Deutsche Bank Research

The global food equation

Food security in an environment of increasing scarcity

September 21, 2009

New and ongoing driving forces are redefining the world food situation. Their combined effect, although impossible to quantify, stands to be a challenge for future food security.

Scarcity is expected to define food production in the coming decades, scarcity of water, and energy, exacerbated by climate change. Competition for land will also be fierce, due to land degradation, urbanisation, biofuel crops and potential carbon sinks.

Demand for food is growing, in line with population and income growth. Globalisation and urbanisation are also contributing to dietary preferences switching towards more resource-intensive food.

Still we believe the growing population (nine billion in 2050) can be fed, provided the right actions are taken. This requires sustained productivity growth in the agricultural sector in an environmentally and socially sustainable manner.

Innovation through a cross-sectoral approach is essential. Particularly promising are the fields of ICT and biotechnology, but also ecologically integrated approaches. The latter work with whole systems rather than individual crops and distribute knowledge, power and autonomy to farmers.

While it is critical to boost food production, **the world's systems for producing and distributing food will also need to change**, so they can better cope with shocks and stresses, make more considerate use of resources and ensure more equitable access to food.

Smallholder production is one important key. 1.5 billion people live in households depending on small farms. In order to move from subsistence to commercial farming, smallholder farmers need access to education, knowledge, assets, credit, markets and risk management.

Reforms are essential in the areas of agricultural support, food aid, trade liberalisation, support regimes for biofuels and intellectual property rights. The possibility of better global governance mechanisms for food security should be examined. Watching what we eat and what we waste can also go a long way to this end.

Multiple business solutions are available along the food chain for various sectors of industry. For banks, lending to small farmers is an area with untapped potential. And investment opportunities exist all along the supply chain.

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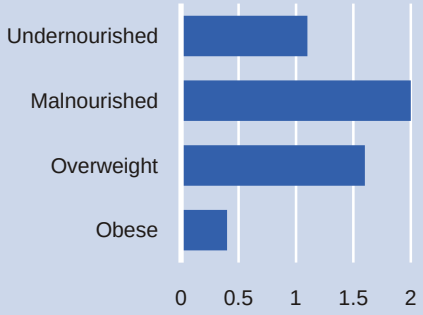


Sources: FAO, WHO **1**

Food: The big picture

The urgency of the financial crisis, together with the recent drop in food prices, has relegated food issues to the background. But even if the human aspects of the food crisis were not compelling enough to take action, tackling food issues appropriately would at least be as important to global economic development as rescue packages and regulation efforts.

We have heard a lot about food prices and new agricultural or trade policies. Masses of articles have investigated the effects of globalisation, economic growth or biofuels, tracked the number of undernourished or obese children, or discussed the components and advantages of a meaningful diet, from a health or environmental perspective. The quantities and types of food we choose to produce, trade or consume have a direct impact on health, the environment, poverty, etc.

How do all these considerations fit together? What is the big picture about food? This report will give a broad overview of the topic food: we analyse and interpret recent trends and emerging challenges in the world food situation. Addressing a topic of such breadth and complexity in a fairly short paper means that we cannot go deeply into each issue, but we do our utmost to cover all important aspects and be as unbiased as possible.

Food is directly connected to health and well-being and thus growth, indirectly to a number of big issues

We first describe the current situation, with three "basic" food-related challenges that impact people in a very direct way:

1. Decrease hunger
2. Reduce diet-related illnesses
3. Increase environmental sustainability.

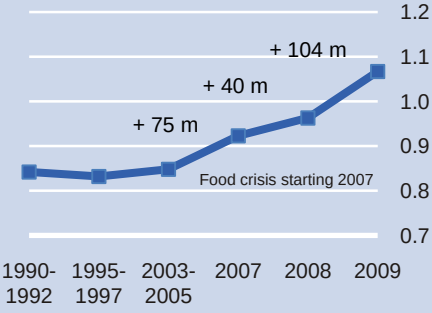
Challenge # 2 is briefly discussed here but will be analysed in a subsequent paper. The main focus of this publication is future global food security: the feeding of the world while preserving environmental sustainability.

"Food: material used in the body of an organism to sustain growth, repair and vital processes, and to furnish energy."

Merriam-Webster on-line

In the second section, we analyse the underlying forces driving the world food situation. For the sake of clarity, we group them according to which side of the food equation they impact. In the first subsection, we discuss the factors driving demand. Then we investigate the forces underlying food production. To conclude this section, we analyse the factors driving access to food. The third section summarises the long-term trends relevant to future global food security. Finally we discuss in the fourth section actions to be taken in order to positively influence future developments.

Number of undernourished people
Bn



Source: FAO **2**

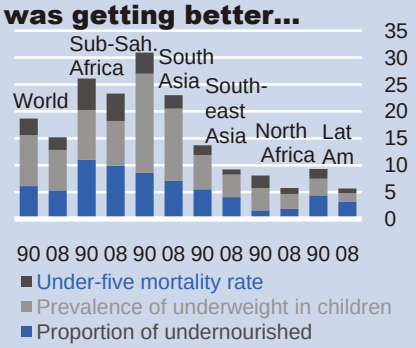
1. Three basic challenges related to food

1.1 World hunger is increasing

"The fact that large numbers of people continue to live in intransigent poverty and hunger in an increasingly wealthy global economy is the major ethical, economic, and public health challenge of our time."

Joachim von Braun, Director General, International Food Policy Research Institute (2007)

The Global Hunger Index was getting better...

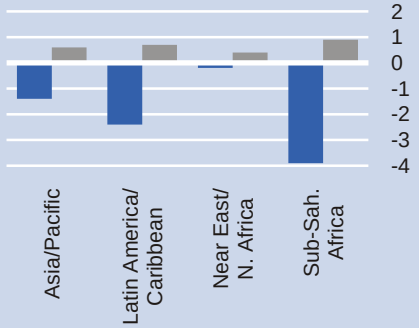


GHI 2008 reflects data prior to 2006

Source: 2008 Global Hunger Index **3**

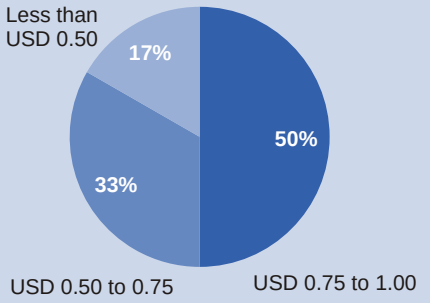
... but high prices made it worse

Change in the proportion of undernourished people (%)



Source: FAO **4**

Poverty: 970 million people living with less than one dollar a day



Source: IFPRI **5**

"Extreme poverty: a trap in which poverty begets poverty and hunger begets hunger"

Mostly in Sub-Saharan Africa

Deutsche Welthungerhilfe 2008

Counting the hungry: One billion hungry people today

In the early 1990s, the number of hungry people started to bottom out, following a two-decade trend of declines. Since then, it has been increasing, according to the latest estimates by the Food and Agricultural Organization of the United Nations (FAO).[1] These increases (see chart 2) are largely attributed to high food prices, followed by the financial crisis: though the latter has helped bring global food prices down, it has also led to falling trade and lower development aid. High food prices have resulted in at least a further 75 million hungry people in 2007. According to the United States Department of Agriculture (USDA)[2], the figure could be as high as 133 million. The FAO now projects that, as a result of the financial crisis, just over one billion people will go hungry by the end of 2009: one-sixth of the world's population.[3]

