade flows which all contribute to global warming. Development cooperation in agriculture is also still pursuing obsolete strategies, which focus on increasing yields through higher energy input, particularly through agrochemicals, but also through mechanization, irrigation and business specialization, for example by separating crop cultivation and livestock farming instead of integrating both.

56 percent losses and waste in the food chain



Of the 4,600 kilocalories per capita per day which are produced by farmers on global average, only 2,000 are finally available for household consumption. Harvest losses, the conversion from cereals and oilseeds (without grass) to meat, distribution losses and waste eat up the calories in between. These global average values disguise more extreme forms of food waste in rich throw-away societies. In addition, an increasing share of arable land is not used anymore for feed and food production but for fuel, energy and fiber production.

Source: UNEP (2009)

The IAASTD calls for a fundamental change to agricultural and trade policies so that they become compatible with international climate targets. Cultivation methods, which are low in emissions and store carbon, as well as climate-friendly forms of production and consumption, must be incorporated into emission reduction strategies.

SDG 12, target 3:
By 2030, halve per capita global food waste at the retail and consumer levels and reduce food losses along production and supply chains, including post-harvest losses

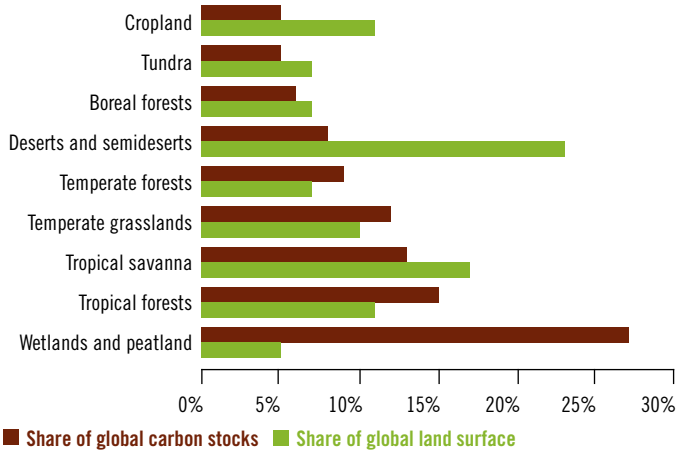
SDG 13, target 2:
Integrate climate change measures into national policies, strategies and planning

Putting carbon back into the soil

The IAASTD does not mention *Climate-Smart Agriculture* (CSA), a concept first presented by the FAO in 2010 as an approach that includes a variety of measures in agriculture and forestry to adapt to climate change, reduce emissions and increase the carbon storage capacity of soils. Since then, it has been interpreted by different stakeholders according to their interests. The World Bank and its agricultural research centers promote it mainly as a concept of compensating for carbon sequestration in the framework of the UN Climate Convention. This has been criticized by peasants' organizations and NGOs. They warn against the expansion of a carbon market that promises high profits from land and forests, especially at large scale, which could give rise to speculation, thus further encouraging land grabs while neglecting real emission reductions. Since CSA lacks clear definitions and standards, it is feared that this could open the door for ecologically harmful practices such as the use of herbicides and the cultivation of genetically modified feed and energy crops which are resistant against these herbicides, thus temporarily reducing the need for plowing.

There is also growing support of regenerative agriculture and land-use practices as a means not only to cut emissions but also to reverse global warming by storing carbon in soils. An initiative launched by the French government in Paris at the climate summit 2015 argues that an annual 0.4 percent growth in soil carbon stocks would make it possible to halt the present increase in atmospheric CO_2. According to the UN Environment Programme (UNEP), under current policy trajectories, emissions are estimated to rise to 60 $GtCO_2e$ in 2030. In order to have a likely chance of staying within the 2°C target, they would have to fall to 42 $GtCO_2e$ by 2030. The IPCC estimates that the agriculture, forestry and land use sector could help closing the gap with an emission reduction potential of up to 10.6 $GtCO_2e$ per year by 2030.

Carbon storage capacity of different soils



Terrestrial ecosystems sequester almost three times as much carbon than is in the atmosphere. Their carbon storage capacity varies. The relation between the global area and the carbon stocks in vegetation and soils shows that only deserts store less carbon than cropland. Systematically improving this storage capacity offers an enormous potential. The IAASTD estimates that "on a global scale, carbon sequestration in soils has the potential to offset from 5 to 15% of the total annual CO_2 emissions from fossil fuel combustion in the near-term." (Global, p. 190)

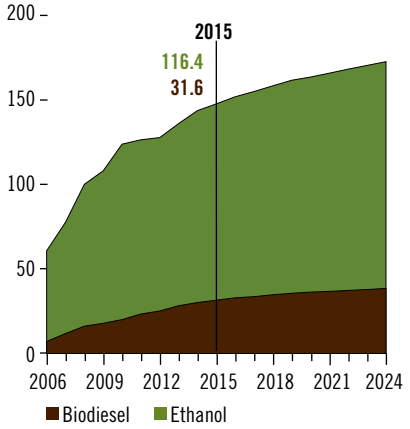
Source: Goblin et al. (2011)

Agrofuels and Bioenergy

"Current trends indicate that a large-scale expansion of production of 1st generation biofuels for transport will create huge demands on agricultural land and water – causing potentially large negative social and environmental effects, e.g., rising food prices, deforestation, depletion of water resources that may outweigh positive effects." (Global, p. 422)

Ethanol and biodiesel boom

Global production of biodiesel and ethanol in billion liters since 2006 and outlook until 2024

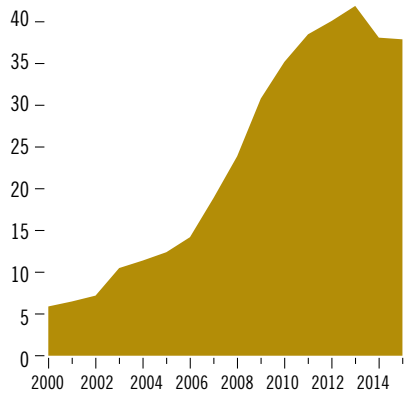


According to OECD and FAO estimates, biofuel production will triple from 2006 to 2024. Earlier estimates were even higher. Policy changes in the US and the EU could alter these lines.

Source: OECD/FAO (2015)

Corn for cars

Share of total US maize supply used for fuel ethanol production in percent



The share of the US maize harvest used to make fuel has increased sixfold since 2000.

Source: USDA (2016)

Over the past decade or so, many governments have regarded the replacement of oil with renewable resources as a "green" silver bullet solution for reducing our dependence on fossil fuel energy and cutting greenhouse gas emissions. It was also hoped that renewable resources would open up new markets for agriculture. IAASTD authors were among the first to warn against this wrong track. Today, most international institutions harbor serious doubts regarding agrofuel production, mainly due to its impact on food prices and the competition it creates for arable land and water. Even the positive climate effects of biofuel usage have become highly contested.

Public blending targets and subsidy measures supporting the production of fuel from maize, rapeseed and other crops have resulted in a significant biofuels boom, both in the EU and the US. For Brazil, Malaysia and Indonesia, sugar cane and palm oil for agrofuel production have become important export goods. Soybean oil is increasingly being used as a feedstock for biodiesel production, as well. Africa's unexploited agricultural land is often considered the "promised land" for the production of renewable fuels.

Following the explosion of global food prices in 2008, and in which the biofuels boom also played a significant role, worldwide disillusionment has been on the rise. In 2011, the World Bank, the International Monetary Fund, the FAO and other UN organizations called on the G20 countries, in particular the US and the EU, to remove all provisions and national policies that subsidize or mandate biofuel production and consumption. Instead, they recommended seeking alternatives to reduce carbon emissions and focus on energy efficiency, including in the agricultural sector. However, due to diverging interests, the G20 countries failed to agree on a common line in the "food or fuel" debate.

The investment-intensive agro-energy boom has generated high profits for a few large companies. For millions of people, however, it has meant market price increases for cereals, sugar and oilseeds; many others have even lost their land. Due to a massive biofuel lobby, neither the EU nor the US has yet made a U-turn on biofuels, but targets have been changed slightly on both sides of the Atlantic. In the US, where 38 percent of the corn supply and 23 percent of soybean oil are converted into ethanol and biodiesel respectively, the heavy subsidies have been questioned. Blending targets set for 2016 were somewhat lower as required by the renewable fuels law. The European Parliament in 2015 approved a seven percent cap on first-generation crop-based biofuels that can be counted toward the EU's 2020 renewable transport energy target of ten percent.

Questionable climate benefits

The IAASTD notes that the frequently quoted positive climate effects of biofuels are controversial. When biofuels are burnt, only as much CO_2 as was previously absorbed by the plant is released into the atmosphere. However, the cultivation of the crops and their processing into fuel requires an intensive energy input. Enormous CO_2 emissions occur if forests are cleared to generate new land, either directly for the cultivation of energy crops or indirectly to replace land for food crops that was converted to produce biofuels elsewhere. This can reduce the positive effects in comparison to oil or, depending on the local plant species and location, even induce more emissions. The IAASTD calculates that two thirds of the world's agricultural land would be required for the cultivation of renewable resources, an equivalent to just 20 percent of global crude oil consumption. At any rate, given the limited availability of water resources and land suitable for cultivation, biofuels directly compete with food cultivation. The production of agrofuels promotes industrial monocultures and enhances their negative impact on rural areas and employment, as well as on the environment. In particular, the IAASTD warns against the expansion of renewable resource cultivation in ecologically valuable natural areas, as this could pose an additional threat to biodiversity. The report is cautious in its assessment of the technical feasibility and efficiency of so-called second-generation biofuels that are produced from algae or the cellulose of trees, shrubs, straw and grass instead of food crops. The problem of competition for increasingly scarce soil and water remains.