In terms of population share, the Global Hunger Index (GHI) shows that the world was making slow progress in reducing food insecurity as a share of the population until 2005-2006 (see chart 3). The food crisis is not reflected in the latest Global Hunger Index: GHI 2008 uses data until 2006. This lag in data availability actually highlights the need for more complete and up-to-date monitoring of developments related to agriculture, food and nutrition. With the upsurge in food prices, progress in reducing the proportion of food-insecure people has been reversed in all the regions.[4]

The countries with the most worrisome hunger status, the highest 2008 GHI scores, are predominantly in Sub-Saharan Africa – where one in every three persons suffers from chronic hunger – and South Asia – which hosts the greatest number of undernourished (300 million).[5] Hunger is obviously tied to poverty, and countries with high levels of hunger are overwhelmingly low or low to middle-income countries.

The vicious cycle of hunger and poverty

"Most of the world's poor people earn their living from agriculture, so if we knew the economics of agriculture, we would know much of the economics of being poor."

Theodore W. Schultz, Nobel Prize Laureate in Economics, lecture to the memory of Alfred Nobel, 1979

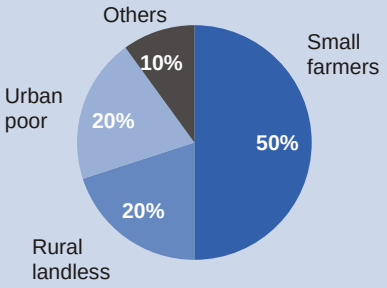
- 923 million people in the world go hungry every day (1.1 bn in 2009)
- 907 million of these live in developing countries
- 969 million people live on less than USD 1 a day
- 17% of those live on less than USD 0.50 a day

Source: FAO for 2007

More than three-quarters of poor people in developing countries – defined as those living on less than USD 1 per day – live in rural areas, and most of them depend directly or indirectly on agriculture for their livelihoods.162 million people, deemed ultra poor, live on less than $0.5 a day. They are overwhelmingly concentrated in Sub-Saharan Africa, where their numbers are growing. "The ultra poor

[1] The FAO labels "hungry" those people being deprived of access to sufficient food on a daily basis - receiving fewer than 1800 calories a day.
[2] FAO (2008a).
[3] FAO (2009).
[4] FAO (2008a).
[5] World Bank (2008).

Many hungry are farmers, not reaping what they sow



Others: Agropastoralists, fisherfolk and forest users

Source: UN

6

often live in remote rural areas; are more likely to be ethnic minorities; and have less education, fewer assets, and less access to markets than better-off people. Their extreme poverty makes it next to impossible for them to climb out of poverty: they find themselves unable to invest in assets and in educating their children; they have little access to credit; and hunger and malnutrition reduce their productivity."[6] About 50% of the hungry are small-scale farmers, while 22% own no land (see chart 6).[7]

Conflict exacerbates hunger. War and violent conflict have been major causes of widespread poverty and food insecurity in most of the countries with high GHI scores. Another common pattern is the lack of general freedom in terms of political rights and civil liberties.

Global Hunger Index by severity and net cereal exporters-importers

<4.9 (low)	**5.0 to 9.9** (moderate)	**10.0 to 19.9** (serious)	**20.0 to 29.9** (alarming)	**≥ 30.0** (extremely alarming)
Net importers	**Net importers**	**Net importers**	**Net importers**	**Net importers**
Belarus*	Albania	Armenia	Angola	Burundi
Bosnia and Herz.	Algeria	Azerbaijan	Bangladesh	Congo, Dem. Rep.
Brazil	China	Benin	Cambodia	Ethiopia
Chile	Colombia	Bolivia	Central African Rep.	Liberia
Costa Rica	Cuba	Botswana	Chad	Niger
Croatia	El Salvador	Cameroon	Comoros	Sierra Leone
Ecuador	Fiji Islands	Congo, Rep.	Djibouti	
Egypt	Gabon	Cote d'Ivoire	Guinea	
Estonia	Guyana	Dominican Rep.	Haiti	
Iran*	Jamaica	Gambia	Madagascar	
Jordan	Malaysia	Ghana	Malawi	
Kuwait	Mauritius	Guatemala	Mozambique	
Kyrgyzstan	Morocco	Honduras	Nepal	
Lebanon	Panama	Indonesia	Pakistan	
Libya*	Peru	Kenya	Rwanda	
Macedonia	South Africa	Mongolia	Sudan*	
Mexico	Suriname	Namibia	Tanzania	
Romania	Thailand	Nicaragua	Yemen	
Saudi Arabia	Trinidad and Tob.	Nigeria	Zambia	
Syria	Turkmenistan	North Korea*	Zimbabwe	
Tunisia	Venezuela	Philippines		
Turkey		Senegal	**Net exporters**	
Uruguay	**Net exporters**	Sri Lanka	Burkina Faso	
	Moldova	Swaziland	India	
Net exporters	Paraguay	Togo		
Argentina		Uganda		
Bulgaria		Vietnam		
Kazakhstan				
Latvia		**Net exporters**	**Note:**	
Lithuania		Myanmar*	For the 2008 GHI, underlying data span is	
Russian Fed.		Uzbekistan	the period 2001 to 2006.	
Serbia and Mont.			For countries marked with *, data are unreliable.	
Slovakia			Cereal exports/imports are measured	
Ukraine			as 2003-2005 average.	

The GHI is a combined measure of three equally weighted percentages: the proportion of undernourished as a percentage of the population, the prevalence of underweight in children under the age of five, and the under-five mortality rate. On a 100-point scale, scores above 10 indicate a serious problem, values above 20 are alarming, values exceeding 30 are extemely alarming.

Source: Global Hunger Index, 2008

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[6] Deutsche Welthungerhilfe (2008).
[7] UN (2005).

It is ironical that most of the food insecure live in rural areas where food is produced, yet they are net food buyers rather than sellers. The recent advent of higher food prices had uneven effects across countries, depending on a range of factors, including whether countries are net importers or exporters of food. Among the 120 countries for which the GHI is calculated, net cereal importers greatly outnumber exporters, even more so for high GHI values.[8] This implies that, by far, countries combating hunger are more likely to suffer from higher prices rather than benefit from them. (For more on price development and trade, please see 2.3.)

Malnutrition: A far-reaching problem

The undernourishment associated with missing macronutrients[9] or micronutrients in poor-quality diets is even more widespread than the undernourishment indicated by underweight alone, in both the developed and developing world. An estimated 2 billion people suffer from one or more vitamin and mineral deficiencies. This results in shorter life-spans, frequent illnesses, or reduced physical and mental abilities.[10]

Consequences of malnutrition, per year

- 3.5 m children die before the age of 5
- 50,000 women die as a result of childbirth
- 18 m infants are born with impaired mental capacity
- 300,000 infants are born with preventable physical defects

Source: Global Alliance for Improved Nutrition

Iron deficiency is the most widespread health problem in the world, impairing normal mental development in 40-60% of infants in the developing world, and causing more than 130,000 deaths (of women and children) each year. Vitamin A deficiency affects 40-60% of children under five years of age in the developing world, compromising immune systems, causing blindness and deaths: an estimated 250,000 to 500,000 vitamin A-deficient children become blind every year and half of the children die within a year of becoming blind. Iodine deficiency in pregnancy is the most common cause of preventable mental retardation and brain damage on the planet – in 60 countries it is associated with a 10-15% lowering of average intellectual capacity. Folate deficiency is responsible for around 300,000 severe birth defects every year. Zinc deficiency causes retarded growth, mental disturbances and recurrent infections.[11] Countries may lose 2 to 3% of their GDP as a result of iron, iodine and zinc deficiencies. In China, vitamin and mineral deficiencies represent an annual GDP loss of up to USD 5 bn according to the World Bank.[12]

Malnutrition also an issue in the developed world, especially among the elderly and the sick

Obviously more prevalent and more acute in the developing world, malnutrition is also to be found in the developed world. The poor, the elderly and the sick are especially affected. The European Society for Clinical Nutrition and Metabolism (ESPEN) reports that 5% of the European population is exposed to the risk of malnutrition. For some subpopulations the share is significantly higher: this is the case for 10% of citizens over 65 years of age, up to 40% of hospital patients and 60% of old-age-home residents. Malnutrition often remains unnoticed and can lead to fatal health troubles. This obviously affects quality of life and can be quite costly. The costs associated with malnutrition of the sick are estimated at EUR 170 billion Europe-wide.

1.2 The world is fat!

"The global obesity epidemic affects all of us – families, communities, and nations around the world. It's a weighty subject in

[8] These considerations give a partial picture only (there is more to food than just cereals), but are still indicative of the situation.
[9] For instance, lack of lipids is a known problem among poor people in India.
[10] www.gainhealth.org.
[11] Ibid.
[12] Alderman (2005).

Overweight and obesity: No small matter

For adults: Age 15 +

	2005	2015
Overweight	1.6 bn	2.3 bn
Obese	400 m	700 m

20 million children under five overweight in 2005

Source: WHO 8

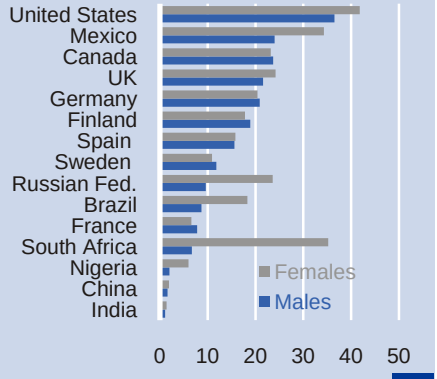
Germans overweight

— 67% of men
— 53% of women
— 15% of the under 18

Source: Federal Ministry of Health

Overweight worldwide

Prevalence of overweight in adults over 15 years, 2005, in %



Source: WHO Global InfoBase 9

every way, with dire consequences for well being, life expectancy, and economic productivity in the years ahead unless seriously confronted."

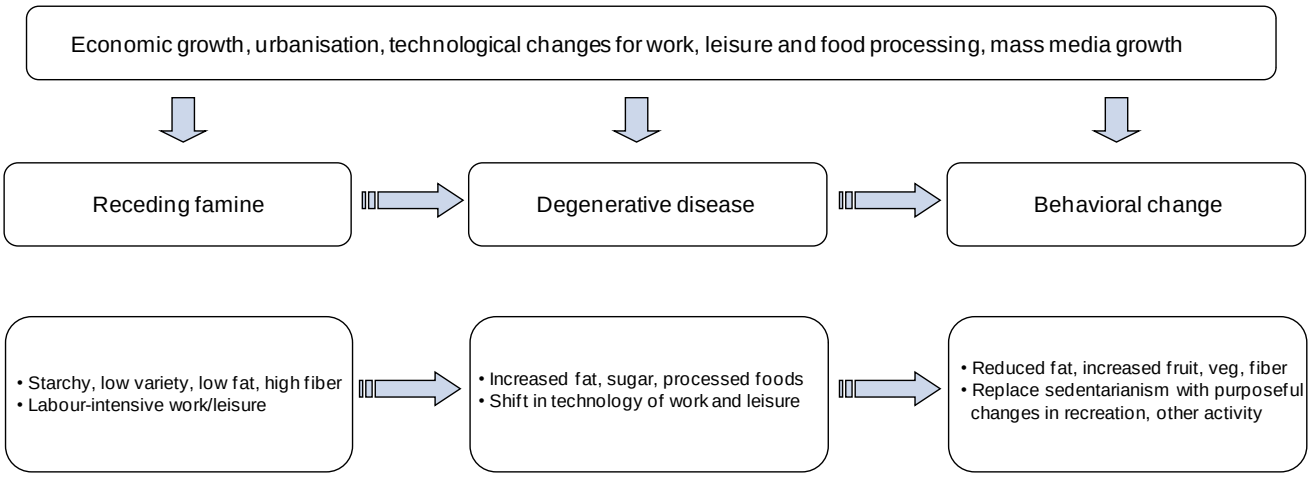
Jeffrey D. Sachs, Director of the Earth Institute (commenting on Barry Popkin's book "The world is fat")

Indiscriminate food intake: too much, not the right type

Diet is one of the leading risk factors for chronic illness. Malnutrition remains a major cause of death globally, especially among children, but other diet-related diseases, such as obesity, heart disease, stroke and diabetes[13] are gaining ground. Cardio-vascular disease is a leading cause of death in both industrialised and developing countries, killing 17 million people each year, according to the World Health Organization (WHO).[14] And the European Union warns that over-eating and sedentary modern lifestyles have raised obesity to the number one public health challenge of the 21st century, with rapidly increasing childhood obesity of particular concern. The German Federal Ministry of Education and Research reports that a third of Germany's health costs are due to diseases resulting from faulty nutrition. Well over 50% of German adults are overweight. Germany actually tops the European list of overweight people after the UK (see chart 9), but fares average in terms of obesity. (The WHO reports that national data differ from international comparable estimates because the latter are adjusted for age distribution, representativeness, risk factors etc.)