"There are also eco-ethical considerations; putting more ecologically fragile and necessary lands into production of biofuels; whether oil palm production in Southeast Asia at the expense of jungles, or soybean production at the expense of rangeland or rain forest. It may not be morally justifiable to purchase oils for biofuels from areas where the environment is being negatively exploited." (North America and Europe, p. 219)

Decentralized energy generation

Biofuels are only a small but rapidly growing part of bioenergy production. Worldwide, three billion people use wood for cooking and heating. Many traditional forms of combustion of wood and charcoal, crop residues and dung are energy inefficient, are harmful to health and climate, and deprive soils of organic matter. According to WHO estimates, 4.3 million people a year die prematurely from illness attributable to the household air pollution caused by the inefficient use of solid fuels for cooking. In some regions, particularly in Africa, the overuse of firewood is also threatening already sparse tree populations, while collecting wood consumes the working time, especially of women, that could better be invested elsewhere. The IAASTD therefore considers it a crucial task for the future to optimize the traditional use of bioenergy and in particular to develop new energy sources, such as solar cookers for poor rural communities.

"Supplying energy to urban areas and industrialized countries may offer short-term economic gains for developing countries in the region, but with high costs for the environment and for the capacity of countries to produce food that is available, accessible and affordable to poor people." (East and South Asia and the Pacific, p. 164)

SDG 15 target 2:
By 2020, promote the implementation of sustainable management of all types of forests, halt deforestation, restore degraded forests and substantially increase afforestation and reforestation globally

Apart from solar and wind energy plants, local biogas plants for the generation of electricity, as well as small plants for the production of biodiesel, are gaining ground in rural communities worldwide despite some "teething problems". As long as they are integrated into the local cultivation of food, they should not be lumped together with the large-scale cultivation of energy crops destined solely for huge industrial plants that produce fuels and energy for the world market, thus competing with food production and threatening rural livelihoods.

"While biofuels may provide prospects for the development of new sources of energy from agriculture, there is the threat of converting natural forests and agricultural lands into monoculture plantations. Furthermore, there is the issue of corporate or community ownership of such initiatives. These developments may have implications for food security, biodiversity, sustainability and livelihoods. Establishing decentralized, locally-based, highly-efficient energy systems is one option to improve livelihoods and reduce carbon emissions." (East and South Asia and the Pacific, p. 64)

A natural way of controlling pests: the Push-Pull method in Ethiopia


A farmer is taught the basic Push-Pull principles

The main sources of income for small-scale farmers in the Tolay region in the southwest of Ethiopia are cereal growing and livestock production. However, many farmers are facing numerous problems presently. Alongside depleted soils, they also have to wage a fight against two dangerous enemies: the stem borer moth and the striga weed. The stem borer moth lays its eggs on maize and sorghum plants; the larvae then bore into the plant's stem, eating it from the inside. Striga is a parasitic weed that penetrates the maize roots, drawing nutrients and water from the plant. If stem borers and striga occur together, they can cause huge crop losses – with fatal consequences for a region such as Tolay, where many live below the poverty line.

The Push-Pull method helps to defeat both enemies. The leguminous plant desmodium is planted in between the rows of maize or sorghum. It then suppresses the growth of the striga weed by natural means – as opposed to the patented alternative of chemical company BASF, which offers hybrid maize varieties resistant to Imazapyr, a herbicide (StrigAway®) that kills the striga seed as it germinates. The smell of desmodium repels the stem borer moths and drives them away from the main crop (*push*). Around the fields, the farmers plant napier grass, which attracts female stem borer moths (*pull*). They place their eggs in the grass where, once they try to bore into the grass, the hatched larvae die in the sticky substance the grass produces. Soils and livestock also benefit from Push-Pull. Like other leguminous plants, desmodium fixes nitrogen from the air with its root nodules. Its organic matter and the animals' manure can then be composted and used to boost soil fertility. The napier grass serves as a highly nutritious extra fodder for the cattle that increases milk production. Farmers can also generate an additional income by selling the remaining grass.

Push-Pull was developed in the 1990s by scientists around Professor Khan at the International Centre of Insect Physiology and Ecology (*icipe*) in Kenya, in collaboration with farmers. In 1995, Hans Herren, then Director General of the *icipe*, was awarded the World Food Prize for leading a biological pest control campaign in Africa, successfully fighting the cassava mealybug – one of the reasons he was later appointed Co-chair of the IAASTD. His Biovision Foundation helps to spread the Push-Pull method from farm to farm. The method has proven successful and has been adopted by more than 120,000 farmers in East Africa. In order to introduce the Push-Pull technique in Tolay, *icipe* is closely cooperating with the Ethiopian Institute of Agricultural Research. In 2013, the first trial fields were planted. Since then, almost 200 "demonstration farmers" and 18 agricultural advisers in and around Tolay have been trained to use and disseminate Push-Pull. Scientists are monitoring progress to be able to adapt the method to the local conditions. In East Africa, a new desmodium species has been introduced which is more drought-tolerant. **www.push-pull.net bit.ly/BiovisionTolay**


Push-Pull requires learning and planning

Adaptation to Climate Change

"Industrialized world agriculture, generally situated at high latitudes and possessing economies of scale, good access to information, technology and insurance programs, as well as favorable terms of global trade, is positioned relatively well to adapt to climate change. By contrast small-scale rain-fed production systems in semiarid and subhumid zones, which continuously face significant seasonal and inter-annual climate variability, are characterized by poor adaptive capacity due to the marginal nature of the production environment and the constraining effects of poverty and land degradation. Sub-Saharan Africa and Central and West Asia and North Africa are especially vulnerable regions." (Synthesis, p. 51)

SDG 13, targets 1:
Strengthen resilience and adaptive capacity to climate-related hazards and natural disasters in all countries

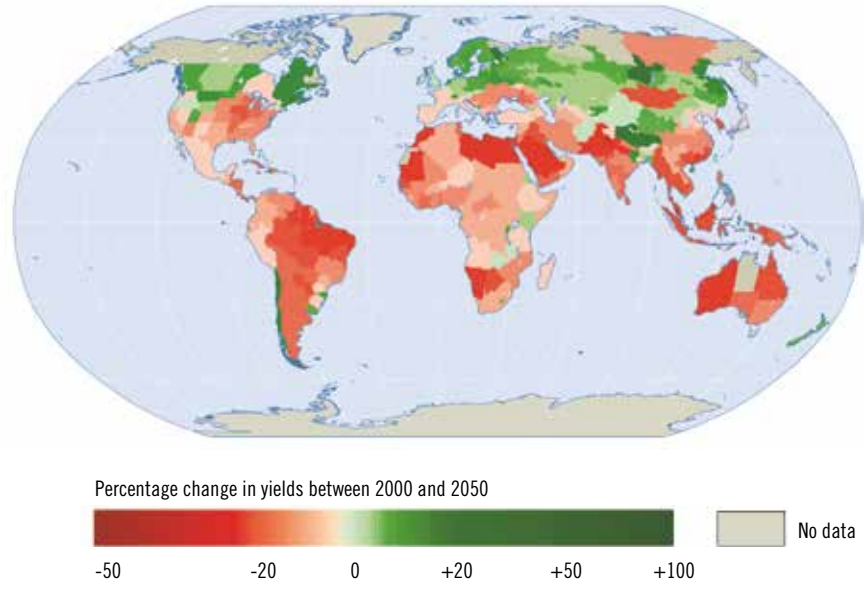
SDG 13, target 3
Improve education, awareness-raising and human and institutional capacity on climate change mitigation, adaptation, impact reduction and early warning

Not only is agriculture one of the main drivers of climate change, it is also its most significant victim. Agriculture will be directly affected by the consequences of climate change, such as droughts and floods, storms and tornados, rising sea levels, groundwater salinity, more frequent and extreme weather events, accelerated loss of species and the spread of old and new diseases. The latest report of the Intergovernmental Panel on Climate Change (IPCC) from 2014 is even more explicit than an earlier assessment from 2007 on which the IAASTD drew upon: Some coastal regions and arid areas will be completely lost for agricultural use. Many regions will suffer heavy losses whereas only a few regions may benefit. Millions of people will lose their homes and their means of existence. Without the implementation of serious measures to combat climate change, the number of people suffering from hunger could rise some 20 percent by 2050.
From what we know today, Africa, Latin America and South Asia will suffer the most from the impact of climate change. In Southern Africa, it is estimated that yields from rain-fed agriculture could decrease by up to 50 percent between 2000 and 2020. In some northern regions of Europe, Asia and America, by contrast, agricultural productivity may even increase, at least temporarily, as a result of climate change. In the medium term, however, today's major export nations and bread baskets of the world, such as the Midwestern United States, Australia, Brazil, Thailand and Vietnam, as well as large parts of India and China, will be threatened by substantial crop losses. Areas that depend on glacier melt water from the Andes and the Himalayas will be particularly hard hit: As the glaciers melt, floods threaten them. Once the glaciers have gone, severe water scarcity will become a problem.

Taking adaptation measures before it is too late

For the first time in its history, the IPCC is warning against crop losses by the end of this century which, even with adaptation, might not be offset, especially if average temperatures rise more than 2 degrees above pre-industrial levels. According to the World Meteorological Organization, 2015 was the hottest year on record and in spring the global average CO_2 concentration crossed the threshold of 400 parts per million. Many impacts of climate change, especially at local level, are not yet foreseeable. Global average values mask extremes that could result in entire regions of the world becoming uninhabitable and increasingly cause extreme weather events. In areas in which it is impossible to calculate the onset of the rainy season, choosing a date for sowing seeds becomes something of a lottery.

Projected impact of climate change on agricultural productivity by 2050



In this map, the World Bank combines three emission scenarios across five global climate models to project how climate change will affect agricultural yields in 2046 to 2055 compared with the period 1996 to 2005. Yields are considered for eleven major crops (wheat, rice, maize, millet, field pea, sugar beet, sweet potato, soybean, groundnut, sunflower and rapeseed) under current agricultural practices and crop varieties. A possible CO_2 fertilization effect from higher ambient CO_2 concentrations is not assumed.