Around 1.6 billion people worldwide are overweight, compared to 100 million fifty years ago. Obesity rates have risen three-fold or more since 1980 in some areas of North America, the UK, Eastern Europe, the Middle East, the Pacific Islands, Australasia and China.[15] The obesity epidemic is not restricted to the developed world; the increase is often faster in developing countries. Indeed, over the past 20 years, a dramatic transition has altered the diet and health of hundreds of millions of people across the developing world. Undernourishment and overconsumption coexist in a wide range of countries and may be found within the same community

Stages of the nutrition transition



Source: Popkin, 2003

[13] For more on diabetes, see Perlitz (2009).
[14] WHO (2006).
[15] http://www.who.int/dietphysicalactivity/media/en/gsfs_obesity.pdf.

and even within the same household. This double burden is caused by inadequate pre-natal, infant and young child nutrition, followed by exposure to high-fat, energy-dense, micronutrient-poor foods and lack of physical activity. Unbalanced diets are often related to low intake of fruits and vegetables and high intake of fats, meat, sugar and salt. Many traditional foods, however, are rich in micronutrients, and expanding their role in production systems and diet could have health benefits.[16]

Potential improvements lie in the hands of individuals and numerous stakeholders from the public and the private sector

The burden of overweight and obesity can be reduced through concerted efforts. At the individual level, people can initiate diet changes and increase physical activity. The public and the private sector have vital roles to play in shaping a healthy environment and making healthier diet options affordable and easily accessible. This is especially important for the most vulnerable in society – the poor and children – who have limited choices about the food they eat and the environment in which they live. Meals offered in schools and kindergarten are also often lacking in nutritional quality.

"Prevention strategies will require a coordinated effort between the medical community, health administrators, teachers, parents, food producers and processors, retailers and caterers, advertisers and the media, recreation and sport planners, urban architects, city planners, politicians and legislators."

The International Association for the Study of Obesity (IASO)

The food industry has played a role in increasing obesity but now major global companies are beginning to make changes towards solving the problem. Initiatives to reduce the fat, sugar and salt content of processed foods and portion sizes, to increasingly introduce innovative, healthy and nutritious choices, and to review current marketing practices can accelerate health gains worldwide. A traffic-light food labelling system is being discussed, in order to make food contents and nutritional value more transparent to consumers.

Food safety

Food and health: A growing issue

The overall issue of food and health is very broad, encompassing food safety anywhere along the food chain: up from pesticide and veterinary drug residues (e.g. antibiotics, hormones) or transgenic plants down to various contaminants like heavy metals or mycotoxins. Outbreaks of diseases transferred from food, such as Salmonella and "mad cow" disease have heightened the demand for food safety standards. The avian influenza pandemic, and more recently the outbreak of porcine influenza have also highlighted the importance of the animal-human link in the food value chain (even if not transmitted through food intake). All in all, health issues are likely to gain importance in the food landscape and to increasingly shape the farming and food system of the future.

1.3 The environment is seriously damaged

Food production → ← Environmental degradation

Environmental degradation is connected to food in two ways. On one hand, it is affecting food supply by limiting yield. On the other hand, it is the result of poor agricultural practices, in several ways.

Loss of biodiversity

75% of the crop genetic base of agricultural crops has been lost during the last 50 years.

Source: IAASTD, 2009

Intensive farming practices have contributed to falling biodiversity, particularly through the use of agrichemicals. Replacing local varieties of domestic plants with high-yield or exotic varieties has in some places led to the collapse of important gene pools. Some researchers also believe that the general tendency towards genetic and ecological uniformity imposed by the development of modern agriculture, such as genetically-modified organisms (GMOs), represents a challenge to the genetic diversity of agro-systems. In Europe, populations of farmland birds, which indicate the health of

[16] Popkin (2003).

the ecosystem as a whole, have declined by almost 50% in the past 25 years.[17]

The European Commission recently published an assessment of the situation of hundreds of habitat types and over one thousand animal and plant species across the EU. Although some species such as the brown bear, the wolf and the beaver are recovering, the overall message is that the conservation status of many habitat types and species is negative. Moreover, the conservation status of all habitat types associated with agriculture is significantly worse than other types of habitat. Explanations for the decline vary: shifts towards more intensive agriculture in some areas, abandonment of the land and absence of management in others.[18]

Business-as-usual is not an option: too severe an impact on the well-being of future generations, and the "GDP of the poor"

An interim report on the economics of ecosystems and biodiversity[19] suggests that a "business-as-usual" scenario would lead to serious consequences in 2050: 11% of the natural areas remaining in 2000 could be lost (predominantly as a result of conversion for agriculture, the expansion of infrastructure and climate change), and almost 40% of the land currently under low-impact forms of agriculture could be converted to intensive agricultural use, with further biodiversity losses – and severe danger to human health and welfare. Indeed, humanity derives multiple goods and services from the environment: food, freshwater, wood, energy, protection from floods and soil erosion, pharmaceutical ingredients and recreation. The world's poor are most at risk from biodiversity loss, since they are the ones most reliant on agriculture, animal husbandry and (informal) forestry. These sectors, sometimes called the "GDP of the poor", are mostly impacted by the loss of natural capital.

Soil degradation

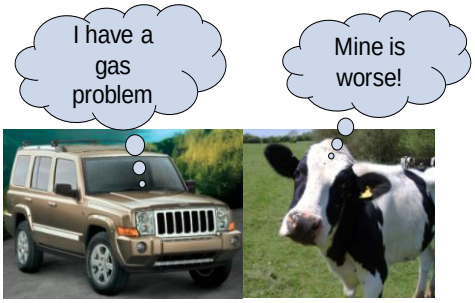
Exposure of topsoil to erosion, over-grazing and overploughing have also been a major contributor to land degradation. Farming only one type of crop on a piece of land year after year exhausts the required nutrients from the soil. Inconsiderate use of water for irrigation depletes water tables and aquifers. It can also cause salinisation: if irrigated fields are not properly drained, the water log allows salts to build up in the soil and its fertility is reduced.

"Land degradation in all its forms is a threat to food production and rural livelihoods, especially in the poorest areas of the developing world."

UN, 2008

There are disagreements over the extent and severity of degraded arable land and estimates should be considered indicative at best. According to the 1991 Global Land Assessment of Degradation, based on expert opinion, nearly 2 billion hectares[20] worldwide have been degraded since the 1950s. This amounts to 22% of all cropland, pasture, forest and woodland. Africa and Latin America appear to have the highest proportion of degraded agricultural land, Asia the highest proportion of degraded forest land.[21] The World Bank (2007) quotes a global figure of 5 to 10 million hectares of agricultural land being lost annually to severe degradation (close to the cropland area of Germany, i.e. 12 million hectares).[22] There is consensus that the problem is significant.

[17] Pan-European Common Bird Monitoring Scheme, 2007.
[18] Commission of the European Communities (2009).
[19] Sukhdev (2008).
[20] 1 ha = 10,000 m^2 (100 m x 100 m).
[21] UN (2008).
[22] The World Bank (2007).



Source: The Environmental Magazine
Motavalli (2008)

Greenhouse gases

Agriculture and food supply chains are also highly significant emitters of greenhouse gases (GHG). Agriculture currently contributes a large amount of man-made emissions: around 22% of total global GHG emissions (up to 30% if deforestation for agriculture is included).[23] The impact of the whole food supply chain on air pollution is even greater when transport and processing are included. Agriculture contributes particularly heavily to global emissions of nitrous oxide (N_20) – through fertiliser use and manures and methane (CH_4), two major GHGs, both much more potent than carbon dioxide at trapping heat in the atmosphere.[24]

Livestock are responsible for 18% of all GHG emissions, a share higher than that of GHG emissions from transportation.[25] Indeed, ruminant animals, such as cows and sheep, produce methane as a result of the digestive process. Dairy cows are particularly significant sources of methane because of the volume of food they eat. Improved nutrition through less gas-forming feedstock may help alleviate the problem. Methane and nitrous oxide emissions through manure can be mitigated by using the animal waste to produce biogas, thus also reducing dependence on fossil energy.

Water pollution

Up to 70% of fertilizer applied to crops can be lost, instead of taken up by crops, polluting groundwater sources, as well as rivers, lakes and coastal zones. Due to fertilisers over-stimulating the growth of algae or phytoplankton, robbing water and other species of oxygen, significant areas of the world's oceans are classified as "dead zones".

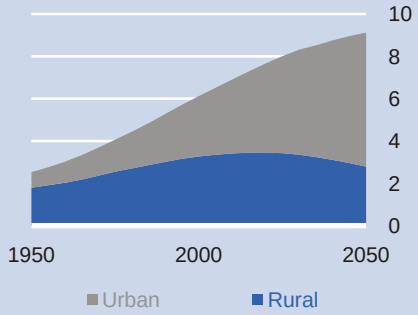
Agriculture has an additional impact on the environment through the inefficient and wasteful use of fertilisers or water: they contribute to further demand for energy resources.

Promising policies

Policies have a vital role to play in promoting agricultural production and economic growth while taking proper account of the value of natural ecosystems. Examples (further discussed below) include: measure the costs and benefits of ecosystem services, reward farmers for good land ownership, share the benefits of conservation with local communities, extend the "polluter pays" principle with market prices reflecting pollution costs.

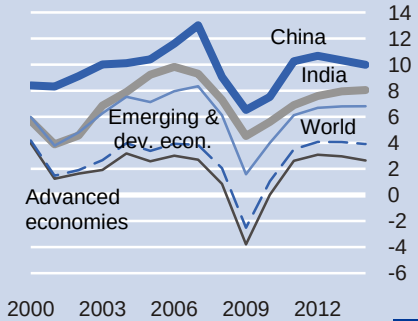
[23] IAASTD (2008).
[24] IPCC (2007).
[25] FAO (2006c).

Global population: Long march to the cities
Bn



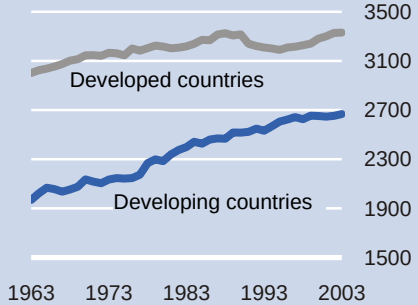
Source: UN Population Division **10**

High economic growth in the developing world ...
GDP growth, constant prices, %



Source: IMF, April 2009 **11**

... translates into increased food consumption
Kcal/capita/day



Source: FAOstat **12**

Meat in moderation rather than "all you can eat": Positive for health and environment

2. The forces driving the food equation

The world food situation is being redefined by new driving forces. Income growth, globalisation, urbanisation, high energy prices and climate change are transforming food consumption, production and markets. In this section, we investigate the forces impacting each of these three areas.

2.1 More demand for food, of a different nature

Demand for food will rise in the coming decades as a result of population growth as well as increasing affluence and rising expectations. The latter prompt more people to eat a resource-intensive diet, rich in meat and dairy products. This increases demand for crops used as animal feedstocks disproportionately.

Population growth drives up demand

Population growth is a driver of increased demand. The world population is projected to grow from 6.5 billion in 2005 to over 9 billion by 2050. This reflects a steady slowdown in the growth rate: from a peak at 2.2% per year in the last decades of the 20th century to 1.6% in 2015, 1.4% in 2015-2030 and 0.9% in 2050.[26] However, the demographic challenge is exacerbated by the fact that almost the entire population growth will take place in developing countries. It will also occur wholly in urban areas: the urban population will swell by about 3 billion people as the rural population contracts. By 2030, 60% of the world's population is expected to live in urban areas. In Africa and Asia, the urban population will have doubled by then.[27] This will affect the nature of demand.

Economic growth in the developing world boosts demand

Numerous parts of the developing world have experienced high economic growth in recent years (see chart 11), especially developing Asia, notably China and India, and to a lesser extent Sub-Saharan Africa. Even after the current slowdown in global economic expansion, the growth in developing and emerging countries is expected to remain close to 7% (compared to around 2.5% in developed economies).

This economic growth is a key force of change in demand: with higher incomes and increased purchasing power, some of the poor will become less poor and be able to afford not only more food but also more diversified food (see chart 12).

Changing nature of demand

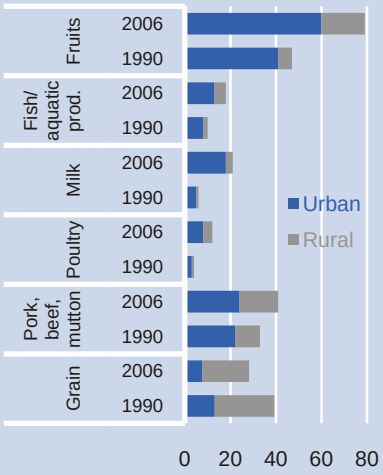
Demand is not only increasing, but changing in nature. Higher incomes, urbanisation and changing preferences are raising domestic customer demand for high-value products in developing countries.

Food consumption is shifting from grains and other staple crops to meat, dairy, fish, eggs, pulses, vegetables and fruits, especially in India and China (see chart 13). As expected, the amount and growth of intake of animal foods are positively correlated with income levels.[28]

[26] United Nations Population Division Database.
[27] Same as above. For more on urbanisation, see Just (2008).
[28] Popkin (2003).

Chinese consumption: increase and shift away from grains

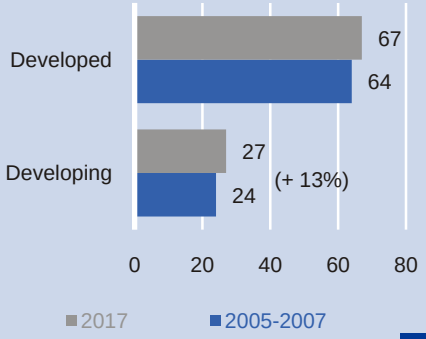
Kg per capita per year, 10 kg for grains



Sources: National Bureau of Statistics of China, IFPRI 13

More meat

Meat consumption, kg/capita



Sources: OECD, FAO 14

More milk products

Change between 2005-2007 and 2017 outside OECD:

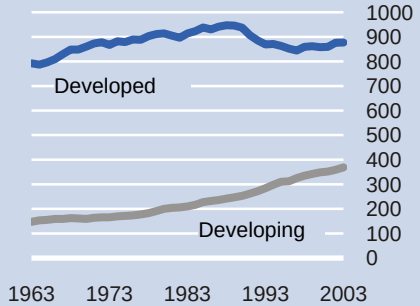
+ 20-40% overall

+ 50% for butter

Source: FAO

Consumption of animal products

Kcal/capita/day



Source: FAOstat 15

More animal proteins

Globally, economic growth in emerging and developing countries will continue to lead to changing dietary patterns, with staple foods of vegetable origin being replaced by proteins of animal origin. In 1985, Chinese people ate, on average, 20 kg of meat (compared to 97 kg in Germany); they are now eating over 50 kg (54 kg in 2003, compared to 84 kg in Germany). Protein demand in developing countries will increase with rising incomes (see charts 14 and 15), especially for low-priced foods such as poultry, pork and eggs. Population and income growth will also largely drive the global dairy consumption increases. Chart 16 displays food consumption patterns for the six major world regions: Asia, OECD (1990), Latin America (and the Caribbean), Sub-Saharan Africa, Middle East & North Africa, Former Soviet Union.