Source: World Bank (2010)

Although adaptation strategies need to differ according to the various world regions, there are still some promising basic principles. As a rule of thumb, an increased level of diversification will reduce the vulnerability of agricultural systems to extreme conditions and thereby increase resilience. Monocultures are obviously more exposed and vulnerable to many climate challenges than cultivation systems that still produce sufficient yields if one crop suffers losses or fails completely in one growing season.
Apart from a greater diversity of plant species and plant communities, cultivating a broader range of plant varieties of a species with different resilience to heat, drought and moisture plays a decisive role. In some climatic zones, maize and wheat are already being cultivated close to the upper temperature limit at which they can still grow or in areas with low rainfall. Farmers in these areas will soon have to seek alternatives, some of which can frequently be found in the local traditions of the respective regions. Irrigation and cultivation methods, as well as plant species and varieties that in the past have been neglected or displaced due to modernization and the breeding of high-yielding varieties, could become a rich source of urgently needed innovation.
Reforestation, the protection of existing forests and timely changes in the composition of tree populations could stabilize local water balances, protect soils against erosion and increase biodiversity, thus strengthening resilience. Agroforestry systems, which combine trees, shrubs, farming and animal husbandry, as well as other forms of intercropping, have also proved successful.

SDG 2, target 4:
By 2030, ensure sustainable food production systems and implement resilient agricultural practices (…) that strengthen capacity for adaptation to climate change, extreme weather, drought, flooding and other disasters

Joint preparations for the inconceivable

Just how much inhabitants of the "global village" in information society already know about climate change is still unfamiliar to many people of rural areas in those regions that will be severely affected by climate changes. Not only knowing but also actually comprehending that nothing will be as it used to be is also difficult for modern city dwellers living in industrialized societies that are usually hungry for change. For many traditional farmers, the IAASTD's message that "business as usual is not an option" does little on its own to create hope for change but instead rather radically challenges their reality and threatens their world view. Not only does a huge demand for education and information exist, but there is also a need for practical and timely adaptation strategies and the impetus to strengthen communities' abilities to learn and act.

"Linking early warning to more effective response requires a people-centered approach to climate change. The quest for early warning must be more than just an 'exercise in understanding how what is happening over there comes be known by us over here'. Instead, the international community should focus on the real stakeholders and add to their capacity for social resilience. On the policy front, the lack of institutionalized early warning systems that survey the impact of climate change on ecological and political crises inhibits the formulation of evidence-based interventions." (Global, p. 417)

In areas where the impact of climate change is already being felt, locally organized and well-functioning early warning systems can save lives. In order to be able to cope with disasters and make a fresh start, poor smallholder families depend on easily accessible and cheap insurances against crop failure that react quickly in the event of loss.
The World Bank warns that climate change could push more than 100 million people into extreme poverty by 2030 due to agricultural shocks and the spread of diseases. Enormous investment is needed to enable rural communities to rise to these challenges. The earlier the investments are undertaken, the more effective and less expensive they will be. It is undisputed that the rural poor will not at all be able to pay for that and their governments only partially. The funds so far provided by the international community are still a drop in the ocean. Developed countries pledged to provide at least 100 billion US dollars annually by 2020 for mitigation and adaptation to address the needs of developing countries. NGOs and poor countries argue this is not enough. There is still a large finance gap and no consensus on what types of finance could count towards the goal.

"Adaptation has a cost and often requires investments in infrastructure. Therefore, where resource endowments are already thin, adverse impacts may be multiplied by the lack of resources to respond." (Global, p. 41)

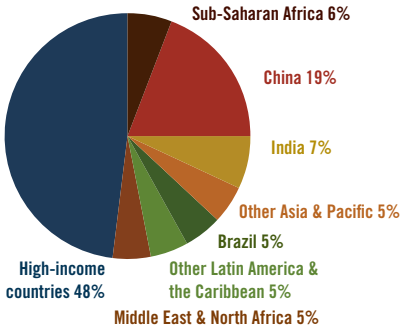
Failed corn crops due to droughts in Tanzania. Floods in Pakistan frequently displace people and destroy harvests.

Knowledge and Science

"The formal AKST system is not well equipped to promote the transition toward sustainability. Current ways of organizing technology generation and diffusion will be increasingly inadequate to address emerging environmental challenges, the multifunctionality of agriculture, the loss of biodiversity, and climate change." (Synthesis, p. 30)

Public spending on agricultural research

Geographic distribution of the $33.6 billion of global public spending on agricultural research and development in 2009 by country or region



Source: FAO (2014b)

As with access to food, knowledge is also extremely unfairly and inefficiently distributed across the globe. "Intellectual undernutrition" and "scientific overnutrition" often occur side by side in modern knowledge-based societies. On the one hand we see an abundance of data, information and specialists that can serve to blur our view of what is essential. On the other hand, there is a huge deficit in general knowledge and agricultural training, extension workers and agricultural colleges. There is also a shortage of scientists dealing with specific local problems, and a lack of skills and expertise in compiling existing knowledge from different fields so that it can produce results and be implemented where it is most needed.

Given that *agricultural knowledge, science and technology* (AKST) are the IAASTD's central subjects, the agricultural scientific community has been reviewed in detail. The report examines the history of their achievements and failures, their roles and self-conceptions. The authors draw a remarkably honest and critical picture of their own profession. They describe scientific progress but also clearly outline the enormous damages caused by science and research in the past. Furthermore, they stress the responsibility that the scientific community itself bears for these damages.

Technology transfer or joint innovation?

Without groundbreaking scientific findings, the increases in agricultural production over the past five decades would have been inconceivable. The IAASTD describes the dominant model of scientific progress as the 'Transfer of Technology' (ToT) model whereby scientific institutions define problems and develop technical solutions to them. These solutions are then conveyed to local farmers via agricultural extension workers serving as executive bodies. This is how the Green Revolution was implemented by national and international public research centers and institutions in particular, and also how increases in productivity in capitalist and socialist industrialized nations were achieved.

"The Transfer of Technology (ToT) model has been the most dominant model used in operational arrangements and in policy. However, the ToT model has not been the most effective in meeting a broader range of development goals that address the multiple functions and roles of farm enterprises and diverse agroecosystems." (Global, p. 58)

Multinational companies, which increasingly take over the role of public extension services, further refined and developed this hierarchical model. To this day, the ToT model is "state of the art" as well as the basis for the "agricultural treadmill" (see p. 21), which is to ensure that successful technologies are "distributed autonomously" under market economy conditions. ToT focuses on increasing productivity, with success being measured in terms of rates of return, i.e. the economic yield per dollar spent on research. As a result, successes and costs that cannot be directly measured from a market economy perspective, such as environmental, health and social factors, escape this assessment.

"Public investments must be targeted using evidence other than simply overall rates of return, as they usually do not include environmental and human health impacts, positive or negative, or information on the distribution of costs and benefits among different groups." (Global, p. 497)

Since the 1970s, so-called participatory concepts have been developed that include the cumulative knowledge of farmers, communities, institutions and NGOs, as well researchers from different disciplines, paying attention to their respective interests and actively involving them in finding solutions. These methods are more time-consuming but achieve more sustainable results as all participants learn together, from each other and from common mistakes, adapting their targets and methods to real problems and conditions. These concepts of joint innovation can unleash enormous forces and dynamics that go far beyond their original purpose. However, they have only established themselves to a limited extent, which the IAASTD explains by highlighting the lack of economic interest in improving common goods and increasing general prosperity on a long-term basis. Frequently, sustainable solutions can lead to lower revenues, such as in the turnover of agrochemicals, machinery and energy. Scientists themselves are also opposed to such joint innovations as these approaches question their traditional authority of science as a universal and unbiased method to describe the objective truth. Scientists' role in society changes fundamentally according to whether they are considered guardians of indisputable certainties or whether they are "simply" just one contribution to a more complex picture of reality and its improvement.

"Given the new challenges we confront today, there is increasing recognition within formal science and technology organizations that the current AKST model, too, requires adaptation and revision. Business as usual is not an option. One area of potential adaptation is to move from an exclusive focus on public and private research as the site for R&D toward the democratization of knowledge production." (Synthesis, p. 18)

The privatization of knowledge

These different perspectives are reinforced through the privatization of agricultural sciences, which also extends to areas of public research and increasingly considers knowledge as private property instead of a common good. This disastrous tendency can be observed in companies' technology and product development as well as in the contested funding market for private and public research. In this market, scientists and their departments compete for "academic excellence" with publications and increasingly extravagant PR measures. The temptation to promise more than the acceptable is increasing in intensity. Real problems (along with illusory ones) are being used as an argument for selling technologies. This is also influencing public and political perception in an ever more subtle and deliberate way.

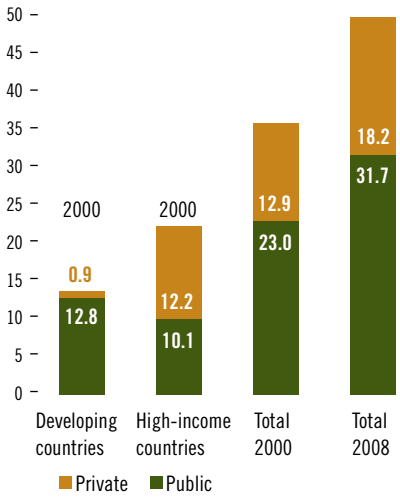
"Today in many industrialized countries an increasing percentage of the funding for university science comes from private commercial sources. It tends to be concentrated in areas of commercial interest or in advanced sciences such as satellite imaging, nanotechnologies and genomics rather than in applications deeply informed by knowledge of farming practice and ecological contexts. (...) A condition of funding is that the source of funds often determines who is assigned first patent rights on faculty research results. In some cases the right to publication and the uninhibited exchange of information among scholars are also restricted. The assumption under these arrangements that scientific knowledge is a private good changes radically the relationships within the scientific community and between that community and its diverse partners." (Global, p. 72)

In most industrialized nations, the public sector is increasingly withdrawing itself from organizing and financing agricultural research. Huge investments in high-tech areas, which are considered strategic future technologies and competitive fields, contrast with the neglect of traditional agricultural training and research. It is being replaced by agrochemical companies who are providing a declining number of specialized farmers with standardized technological package solutions for cultivating a decreasing number of crop varieties, as well as for industrial forms of high-performance livestock farming.