The switch to a diet rich in animal proteins – part of the nutrition transition described in 1.2 – has wide-ranging consequences on health and the environment. Because people eating meat in moderation (or not at all) enjoy lower levels of blood cholesterol, and suffer less frequently from obesity and hypertension, their life expectancies are several years greater.[29] The environmental consequences extend far beyond the impact on climate change discussed in 1.3. Livestock production consumes 8% of the world's water, mainly to irrigate feed crops for cattle. It causes 55% of land erosion and sediment. It uses 37% of all pesticides. Nitrates, heavy metals and antibiotics present in manure can seep into groundwater and pollute surface water, threatening public health.[30] A meat-intensive diet is associated with an inefficient use of natural resources: water, energy and grain. "2000 pounds of grain must be supplied to livestock in order to produce enough meat and other livestock products to support a person for a year, whereas 400 pounds of grain eaten directly will support a person for a year."[31]

Given the magnitude of these impacts, it may be worth questioning the industrial world's food habits – and considering the potential for change. According to The Lancet, "for the world's higher-income populations, GHG emissions from meat-eating warrant the same scrutiny as do those from driving and flying."[32]

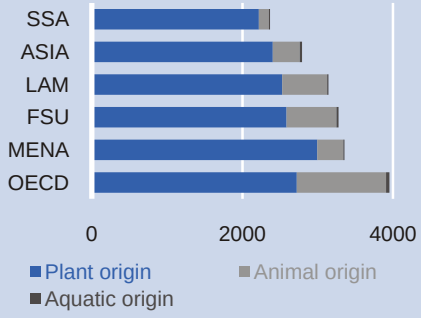
It may also be worth questioning the "inescapability" of the nutrition transition. Does the developing world really need to go through the same process integrally, or could education help skip some undesired side-effects – for both health and the environment?[33]

More convenience

More generally, changes in lifestyle and urbanisation worldwide are altering preferences and reducing the time consumers wish to spend on food preparation. The demand for ready-to-cook and ready-to-eat foods in general is rising, particularly in urban areas. These foods do not always have the same nutritional value as fresh or home-made food, and tend to have a higher environmental footprint (energy consumption during processing, additional air pollution etc.). But they address a need of predominant current lifestyles.

[29] McMichael (2007).
[30] FAO (2006c).
[31] M.E. Ensminger, the former Chair of the Department of Animal Sciences at Washington State University, quoted in Motavalli (2008).
[32] McMichael (2007).
[33] It is also important to keep in mind the other benefits of animals for transport, soils (manure), energy (biogas), clothing (leather, wool), etc.

Uneven food consumption across regions
2003, availabilities n kcal/person/day



Source: B. Dorin, based on FAO data (Inra-Cirad, 2009) 16

In terms of market size, global processed food sales are currently estimated at well over USD 3 trillion per year, or around three-quarters of total world food sales. While the majority of this value in food processing currently resides in the developed world, dietary and lifestyle changes in the developing world will drive strong growth.

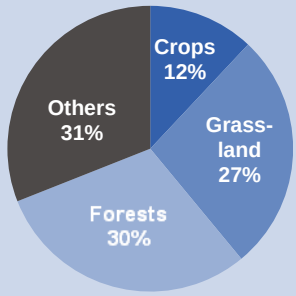
More health benefits desired

Consumers are increasingly interested in the health benefits of food. On the one hand, wholesome, organic (possibly locally grown) food is increasingly in demand by the Lohas – people engaged in a Lifestyle of Health and Sustainability. On the other, consumers have begun to look beyond the basic nutritional benefits of food, to the disease prevention and health enhancing compounds it contains. They are increasingly interested in functional foods, enriched with vitamins, minerals, fibres, omega-3 fatty acids, live cultures (e.g. probiotics) etc. Monitoring will be crucial in this fast-growing area, especially when it spreads globally, to prevent excesses and unverified claims.

Functional foods: also functional for the poor?

Interest groups include people with particular nutritional needs, such as the elderly, children, the sick, and the undernourished or malnourished. In fact, the 2008 Copenhagen Consensus ranked micronutrient supplements as the top development priority out of more than forty interventions considered for a better world.[34] For instance, enriching children's food with vitamin A and zinc has the potential to significantly reduce child mortality until a balanced diet is available.[35]

Total land: 134 million km²



Source: 2007 World Development Indicators 17

2.2 Factors affecting world food supply

According to the FAO[36], in order to feed a population of more than 9 billion and free the world from hunger, global food production must nearly double by 2050. Food production will be shaped by a multitude of factors, both natural and human-driven: land and water availability, energy supply, climate change, agricultural science and technology innovations, and access to finances. Another aspect, beyond the scope of this paper, is fisheries: aquaculture shows great potential as a food source for the 21st century.

Land constraints

Increasing the amount of land under cultivation is one means of producing more food, and is the way agriculture has grown through most of history. (Land in agricultural use has increased by 12% since the 1990s to close to 1.5 billion hectares.) In theory, there is still land potentially convertible to agricultural use. But the cost of bringing new land into production can be high, either financially or from an environmental point of view. Large investments in infrastructure would be required in Sub-Saharan countries. Subtropical and tropical forests and woodlands would need to be cut in some regions, like in Latin America.[37]

Competition for land is fierce, due to:
- Land degradation
- Urbanisation
- Biofuel crops
- Carbon sequestration (potentially)

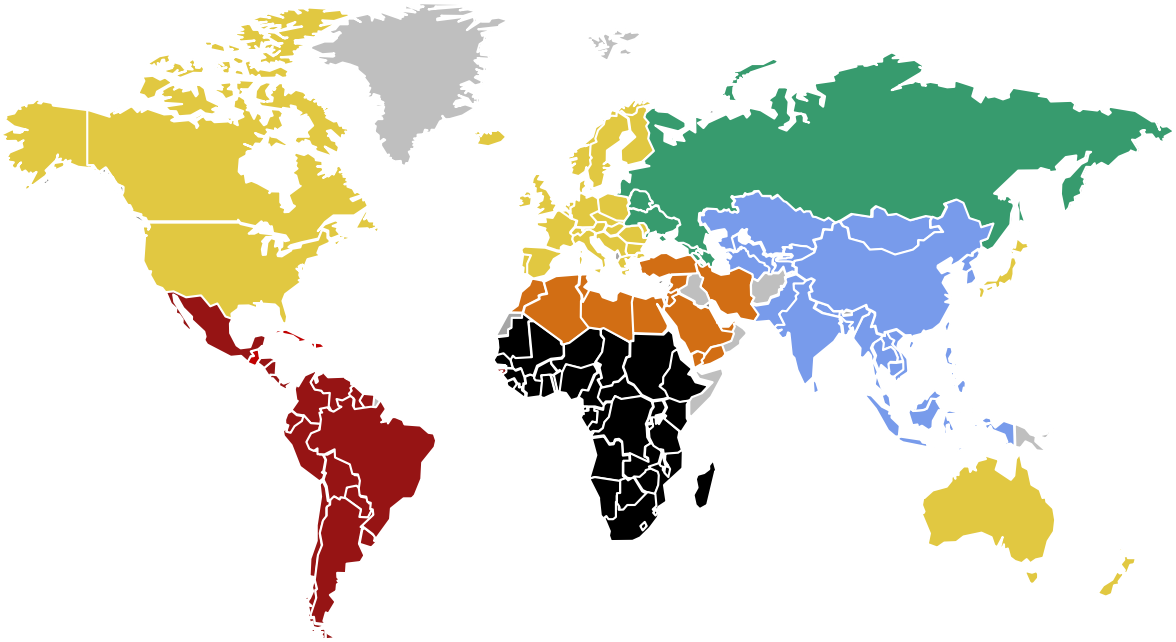
[34] www.copenhagenconsensus.com.
[35] See Horton *et al.* (2008).
[36] FAO (2008).
[37] World Bank (2007).

Land and human resources by region in 2003

Million hectares in parentheses, if not otherw ise indicated

Shares of	OECD -1990	LAM	SSA	MENA	FSU	ASIA
Forests	25% (981)	23% (922)	16% (634)	1% (35)	21% (843)	13% (533)
Pastures	22% (736)	16% (553)	24% (827)	10% (337)	11% (360)	17% (565)
Cultivated land	27% (416)	11% (164)	13% (204)	6% (90)	13% (202)	30% (462)
Arable land	23% (900)	25% (984)	26% (1054)	2% (92)	10% (409)	14% (538)
Farmers	2% (22 m)	3% (43 m)	15% (195 m)	3% (44 m)	1% (20 m)	76% (1014 m)
Population	16% (987 m)	9% (538 m)	11% (714 m)	6% (400 m)	4% (279 m)	53% (3330 m)

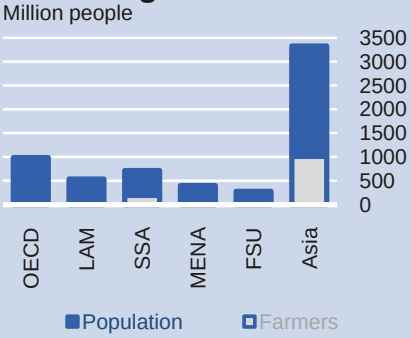
Source: B. Dorin, based on FAO data (Inra-Cirad, 2009) 18



OECD = OECD-1990
MENA = Middle East and North Africa
FSU = Former USSR
ASIA = Asia
LAM = Latin America and Caribbean
SSA = Sub-Saharan Africa

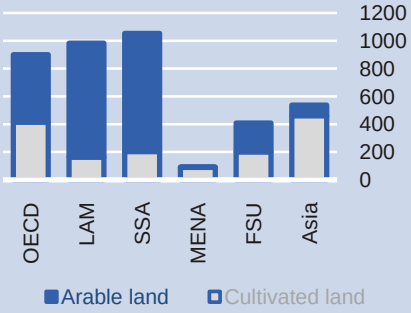
(Geographies excluded from the analysis due to lack of data are displayed in grey: Afghanistan, Antarctica, Bhutan, French Guyana, Greenland, Irak, Oman, Papua/New-Guinea, Serbia/Montenegro, Somalia and smaller states/islands.)

Population and farmers across regions
Million people



Sources: DBR, B. Dorin, FAO **19**

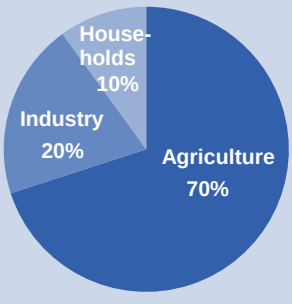
Arable and cultivated land across regions
Million hectares



Sources: DBR, B. Dorin, FAO **20**

Towards a "code of conduct" to regulate land grabbing – a potential win-win?

Agriculture uses most of the world's fresh water



Source: UN World Water Development Report, 2009 **21**

In the more densely populated parts of the world, the land frontier has closed. In 1.3 we introduced the issue of land degradation caused by poor agricultural practice. Another significant source of cropland loss is the growth of cities and infrastructure, especially roads, through soil sealing. The covering of soil negatively affects food production, directly through loss of cropland, indirectly through disruption of the ecological functions of soil in neighbouring areas: the creation of a horizontal barrier between soil and air causes disruption of water fluxes, reduces groundwater recharge and contributes to diversity loss (through habitat fragmentation). Urban growth also tends to occur on highly productive agricultural land (in floodplains and along the coasts). The problem is more acute in intensively urbanised countries like Germany or Holland.[38] Consistent land use planning is called for.

There are also new demands for land. Biofuel production takes away land which could be used to grow crops for food or feed. Carbon sequestration is to be likely driver of future demand for land.[39] Indeed, forests and stable grasslands can store large amounts of carbon in their vegetation and root systems for long periods of time. Increasing their area is one way to mitigate climate change. Existing international carbon trading rules already allow for afforestation projects to qualify for emissions trading permits, under Kyoto's Clean Development Mechanism.[40]

Nervousness about food security among countries importing agricultural commodities has led to "land grabbing". In order to secure agricultural supplies to feed their own population, some countries are investing in agricultural production in developing countries, regardless of the food situation in that country. Current and pending investments in farmland could amount to fifteen to twenty million hectares (150 to 200 billion square metres), which is around 150% of the cropland area of Germany.[41] The benefits to the host country are not clear. In the best-case scenario, capital investments in infrastructure, technology and productivity gains will contribute to rural growth and poverty reduction. But they may also stay concentrated among a few landowners.The International Food Policy Research Institute calls for regulation of investments in overseas farmland (potentially asking investors to refrain from exporting in case of food shortage in the host country). Financial institutions have a role to play as investment partners.

Water scarcity

Fresh water is becoming scarce, and this is expected to be a significant limiting factor on agricultural production capacity in the 21st century.

On one hand, water consumption per capita is increasing: 350 m^3 in 1900 and 642 m^3 in 2000 on average, per person, per year.[42] In addition, the world population is growing. Water withdrawals have tripled over the last fifty years.[43] On the other hand, fresh water availability is limited, as only a tiny fraction of the world's water is freshwater available at the surface, as lakes, soil moisture, air humidity, marshes, wetlands, rivers and in biomass. Urbanisation

[38] Montanarella and Toth (2008) as well as website from the European Commission's Institute for Environment and Sustainability.
[39] Heymann (2007), Evans (2009).
[40] Evans (2008).
[41] Estimate by Joachim von Braun, IFPRI director, reported in Nakomoto (2009).
[42] Clarke and King (2004).
[43] United Nations (2009).

and irrigation have already started depleting both surface water (rivers) and groundwater stocks.