A few emerging economies in Asia and Latin America have seen a huge increase in public agricultural research and training. In Asia and the Pacific, increases in the last decade were mainly due to China's growing public agricultural R&D budget. However, in most poor countries these public investments in agricultural knowledge, research and innovation have stagnated since the 1980s. Although public agricultural R&D spending in Sub-Saharan Africa increased by one third between 2000 and 2011, only three countries, Nigeria, South Africa and Kenya, accounted for half of the money spent while smaller countries are facing underinvestment, a low share of qualified researchers and poor research infrastructure. Even the 15 international agricultural research centers (CGIAR), whose research and plant breeding played a crucial role in the Green Revolution, have a comparatively small budget. The result is that those areas in which science and research are needed most have for decades received the least investment. Small-scale agriculture, whose needs differ greatly from those in industrial agriculture, still fails to receive enough attention from the scientific community.

Public and private agricultural R&D spending

Public and private spending on agricultural research and development by region in 2000 and 2008 in billion dollars



Sources: Synthesis, p. 26; IFPRI (2012)

Traditional and local knowledge

Nowadays, all knowledge that is not part or the result of modern science is referred to, either patronizingly or somewhat unwittingly, as "traditional" or "local" knowledge. In practice, this knowledge is the most important tool that farmers, forest workers, pastoralists, fishermen, housewives and healers, as well as gardeners and craftsmen around the world have at their disposal. Having evolved over the course of history, this knowledge in its own way comprises important interrelations between the respective locations which, in their complexity, often overwhelm specialized natural scientists who think in a monocausal way. Traditional and local knowledge also has its weaknesses as country lore about the weather proves, especially in times of climate change. The IAASTD lists many examples of valuable traditional knowledge that are not part of the perception of "modern" agricultural research and development. These include centuries-old forms of sustainable water and soil management, biological pest control and joint seed development, as well as the immense stock of knowledge and experience with regard to the diversity and benefits of seeds, wild plants, animals and microorganisms for nutrition and medicinal use.

*"**Local knowledge**: The knowledge that is constituted in a given culture or society.*
***Traditional (ecological) knowledge**: The cumulative body of knowledge, practices, and beliefs evolved by adaptive processes and handed down through generations. It may not be indigenous or local, but it is distinguished by the way in which it is acquired and used, through the social process of learning and sharing knowledge." (Global, p. 564)*

Qanats, an ancient irrigation system

"Public investment to support effective change in agricultural knowledge systems should be directed to:

- *promoting interactive knowledge networks (associating farmers, farmers' communities, scientists, industrial and actors in other knowledge areas) and improve access for all actors to information and communication technologies;*
- *supporting ecological, evolutionary, food, nutrition, social and complex systems' sciences and the promotion of effective interdisciplinarity;*
- *establishing capacities and facilities to offer life-long learning opportunities to those involved in the agri-food arena. (...)*

Increased investments are needed in agricultural knowledge, science and technology that can improve the sustainability of agricultural systems and reduce their negative environmental effects with particular attention to alternative production systems, e.g., organic and low-input systems; addressing goals such as:

- *reducing greenhouse gas emissions from agricultural practices;*
- *limiting the vulnerability of agroecological systems to the projected changes in climate and climate variability (e.g., breeding for temperature and pest tolerance);*
- *understanding the relationship between ecosystem services provided by agricultural systems and their relationships to human well-being;*
- *addressing economic and non-economic valuation of ecosystem services;*
- *improving water use efficiency and reducing water pollution;*
- *developing biocontrols of current and emerging pests and pathogens, and biological substitutes for agrochemicals;*
- *reducing the dependency of the agricultural sector on fossil fuels."*
  (Synthesis, p. 33)

Between oblivion and biopiracy

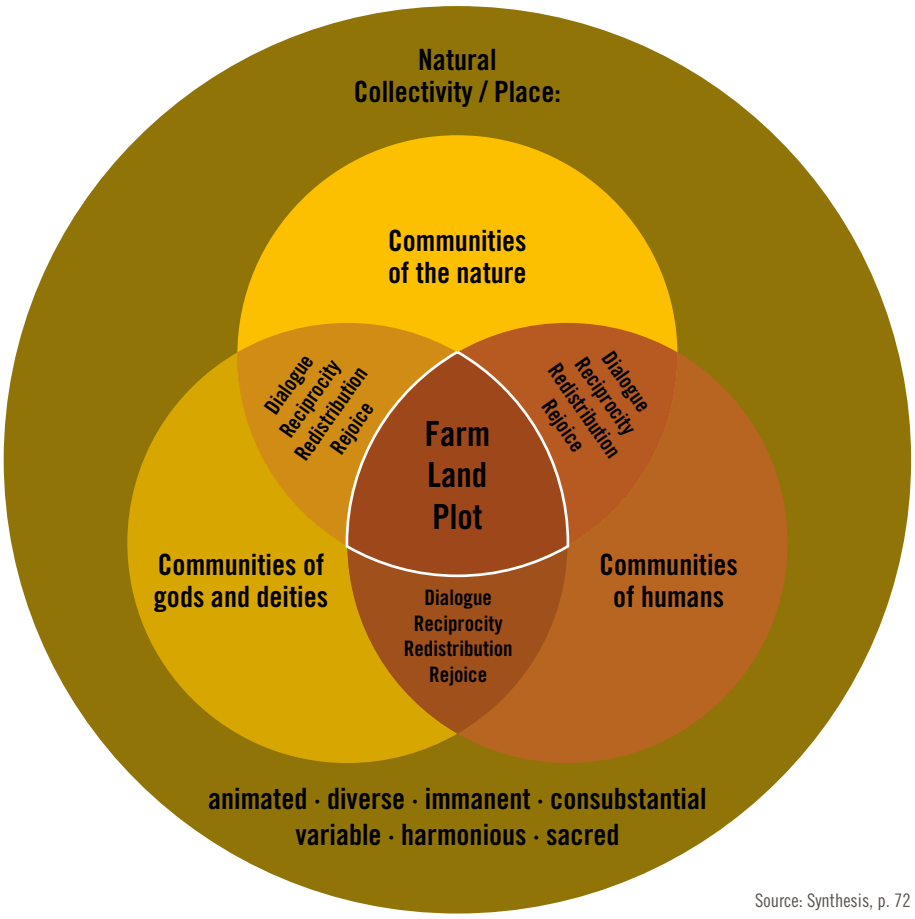
Combining traditional and local knowledge with the findings of modern science in practice (and on an equal footing) entails huge opportunities. However, it also bears risks: Many guardians of traditional knowledge have become suspicious due to experiences of their knowledge simply being taken or even expropriated through patenting. For example, to date, no effective international agreements exist that prevent biopiracy or implement fair forms of benefit sharing. Models for integrating local and traditional knowledge and the rights of its guardians in the international scientific market in a fair and respectful way are meanwhile being discussed intensively. Nevertheless, they are only rarely implemented in practice.

The enormous wealth of traditional and local knowledge often eludes scientific description. One reason for this is the regional, cultural and spiritual diversity of the knowledge and communication systems in which traditional knowledge is used and passed on.

When such connections dissolve, knowledge is quickly lost. One example is the loss of regional and local languages. With their disappearance, also the concepts and knowledge of local biodiversity and ecology, as well as of their interrelation and benefit, will be lost.

In India the seeds and oil of the neem tree are traditionally used to fight funguses and insects. International protests caused the European Patent Office to revoke a controversial patent.

The Andean cosmovision



Source: Synthesis, p. 72

The local *Pacha* (Mother Earth) is a micro-cosmos, a representation of the cosmos at large. Within the local *Pacha* there is the *Ayllu* (community). The *Ayllu* is comprised of three communities: people, nature and spirits. Harmony is not given, it has to be regularly procured through dialogue, reciprocity, redistribution and rejoicing flowing among the three communities. Nurturance and respect are fundamental principles in these exchanges. The place par excellence for the three communities to interact is the *chacra* (plot size: one to two hectares). Knowledge created and transferred from another place has to be instituted in the *chacra* through and in harmony with the dialogue among the members of the *Ayllu* and in conformity with the rituals and ceremonies that support such dialogue. (Synthesis, p. 71)

Speechless in the global village

A globalizing world has offered opportunities that are welcomed and actively sought by traditional and local people, yet have also brought new risks, especially for the vulnerable and ill-prepared. The IAASTD has warned that mutual misunderstanding across languages and other divides can undermine opportunities for collaboration especially when engagement is not mediated by inter-personal interactions but by impersonal bureaucracies, companies or commercial operations.

"Sub-Saharan Africa is the only region where formal education and government services function in languages different from the first languages of almost the entire citizenry." (Sub-Saharan Africa, p. 101)

"Local and traditional knowledge about the environment is embedded in languages that are typically not formally used in extension (except ad hoc in the field) or in research, except to mine information. This hinders the ability to leverage local knowledge." (Sub-Saharan Africa, p. 109)

Language and communication barriers also set painful limits for the authors of the IAASTD. Since a common language is the precondition for cooperation and teamwork in the "global village" of the Internet, the lack of it can become a disqualifying criterion. It also turned out during the IAASTD process that scientists from various disciplines even speak in different tongues when actually talking in English.

Investment in the future

The IAASTD advocates a new form of ethics of science and openness, which neither hides in an "academic ivory tower" nor in a "knowledge bunker" of the private sector. The report calls for a huge increase in public investment in agricultural knowledge and urges that it be conveyed on all levels. Public funds must be specifically used to serve public goods which are of strategic importance for food security, climate change mitigation, along with sustainability issues, given the fact that sufficient private sector funding is practically unavailable. The SDGs recognize the need for more investment in agriculture. SDG 2 aims at increased investment in rural infrastructure, agricultural research and extension services. It remains to be seen whether this investment will also benefit small-scale farmers.

SDG 2, target 2a:
Increase investment, including through enhanced international cooperation, in rural infrastructure, agricultural research and extension services, technology development and plant and livestock gene banks in order to enhance agricultural productive capacity in developing countries

Learning from others: "From Farmer to Farmer in Nicaragua"


A promoter explains how to terrace slopes

In 2004, when the national farmers' association, UNAG, launched an organic farming program under the name "From Farmer to Farmer" in Jucuapa in the north of Nicaragua, it was a reflection of the hard times that had been experienced by the local farmers. In the region of Matagalpa, 54 percent of the population was living below the poverty line and malnutrition was common in rural areas. The price for coffee, the country's most cultivated crop, had been very low for years, leaving many farmers and agricultural workers facing crisis; many fincas had to give up. There was also a low degree of organization between farmers, with only one cooperative existing in Jucuapa. On their one or two hectares of land, the farmers cultivated coffee, maize or beans, mostly in monocultures. After carefully analyzing the situation, UNAG started to train the first 60 peasant families in Jucuapa in two key areas: enhancing soil fertility (for example by producing organic fertilizer, using cover crops and crop residue, and avoiding erosion through terraces and walls) and diversifying crops. They were taught how to establish mixed cultivation in order to achieve an effective symbiosis of different crops, including fruit trees, roots and tubers, and cereals. As a key element of the program, UNAG trained an initial ten farmers to become "farmer promoters" – volunteers who shared their experiences with others. For several years, these multipliers spread their knowledge from village to village, passed on tips and tricks, and taught their farming colleagues useful techniques. These included valuable skills, such as how to make compost or how to build drainage canals to prevent erosion. Regular visits to other farmers in the area who had successfully switched to organic helped augment the effective exchanges of knowledge.

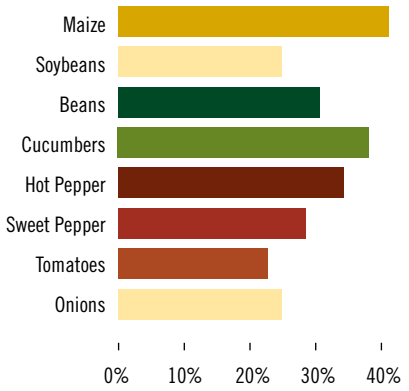
UNAG is also working to promote greater gender equality and improve local management. The successes can be seen in Jucuapa, where it is obvious that women now have their own say in all matters. Furthermore, the farmers who joined forces in groups have been able to enhance their influence with the authorities and improve their organizational structure. Today, more than half of the population in the Jucuapa area is participating in organic farming training. Mixed cultivation is predominant in the fields; the number of farms cultivating more than ten different crops tripled between 2009 and 2015. The farmers also consume a more balanced diet and their income has increased remarkably. If one crop fails, they can still generate enough income from the other products. Farmer Pablo Cruz and his wife Cristina were even able to purchase more land for the very first time. This in turn gives them the confidence to assert, "We will have something to eat every day." The Farmer to Farmer program currently reaches more than 20,000 peasant families in more than 1,000 villages. UNAG coordinates the knowledge exchange between the regional programs, which otherwise work independently, and 4,000 promoters are passing on their knowledge and experience to the farmers. **bit.ly/SwissaidNic**


Pablo Cruz now also harvests papaya

Seeds and Patents on Life

"In the context of newly emerging Intellectual Property Rights regimes and the development of biotechnology (...), a major theme of consolidation in the agricultural plant biotechnology and seed industries has emerged. This consolidation significantly altered the course of germplasm management and marked a major shift in the relationship between the public and private sector." (Global, p. 94)

Monsanto's vegetable seed market share

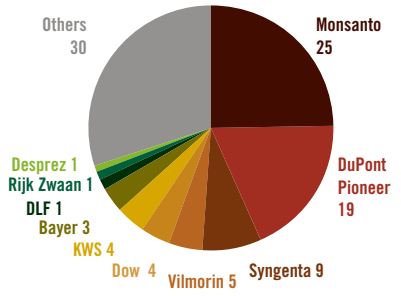


A single company, namely Monsanto, controls the lion's share of the seeds for maize, soybeans and important vegetables. Monsanto also controls 90 percent of the total trade in genetically modified seeds, either directly or through patent licenses.

Source: Synthesis, p. 28

Highly concentrated seed market

Market share of the world's top ten companies in global seed sales in 2014 in percent



The three agrochemical corporations Monsanto, Syngenta and DuPont control more than half of the global trade with patented seeds.

Source: Vilmorin (2016)

The way seeds – the very basis of our food system – are treated globally is a reflection of the privatization of agricultural knowledge. Describing the development of the past hundred years, the IAASTD voices deep concerns regarding the future of our plant genetic resources, their diversity and universal accessibility. For millennia, farmers have maintained, exchanged and improved seeds as a common heritage. At the beginning of the 20th century, seeds were still a public good that scientists improved according to the latest discoveries in genetics, especially Mendel's laws of inheritance, which were "rediscovered" at that time. Public institutions systematically categorized seeds and made them available to farmers.

Based on modern knowledge, the first large public seed collections were established, among others by Nikolai Vavilov in Leningrad. In the 1930s and 40s, and for the first time ever, private plant breeders staked claims to intellectual property rights for newly developed varieties. However, the International Convention for the Protection of New Varieties of Plants (UPOV), agreed upon in 1961, still ensured that the genetic material remained freely available to everyone for the purpose of breeding other varieties and that farmers were permitted to reuse and exchange the seeds and propagating material. Through the US company Pioneer Hi-Bred's introduction of hybrid seeds in the 1920s, the basis was laid for plant breeding to become a profitable business for private companies. As these high-yielding hybrids do not produce seeds of uniform quality in the next generation, they have the effect of a "biological" plant variety protection.

Since the 1940s, international agricultural research centers have specifically developed new high-yielding varieties, with funding from groups such as the Rockefeller or the Ford Foundation. These varieties have mainly been developed in public non-commercial programs and made an important contribution to increasing cereal yields and fighting hunger in the 1960s and 70s. However, these high-yielding varieties were accompanied by a rapid global increase in the commercial use of pesticides and fertilizers.

In the 1980s, some companies began to systematically invest in genetic engineering. For the first time, exclusive patents on genetic modifications and isolated genetic information made it possible to stop others using certain genetic traits in plant breeding. Since the turn of the millennium, companies have been increasingly successful in even obtaining patents on the results of conventional plant breeding, for example Syngenta's patent on a tomato with a higher content of healthy compounds known as flavonols, or in the case of Monsanto's "severed broccoli" patent, on broccoli plants featuring a long stalk. At the same time, plant variety protection was tightened. The UPOV version from 1991 prohibits farmers from exchanging or selling patented seeds and restricts their reuse.

In the 1990s, the seed market became increasingly dominated by a small number of multinational chemical companies and pesticide producers, such as Monsanto, DuPont, Syngenta, Dow Chemical and Bayer. These companies have a clear interest in producing and promoting seeds that depend on their products, thus ensuring continuous sales. They focus on just a few profitable plant species, which are cultivated by solvent farmers on a large scale, as well as on regions that offer the necessary infrastructure and legal protection. This includes varieties that have been genetically engineered to tolerate herbicides or high-yielding varieties that depend on both fertilizers and pesticides for optimal growth. Over the last twenty years, the global commercial seed market has become highly concentrated as a result of countless mergers and acquisitions, a concentration process that is still ongoing. In 2008, the IAASTD warned that the top ten agribusiness companies dominated 50 percent of the global trade of protected varieties. A few years later, only five companies control 60 percent of commercial seed sales.

The IAASTD questions the benefit of patents and intellectual property rights for innovation, research and the dissemination of knowledge in the seed sector. Over the past years, hopes were dashed that the International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA) would uphold the fair exchange of genetic resources between private and public plant breeders in a way that would be oriented towards the common good.

"There are already commercial seed companies that spend far more on legal services than on research. This preponderance of legal over research expense in fighting through the patent thicket may be a 'warning' to public research institutions that emulating commercial plant breeding practices to produce public goods may be a less an optimal production pathway." (Global, p. 478)

Patents against diversity and development?

Multinational companies stockpile patents on plants, animals, genetic information and processes, thus making research, development and especially marketing more complicated for their competitors but also in publicly funded research. Their exploitation strategy for the new "raw material of knowledge", including the increasing amounts of accumulated genomic data, results in barring others from using and further developing this knowledge. The looming threat alone of a long legal dispute of uncertain outcome is often sufficient to hamper further development.

Since the publication of the IAASTD, the global concentration of the seed market has advanced even further. In Africa, many attempts have been made and are still under way to drastically tighten plant variety protection at regional and national level. Together with the seed industry and private donors, industrialized countries are exerting pressure on African governments to harmonize their seed and plant variety protection laws through free trade agreements and development projects. Establishing an economically profitable seed market is one of the central strategies of the Alliance for a Green Revolution in Africa, which was initiated by the Gates Foundation and the Rockefeller Foundation. In Latin America, one of the fastest growing seed markets, the privatization process is further increasing, especially in the case of the major cash crops soybeans and maize. In Asia, by contrast, and especially in India and China, farmers still have relatively strong rights. In the European Union, as almost everywhere else in the world, patents on seeds are a bone of contention, reflected in the resistance against large seed companies and against the practice of the European Patent Office of granting patents on conventionally bred plants.

The concentration in the seed market and the loss of agrobiodiversity has reached alarming levels. FAO estimates that 75 percent of crop diversity was lost between 1900 and 2000. Today, 75 percent of the world's food is generated from only 12 plant species and five animal species. Just five cereal crops (rice, wheat, maize, millet and sorghum) provide 60 percent of the energy intake of the world population.

A European patent on conventionally bred broccoli, which has a longer stalk than other varieties, making it easier to mechanically harvest the crop, caused a bitter legal dispute.

SDG 2, target 5:
By 2020, maintain the genetic diversity of seeds, cultivated plants and farmed and domesticated animals and their related wild species, including through soundly managed and diversified seed and plant banks at the national, regional and international levels, and promote access to and fair and equitable sharing of benefits arising from the utilization of genetic resources and associated traditional knowledge, as internationally agreed

Seeds in farmers' hands: escaping poverty through diversity and local knowledge

Lined up: the diversity of local rice varieties

In the Philippines, once the leading economy in Southeast Asia, 38 percent of the population now live on less than three dollars a day, while one in seven people are undernourished. With the "Green Revolution", the once diversified traditional form of agriculture was fundamentally transformed. The much-lauded high-yielding varieties, offered in combination with chemical fertilizer and pesticides, led many small-scale farmers into a debt trap: the price of inputs and resources increased while yields failed to match expectations. It also caused the erosion of rice genetic diversity.

To escape this dead end, farmers, scientists and non-governmental organizations joined forces in the 1980s and founded MASIPAG, the Farmer-Scientist Partnership for Development. They collected and maintained more than 1,300 traditional rice varieties and bred 1,288 new MASIPAG rice varieties that are specifically adapted to local soils and climate conditions. Each year, these rice varieties are grown and are further developed on almost 200 trial farms. The farmers learn how to assess their varieties, how to choose those which are best-adapted to the natural conditions of their plot of land and how to identify which seeds can best be used for breeding new varieties. With support from scientists, the farmers themselves have become experts. The MASIPAG members exchange their knowledge and seeds. It has resulted in a knowledge partnership based on an equal footing, taking the needs at the grassroots level into consideration and increasing the self-confidence of the farmers. "International agricultural research is dominated by multinational companies. At MASIPAG, the farmers have regained control over their most important resource: seeds," says Manny Yap, the former national coordinator of MASIPAG. Currently, there are more than 30,000 MASIPAG farmers in 563 member organizations. The secret of MASIPAG's success is diversity. The farms opt for a broad range of crops and rice varieties to prevent a total crop failure. Since priority is not only given to yield when choosing a rice variety, but also to its adaptation to local conditions, one variety is always able to withstand droughts or floods. This is the best, cheapest and most reliable insurance in the face of climate change. For a study commissioned by MASIPAG and Misereor (German Catholic Bishops' Organization for Development Cooperation), 840 organic, partially organic and conventional farmers were interviewed. The study found that MASIPAG rice could keep up with high-yielding varieties without the need for pesticides. Since the farmers are largely independent from external inputs and as the great variety of products they cultivate enables them to compensate for crop failures, they are able to increase their income and earn more than the conventional farms. The food security and health of MASIPAG families has also improved. The success of the movement shows how progress can be achieved if farmers in the fields develop solutions.

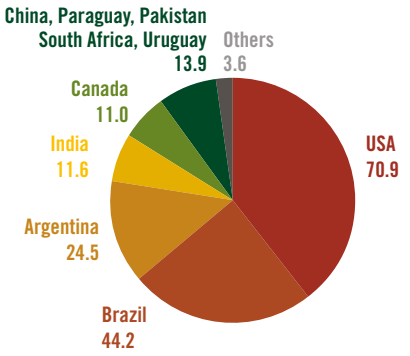
ww.masipag.org bit.ly/MisereorReport

MASIPAG farmer Lucio at work

Genetic Engineering and Biotechnology

Global area of genetically modified crops

Distribution of the global area planted with GM crops in 2015 in million hectares



Worldwide, 90 percent of GMO cultivation is taking place in just five countries. In Latin America and the US, large monocultures of soybean dominate. In India and China, GM cotton is also grown by small-scale farmers. According to the pro-GMO organization ISAAA, 179.7 million hectares were planted with GMOs in 2015. This is 12.8 percent of the global area of arable land.

Source: ISAAA (2015)

When initiating the IAASTD process in 2003, one of the World Bank's main objectives was to settle the dispute over the use of genetically modified organisms (GMOs) in agriculture by reaching a broad scientific consensus on the issue. This aim, however, was not achieved. In the end, the scientists only reached agreement on the fact that they did not agree about the opportunities and risks of this form of technology.

Since the discovery of the genetic code (DNA), groundbreaking findings in molecular biology have revolutionized our understanding of nature. A new image of life has emerged: living organisms are seen as information systems the functioning of which can seemingly be analyzed with the help of computers and deliberately manipulated. However, the more geneticists advance into the complex interaction between DNA, RNA and proteins, genetics and epigenetics, genetic make-up and the environment, the more confusing the picture becomes.

The IAASTD sees huge potential for food and agriculture in the wide field of modern biotechnologies. The cultivation of crops whose genetic information has been artificially altered only accounts for a small part of this field, albeit a highly controversial one. Multinational companies make good money with GMOs, selling them in combination with the compatible pesticides. They make their profits with large-scale, pesticide-intensive monocultures of maize, soybean, cotton and rapeseed. Only two traits have been commercialized on a large scale. Firstly, herbicide tolerance that allows the use of total herbicides in every stage of plant growth and any quantity. Secondly, insect-resistant Bt crops that produce toxins from the bacterium 'Bacillus thuringiensis', reducing the need to use insecticides. However, both are only effective for a limited time.

In the meantime, IAASTD predictions have become a reality: nature is adapting and an increasing number of weeds have become resistant to certain herbicides. The use of herbicides has therefore multiplied where genetically modified crops have long been grown. Farmers are turning to a whole mix of agrochemicals in an effort to fight the weeds. Insects can also develop a resistance to Bt toxins. In addition, other Bt resistant insects use the host plants that have become available and are controlled with additional insecticides. This fundamental dilemma of the chemical control of organisms, which have turned into pests due to large monocultures, is not solved by methods of genetic engineering. This may also be due to the fact that a solution would be damaging to the business interests of GMO manufacturers.

"Two framing perspectives on how best to put modern biotechnology to work for achieving sustainability and development goals are contrasted in the IAASTD. The first perspective argues that modern biotechnology is overregulated and this limits the pace and full extent of its benefits. According to the argument, regulation of biotechnology may slow down the distribution of products to the poor. The second perspective says that the largely private control of modern biotechnology is creating both perverse incentive systems, and is also eroding the public capacity to generate and adopt AKST that serves the public good." (Synthesis, p. 43)

There have not yet been any verifiable yield increases directly brought about by genetic engineering. Even the US Department of Agriculture has been compelled to admit that there is no evidence that GM crops have increased yields since the beginning of their commercial use in 1996. Convincing concepts for reliable long-term assessments of the associated environmental and health hazards are still missing. It is doubtful whether genetic engineering will play an important or indispensable role with regard to other plant breeding objectives, such as drought resistance or salt tolerance that could not be met with conventional breeding. Attempts to biofortify staple crops with vitamins, which receives a lot of media attention, has to date remained in an experimental stage.

Billions invested but zero contribution to fighting hunger

The public controversy over genetic engineering has gained momentum in recent years. While GMO cultivation has almost stagnated in Europe, the area in North and South America has witnessed increases. In the United States, where about half of arable land is used for GM crops, there is also a growing movement that is campaigning for the labeling of GM foods which is already mandatory in the EU, Russia and other countries. In Africa, both public and private development organizations, as well as companies, are pushing for the adoption of GM crops. There are many controversies surrounding the cultivation of GM maize in South Africa and yields are problematic.

Genetic engineering exacerbates problems resulting from the privatization and patenting of knowledge and seeds, including patents on individual naturally occurring DNA sequences that are treated like inventions. The extent of its monopolization in the hands of a few multinational corporations is unprecedented. As GMOs are also both costly and research-intensive, the IAASTD projects that they will not benefit smallholders in

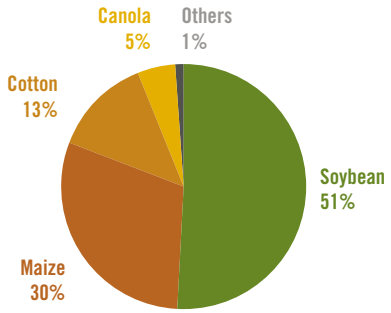
developing countries or play a significant role in the fight against hunger. In particular, poorer countries are faced with serious problems resulting from the complex safety regulations and control provisions that are required, as well as from the unresolved questions regarding cross-breeding of genetic properties and the coexistence with GMO-free cultivation methods and products.

Despite all that, many consider genetic engineering as the ideal way to provide a "Second Green Revolution", above all the members of Croplife, the association of agricultural biotechnology companies. In 2008, they withdrew from the IAASTD process, protesting against its allegedly ideological stance on GMOs, pesticides and global trade. Yet both scientists and politicians alike have promised enormous gains in productivity and the potential for replacement of scarce raw materials and energy sources rooted in "new products". Their business model is based on making profits with "intellectual property", just as has been the case in the software sector. Genetic engineering in food and agriculture has become a symbol for a concept of progress that consists in an industrial and information-based form of dominating and exploiting nature in the "knowledge-based bio-economy". New techniques of genome editing have emerged that allow precise changes in the DNA of living cells, sparking new debates and threatening to bypass existing GMO regulations.

Genetic engineering remains a bone of contention, a symbol for the global resistance of civil society and the widespread rejection in the population, especially in Europe. In this context, it stands for reckless industrialization, the private appropriation of nature as "biomass", the arrogance of science, and the greed and power of international monopolies, as well as for the imponderable risks at the expense of society and future generations. The IAASTD can only reflect what it sees, but cannot solve this conflict.

Genetically modified crops: "The Big Four"

Global area under cultivation with GMOs in 2015 according to crop type



The cultivation of GM crops is mainly limited to large monocultures of maize, soybeans, cotton and rapeseed. The products, except some oil, are not used for food purposes. Almost all GMOs are herbicide-tolerant, insect-resistant or both.

Source: ISAAA (2015)

"Crops derived from GE technologies have faced a myriad of challenges stemming from technical, political, environmental, intellectual-property, biosafety, and trade-related controversies, none of which are likely to disappear in the near future." (Global, p. 95)

Fighting against glyphosate on Argentina's soybean fields: the Mothers of Ituzaingó

Aerial spraying of crops with glyphosate

Do genetically modified crops reduce pesticide use? In Argentina, GM soybeans are grown on 21 million hectares, mostly for export to China and Europe. In 2012, the last year for which official figures are available to the public, 335 million liters of pesticides were sprayed on Argentinean fields, almost nine times as much as in 1990. Although the level of pesticide use remained fairly constant after GM soya was initially introduced in 1996, it has increased dramatically since 2002. Glyphosate, a herbicide marketed by biotech giant Monsanto under the trade name *Roundup*, is the most widely used agrochemical in Argentina. While the average amount of glyphosate applied per hectare was three liters in 1996, this figure is now closer to an average of 12 liters per year; in some areas an even greater amount is used. Due to the constant spraying, more and more weeds are becoming resistant.

Today, the neighborhood of Ituzaingó Anexo on the outskirts of Córdoba is almost completely surrounded by soy fields. And it is here that the community has started to take action. Ever since her daughter died from kidney malformation in 1998, just three days after birth, Sofía Gatica has suspected that the aerial spraying of glyphosate right in front of her doorstep could have been linked to her daughter's death. When Sofía started talking to her neighbors, she discovered that more and more people were suffering from cancer, respiratory and skin diseases, and that women were increasingly giving birth to children with deformities. In 2001, she founded the activist group Mothers of Ituzaingó. Together with other women who were affected she went door to door to systematically document the diseases in the neighborhood.

Amongst the 5,000 inhabitants of Ituzaingó, more than 200 cases of cancer occurred, a rate many times higher than the national average. A report commissioned by Argentina's former president Cristina Kirchner found that 33 percent of the inhabitants of Ituzaingó die from tumors and that 80 percent of local children have several agrochemicals in their blood. Many babies are born with a cleft lip, without a jawbone, without a thumb or with extra fingers. This coincides with findings of the late Argentinean scientist Andrés Carrasco, who provided evidence that glyphosate causes malformations in the embryos of frogs and chickens.

In 2012, thanks to pressure from the Mothers of Ituzaingó, a soya farmer and a pilot of a pesticide-spraying aircraft were convicted: They were found guilty of illegally spraying on land near residential areas, endangering the health of inhabitants. In the same year Sofía Gatica was awarded the renowned Goldman Environmental Prize for her commitment to the fight against pesticides and GMOs. Activists have also received death threats, but the Mothers of Ituzaingó are determined not to give up. They are now spearheading protests against the construction of a Monsanto corn processing plant in Malvinas Argentinas close to Córdoba. **bit.ly/Gatica**

Sofía Gatica is fighting against *Roundup*

Hans Rudolf Herren, a Swiss agronomist and entomologist, is a pioneer in biological pest control and the Co-chair of the IAASTD. In 1995, he received the World Food Prize for fighting a cassava pest in Africa. Until 2005, he led the International Centre of Insect Physiology and Ecology (icipe) in Kenya. Today, he is president of the Millennium Institute in Washington and the Swiss 'Biovision Foundation'. In 2013 he won the 'Right Livelihood Award'.

"We need a radical transformation of agriculture"

Benedikt Haerlin: *The IAASTD has become a milestone in the debate on sustainable agriculture. Where do you see the main impact of the report today, seven years after its initial publication?*
Hans Herren: The key option for action that came from the IAASTD report is that agriculture, on a global scale, needs to transition to agroecology as the way ahead to deal with the challenges of sustainable and equitable development. It is very satisfying to see that the debate and action around agroecology has picked up momentum, not least with FAO's 'overture' towards agroecology with an international symposium in Rome in September 2014 and three regional meetings in 2015. The report is gaining traction at many different levels. Its essence that business as usual is not an option and agroecology is the answer has been reflected in several paragraphs of the Rio+20 declaration, which has found its way into the now universally approved Sustainable Development Goals (SDGs) and further into the COP21 Climate Conference in Paris in December 2015.

Which of the messages have made it to the mainstream of international discussions?
Herren: The recognition that present agriculture and food systems are not in line with the need for a sustainable world. Agriculture must transform from being a contributor to a solver of problems such as climate change, public health, environmental degradation, loss of farmers and rural to urban migration. The need for a radical reset towards sustainability in all three dimension, environmental, social and economic – these messages have been heard and made their way into the debate around food and farming systems. They are now slowly moving into mainstream, despite a very strong pushback by vested interest, agro-industry and large foundations.

… and which of them have been the most ignored?
Herren: What has been most ignored is the need to also radically transform industrial food systems. It is still assumed that developed countries, with their unsustainable industrial agriculture and food systems have to "feed the world". The message that countries need to maximize their own capacity to produce food and protect their own farmers, also addressed as food sovereignty, has yet to be taken into account in the agriculture and food policies of developed countries. Along these lines, developing countries still need to make more efforts to implement the options for action outlined in the IAASTD, rather than go the "easy" way and follow productivist models promoted by the World Bank, the Bill & Melinda Gates Foundation, etc., which are doomed from day one and do not follow the IAASTD's insightful recommendations. For example it was suggested that all countries carry out an assessment "a la IAASTD" to evaluate the transformation needs and pathways but little or nothing has happened, except a Biovision and Millennium Institute project in Senegal, Kenya and Ethiopia, which aims at the development of guidelines for efficient national ag and food system assessments.

"We reaffirm the important work and inclusive nature of the Committee on World Food Security (CFS), including through its role in facilitating country-initiated assessments on sustainable food production and food security."
(§115, Rio+20 declaration "The Future We Want")

Many of those participating in the first report have suggested a follow-up IAASTD. But this seems not to be an option any longer. Do you have an explanation for that?
Herren: With the establishment of the Intergovernmental Panel on Biodiversity (IPBES), which is in some ways in competition with the original IAASTD, there is little chance that the IAASTD can be revived. Perhaps the best way forward is to have the national assessments recommended by the IAASTD. This was taken up in the Rio+20 declaration suggesting that FAO's Committee on Food Security (CFS) assists countries in developing guidelines for efficiently carrying out these assessments.

Do you see other international efforts or even institutions that have taken up the spirit of the IAASTD?
Herren: The IPBES is certainly one of the processes which has a lot to do with agriculture but covers it from an ecosystem and biodiversity angle. I think this is very unfortunate as the two processes should be one. It should also be noted that the IAASTD would have had room to grow and expand, so as to cover, in a very integrated and holistic manner, what the IPBES is now doing out of context. For me this is the greatest missed opportunity to agriculture, the food system and the environment.

Herren with farmers in Kenya

How do you assess the Sustainable Development Goals (SDGs) adopted in 2015? My impression would be that quite a bit of the IAASTD messages have actually been taken up there.
Herren: Yes, lots of what the IAASTD, the Rio+20 declaration and the last two UN Secretary General reports on agriculture have highlighted is now part of the SDGs, not only in goal 2 but across all goals. There is a tremendous opportunity to create synergies, given that agriculture and food are so closely linked to all sectors and sustainable development dimensions. It is now imperative that they are implemented without delays focusing on the food system, sustainable agriculture and agroecology.

The implementation and even the evaluation criteria of the SDGs are still to be seen…
Herren: We are still at the very beginning of the implementation. We have 17 goals, 169 targets

and 304 indicators, the latter still being discussed. The targets relating to agriculture and food are many and very relevant to support the needed transformation as was recommended in the IAASTD. The main effort will be to carry out the national assessments to inform about the policies that are required to achieve these targets. More work is needed to localize the indicators for goal 2 on hunger and others linked to food and agriculture and it is important that this work includes the relevant stakeholders.

What role is assigned to agriculture in the Paris Agreement on climate change and its follow-up?
Herren: Much too little importance has been given to agriculture and food systems to address climate change, in particular when it comes to mitigation. Ahead of COP21, France launched the 4/1000 initiative whose aim is to take carbon out of the atmosphere by increasing soil carbon content by 0.4 percent each year. The idea behind it is that reducing emissions is not enough, we also need to reduce the amount of carbon already in the atmosphere if we want to have a small chance of keeping global warming below 2°C. That initiative received too little attention and is now part of the COP22 agenda.

Is 'Climate-Smart Agriculture' a lesson learned from the IAASTD?
Herren: Climate-Smart Agriculture could also be called Green Revolution 2.0. It is just more of the same old model some want to maintain given the huge vested interests the agribusiness has in selling inputs to farmers, be it seeds, fertilizers or precision agriculture gadgets. With all we know about the need for holistic and systemic approaches to agriculture, this is clearly wrong-headed and diverts too much attention from what needs to be done, i.e. embracing agroecological/regenerative practices. The latter two are going hand in hand, as the basic premise is to work with nature, not against it, using natural processes to regenerate soils and seeds and work in highly diversified systems, with diverse crops and animal breeds of very distinct genetic makeup.

Bioeconomy and sustainable intensification are also buzzwords that seem to point in a totally different direction than the IAASTD. Is there a counterreform under way, also within the academic world?
Herren: Yes, there are many ways of keeping the status quo while pretending to make changes. One of the main excuses for not making more radical changes is that it is too expensive. The truth is that it is irresponsible not to spend money to transform the system *now* to agroecological and regenerative practices and science. In its Green Economy Report in 2011, UNEP clearly demonstrated that IAASTD's recommendations can be implemented by 2050 with spending only about a third of the total agricultural subsidies paid today. We would still produce enough food in the quantity and quality needed to nourish well nine to ten billion people, while using less land and water.

Looking back at the period of agricultural development since the 1980s, do you see more light or darkness?
Herren: I think that there is light at the end of the tunnel *but* we have to keep watching the politics that undermine the urgently needed transformation of agriculture. Positive developments can be seen in many places, more good science is being produced in support of sustainable agriculture as defined by the IAASTD but governments are still not ready to pay the bill for R&D in the area of agrocecology, organic, regenerative agriculture, leaving the work to NGOs. This is one of the main reasons why it is so difficult to get these modern and efficient agricultural practices to farmers. As long as the CGIAR, regional and national R&D organizations only pay lip service to agroecology, we will not see a change in the near future. Governments need to live up to their responsibilities now and fund R&D with public funds to create public goods and accelerate the development and extension of sustainable agriculture practices.

Hans Herren is the author of the chapter on agriculture in UNEP's Green Economy Report.

The world has not become a safer place since the IAASTD was adopted; war and terror combined with utter ignorance have resulted in the largest number of refugees since World War II. What role do you see for subsistence farming and small-scale farmers in this new area of globalization?
Herren: Smallholder farmers need to be better supported with information, market access and also land rights, so that they can move on from their present subsistence, smallholder condition to viable units. In some areas of the world we do need more farmers, in others some farmers will need to move on to sell and repair farm machinery, to become food processors, etc. There is not one recipe for all situations. But the one element that will make a change possible and sustainable is to change the price structure of food. The constant push on food prices to accommodate the poor is wrong-headed. We need to eliminate poverty instead and deal with the growing inequality. This will allow farmers to move on and up. Realistic food prices include externalized costs, both positive and negative. The present pricing system for food is actually at the root of most problems on farms and in rural areas.

Ten Lessons and Challenges

Subdivided into 292 different statements, in the third chapter of the Global Report, IAASTD authors provide a comprehensive overview of the current state of knowledge about global agriculture (AKST: Agricultural Knowledge, Science and Technology). As a quintessence of this important chapter, they drew up "Ten Lessons and Challenges", which are quoted in their entirety in the below (Global, pp. 223-225).

"This Chapter has presented an analysis of the positive and negative impacts of AKST over the last 50 years, which allows us to address the key IAASTD question: *'What are the development and sustainability challenges that can be addressed through AKST?'* We highlight ten concerns that pose the key AKST challenges to improving agriculture's sustainability, while meeting the needs of a growing population dependent on a limited and diminishing resource base.

First, the fundamental failure of the economic development policies of recent generations has been reliance on the drawdown of natural capital, rather than on production from the "interest" derived from that capital and on the management of this capital. Hence there is now the urgent *challenge* of developing and using AKST to reverse the misuse and ensure the judicious use and renewal of water bodies, soils, biodiversity, ecosystem services, fossil fuels and atmospheric quality.

Second, AKST research and development has failed to address the "yield gap" between the biological potential of Green Revolution crops and what the poor farmers in developing countries typically manage to produce in the field.
The *challenge* is to find ways to close this yield gap by overcoming the constraints to innovation and improving farming systems in ways that are appropriate to the environmental, economic, social and cultural situations of resource-poor small-scale farmers. An additional requirement is for farm products to be fairly and appropriately priced so that farmers can spend money on the necessary inputs.

Third, modern public-funded AKST research and development has largely ignored traditional production systems for "wild" resources.
It has failed to recognize that a large part of the livelihoods of poor small-scale farmers typically comes from indigenous plants (trees, vegetables/pulses and root crops) and animals.
The *challenge* now is to acknowledge and promote the diversification of production systems through the domestication, cultivation, or integrated management of a much wider set of locally-important species for the development of a wide range of marketable natural products which can generate income for the rural and urban resource poor in the tropics – as well as provide ecosystem services such as soil/water conservation and shelter. Those food crops, which will be grown in the shade of tree crops, will need to have been bred for productivity under shade.

Fourth, AKST research and development has failed to fully address the needs of poor people, not just for calories, but for the wide range of goods and services that confer health, basic material for a good life, security, community wellbeing and freedom of choice and action. Partly as a consequence, social institutions that had sustained a broader-based agriculture at the community level have broken down and social sustainability has been lost.
The *challenge* now is to meet the needs of poor and disadvantaged people – both as producers and consumers, and to reenergize some of the traditional institutions, norms and values of local society that can help to achieve this.

Fifth, malnutrition and poor human health are still widespread, despite the advances in AKST. Research on the few globally-important staple foods, especially cereals, has been at the expense of meeting the needs for micronutrients, which were rich in the wider range of foods eaten traditionally by most people. Now, wealthier consumers are also facing problems of poor diet, as urban people are choosing to eat highly processed foods that are high in calories and fat, while low in micronutrients. In addition, there are increasing concerns about food safety.
The *challenge* is to enhance the nutritional quality of both raw foods produced by poor small-scale farmers, and the processed foods bought by urban rich from supermarkets. A large untapped resource of highly nutritious and health-promoting foods, produced by undomesticated and underutilized species around the world, could help to meet both these needs.
Negative health impacts have also arisen from land clearance, food processing and storage, urbanization, use of pesticides, etc., creating procurement and marketing challenges for food industries and regulatory challenges for environmental and food safety organizations.

Sixth, intensive farming is frequently promoted and managed unsustainably, resulting in the destruction of environmental assets and posing risks to human health, especially in tropical and sub-tropical climates.
Many practices involve land clearance, soil erosion, pollution of waterways, inefficient use of water, and are dependent on fossil fuels for the manufacture and use of agrochemicals and machinery.
The key *challenge* is to reverse this by the promotion and application of more sustainable land use management. Given climate change threats in particular, we need to produce agricultural products in ways that both mitigate and adapt to climate change, that are closer to carbon-neutral, and that minimize trace gas emissions and natural capital degradation.

Seventh, agricultural governance and AKST institutions alike have focused on producing individual agricultural commodities.
They routinely separate out the different production systems that comprise agriculture, such as cereals, forestry, fisheries, livestock, etc., rather than seeking synergies and optimum use of limited resources through technologies promoting Integrated Natural Resources Management. Typically, these integrating technologies have been treated as fringe initiatives.
The *challenge* now is to mainstream them so that the existing set of technologies can yield greater benefits by being brought together in integrated systems. A range of biological, ecological, landscape/land use planning and sustainable development frameworks and tools can help; but these will be more effective if informed by traditional institutions at local and territorial levels.
Because of the great diversity of relevant disciplines, socioeconomic strata and production/development strategies, sustainable agriculture is going to be more knowledge-intensive than ever before. This growing need for knowledge is currently associated with a decline in formal agricultural extension focused on progressive farmers and its replacement by a range of other actors who often engage in participatory activities with a wider range of farmers, but who often need greater access to knowledge.
Thus part of the challenge is to reinvent education and training institutions (colleges, universities, technical schools and producer organizations), and support the good work of many NGOs by also increasing long-term investments in the upstream and downstream transfer of appropriate knowledge.

Eighth, agriculture has also been very isolated from nonagricultural production-oriented activities in the rural landscape.
There are numerous organizational and conceptual "disconnects" between agriculture and the sectors dealing with (1) food processing, (2) fiber processing, (3) environmental services, and (4) trade and marketing and which therefore limit the linkages of agriculture with other drivers of development and sustainability.
The *challenge* for the future is for agriculture to increasingly develop partnerships and institutional reforms to overcome these "disconnects". To achieve this it will be necessary for future agriculturalists to be better trained in "systems thinking" and entrepreneurship across ecological, business and socioeconomic disciplines.

Ninth, AKST has suffered from poor linkages among its key stakeholders and actors.
For example:
(1) public agricultural research is usually organizationally and philosophically isolated from forestry/fisheries/environment research;
(2) agricultural stakeholders (and KST stakeholders in general) are not effectively involved in policy processes for improved health, social welfare and national development, such as Poverty Reduction Strategies;
(3) poor people do not have power to influence the development of prevailing AKST or to access and use new AKST;
(4) weak education programs limit AKST generation and uptake (especially for women, other disadvantaged groups in society and formal and informal organizations for poor/small farmers) and their systems of innovation are not well connected to formal AKST;
(5) agricultural research increasingly involves the private sector, but the focus of such research is seldom on the needs of the poor or in public goods,
(6) public research institutions have few links to powerful planning/finance authorities, and
(7) research, extension and development organizations have been dominated by professionals lacking the skills base to adequately support the integration of agricultural, social and environmental activities that ensure the multifunctionality of agriculture, especially at the local level.
The main *challenge* facing AKST is to recognize all the livelihood assets (human, financial, social,

cultural, physical, natural, informational) available to a household and/or community that are crucial to the multifunctionality of agriculture, and to build systems and capabilities to adopt an appropriately integrated approach, bringing this to very large numbers of less educated people – and thus overcoming this and other "disconnects" mentioned earlier.

Finally, since the mid-20th century, there have been two relatively independent pathways to agricultural development – the "Globalization" pathway and the "Localization" pathway.
The "Globalization" pathway has dominated agricultural research and development, as well as international trade, at the expense of the "Localization", the grassroots pathway relevant to local communities. As with any form of globalization, those who are better connected (developed countries and richer farmers) tend to benefit most.
The *challenge* now is to redress the balance between Globalization and Localization, so that both pathways can jointly play their optimal role. This concept, described as Third-Generation Agriculture, combines the technological efficiency of second-generation agriculture with the lower environmental impacts of first-generation agriculture. This will involve scaling up the more durable and sustainable aspects of the community-oriented "grassroots" pathway on the one hand and thereby to facilitate local initiatives through an appropriate global framework on the other hand.

In this way, AKST may help to forge and develop Localization models in parallel with Globalization. This approach should increase benefit flows to poor countries, and to marginalized people everywhere. This scaling up of all the many small and often rather specific positive impacts of local AKST held by farmers and traders could help to rebuild natural and social capital in the poorest countries, so fulfilling the African proverb:

"If many little people, in many little places, do many little things, they will change the face of the world."

This will also require that developed country economies and multinational companies work to address the environmental and social externalities of the globalized model ("Enlightened Globalization"), by increasing investment in the poorest countries, by honoring their political commitments, and by addressing structural causes of poverty and environmental damage with locally available resources (skills, knowledge, leadership, etc.). In turn, this is highly likely to require major policy reform on such issues as trade, business development, and intellectual property rights – especially in relation to the needs of poor people, notably women.

The ten lessons above have drawn very broadly on the literature. A specific lesson-learning exercise covering 286 resource-conserving agricultural interventions in 57 poor countries (Pretty et al., 2006) offers an illustration of the potential of implementing more sustainable approaches to agriculture with existing strategies and technologies.

In a study covering three percent of the cultivated land in developing countries (37 million hectares), increased productivity occurred on 12.6 million farms, with an average increase in crop yield of 79 percent. Under these interventions, all crops showed gains in water use efficiency, especially in rainfed crops and 77 percent of projects with pesticide data showed a 71 percent decline in pesticide use. Carbon sequestration amounted to 0.35 tons of carbon per hectare and year. There are grounds for cautious optimism for meeting future food needs with poor farm households benefiting the most from the adoption of resource-conserving interventions.

Thus great strides forward can be made by the wider adoption and upscaling of existing pro-poor technologies for sustainable development in parallel with the development of ways to improve the productivity of these resource-conserving interventions. These can be greatly enhanced by further modification and promotion of some of the socially and environmentally appropriate AKST described in this chapter."

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On behalf of the United Nations and the World Bank, in a four-year-process, more than 400 scientists worked together with the objective of answering this vital question, summarizing the state of global agriculture, its history and its future. The result was the International Assessment of Agricultural Knowledge, Science and Technology for Development (IAASTD) published in 2008. The findings contained in the IAASTD reports are disconcerting and alarming, providing a warning about the misleading ways of the past and offering new ways of moving forward. The authors provide recommendations for a sustainable future of food and farming. These solutions can serve to guide the way to meeting Sustainable Development Goal 2 that aims at ending hunger, achieving food security and improved nutrition and promoting sustainable agriculture. This brochure provides the key IAASTD messages by topics and offers updated figures and new developments in food and farming.