Unsustainable water usage due to
- higher household usage
- urbanisation
- irrigation
- changing diet patterns

Agriculture is by far the most significant user of water (see chart 21) – over 90% in some developing countries. Changing diet patterns also contribute to unsustainable water usage. Part of the current pressure on water resources comes from high consumption of meat and dairy products, leading to high demand for animal feed. Indeed, there are wide discrepancies in the amounts of water needed to produce different kinds of food. Bovine meat production requires 8-10 times more water than cereal production.[44] These considerations also show how the problem can be alleviated, if the rich world could switch to a less water-intense diet.

Number of people living in countries chronically short of water:
- 2000: half a billion (out of six billion)
- 2050: four billion (out of nine billion)

Source: Clarke and King (2004)

Overall, irrigation is a crucial part of the food situation, as it has the potential to increase land productivity significantly (sometimes enabling two or even three crops a year). Today, irrigated agriculture covers about 20% of cultivated land – 275 million hectares – and accounts for 40% of global food production.[45] But water scarcity is a real challenge, which will, on balance, be exacerbated by climate change.

Technology improvement, awareness, water pricing

More sustainable water use is essential. Technology has a role to play by increasing watering efficiency, through overhead sprinkler irrigation (having an efficiency of around 75%[46]), drip irrigation (90%), rainwater tanks or water reuse (also in closed greenhouses). Raising users' awareness is essential. Water pricing (accounting for local environmental, economic and institutional conditions) can trigger reduced water use, through improving irrigation efficiency or modifying crop patterns (selection and timing, for lower irrigation requirements).[47]

Climate change

Climate change → Food production ←

According to the Intergovernmental Panel on Climate Change (IPCC), the earth is likely to warm by 0.2°C per decade for the next two decades, and to rise between 0.6°C and 4.0°C by the end of the century, depending on future emissions. Given its share of greenhouse gas emissions (see 1.3), agriculture significantly contributes to the problem. And climate change will impact food production in several ways.

Different impacts by region and crop type, driven by
- temperature increase
- carbon fertilisation
- water availability
- hurricanes and floods
- agriculture's own emissions

The direct impact of temperature increases on yields depends significantly on latitude and crop type. It is expected to be negative at lower latitudes in the coming decades, and on the globally aggregated yields in the long term.[48] Some crops may experience higher yields with a moderate temperature increase in higher latitudes, especially when the uncertain "carbon fertilisation" effect is factored in. Because CO_2 is used in photosynthesis and reduces plants' water loss through respiration, some plants are known to benefit substantially from higher CO_2 levels: wheat, rice, soybeans and legumes for instance.[49]

[44] United Nations (2009).
[45] Same as above.
[46] European Environmental Agency (2009).
[47] A new pricing initiative in Spain's Guadalquivir river basin involved both a fixed and variable charge linked to water use (altogether higher, on average, than the previous charge). It resulted in a 30% reduction in water consumption (for the same crop types). Reported in EEA (2009).
[48] IPCC (2007).
[49] Cline (2007).

Another effect of climate change on agriculture will be water availability.[50] Current models predict more precipitation at higher latitudes, and less in the tropics. Finally, climate change drives extreme weather events, such as hurricanes and floods. Their impact is often omitted in future projections.[51] With the increased risk of droughts and floods due to rising temperatures, crop-yield losses are imminent.

A huge challenge overall, especially in the South

All in all, climate change is a huge challenge for food production. Over the next few decades, there will be winners and losers, with losers concentrated in lower latitudes. Global warming was originally caused by the rich industrial nations, but the risks are particularly great in developing countries. Over the long term, humankind needs to prepare for uncomfortable consequences of climate change for agriculture and food security, especially in Africa and some parts of Asia and Latin America.

Agriculture needs to adapt

Agriculture needs to adapt, also by reducing its own emissions.[52] Well-managed crop and pasture land can sequester significant amounts of carbon and positively affect other GHG emissions (CH_4 and N_2O) – while also improving soil health and reducing erosion. Conducive practices include rotational grazing, decreasing tillage, planting cover crops, converting marginal crop land (land less suitable for crops, such as field strips adjacent to streams for instance) to trees or grass.[53] Changes in farming which have the highest potential climatic leverage involve livestock, e.g. improved forage quality to reduce methane emissions.

Energy: Supply and prices

The 20th century saw a major shift in agriculture: mechanisation and pesticides replaced human and animal labour, inorganic fertilisers replaced manure and compost. Underlying these changes, there was also a shift towards reliance on fossil fuels. Today the links between the world's food and energy economies are stronger than ever.

The links between food and energy are strong and complex

- fertilisers
- fuel for transport
- irrigation, crop drying, heating
- processing of crops and foods, refrigeration
- biofuels

The food sector uses about 10-15 percent of all energy in the industrialised countries, somewhat more in the United States.[54] Chemical fertilisers account for an important part of energy usage, the largest in developed-country agriculture. Fuel for transport, either internationally or for domestic distribution networks is another important aspect of the food-energy linkage. On farms, there is the energy needed to extract water for irrigation, dry crops, heat greenhouses and livestock sheds, and fuel tractors. Further down the value chain, there is the energy needed to process crops and foods, to provide power for refrigeration and to cook food in the home.[55] Experts argue about which part of the agriculture and food value chain uses the most energy. In a world of tighter energy supplies it is possible that a greater reliance on food grown locally, organically would be beneficial. What is clear is that the level of oil prices is highly significant for the production and distribution of food and agriculture.

Fuels → ← **Crops**

Fuels are used to produce crops, but crops are increasingly used to produce fuel.[56] A few years ago, biofuels enjoyed broad-based

[50] Heymann (2007).
[51] Evans (2008).
[52] For more on agriculture and climate change, see Kahn and Zaks (2009).
[53] Bongen (2003).
[54] Hawken (1999).
[55] FAO (2008a).
[56] Auer (2005).

support because of their role in reducing CO_2 emissions and lowering dependence on oil. They are now widely debated because of their environmental, economic and social impacts.[57] Indeed, the additional land requirement leads to the destruction of ecosystems – which normally remove CO_2 from the atmosphere – and, during the manufacturing and refining process, biofuels sometimes use up more energy than they save. They have also significantly contributed to rising global food prices, according to most estimates.

The competition between food and fuel is real: the grain required to fill the tank of a sport utility vehicle with ethanol (240 kg of corn for 100 l of ethanol) could feed one person for a year.[58] Even if part of the supply comes from imports, producing substantial amounts of wheat and rapeseed leads to tough competition for land usage. In Germany, the acreage of land for growing renewable energies was estimated at 1.75 million hectares in 2008 (15% of the total cropland area).[59] Second-generation biofuels – using other sources of biomass (cellulose from wood or even waste) – are still in the developmental stage but show higher potential benefits.[60]

Demand for oil is likely to remain weaker during the economic downturn. Longer term, an oil-supply crunch is likely, both because of below-ground resource constraints and because of inadequate investment by oil companies to develop new oil supplies – requiring people, equipment and engineering skills.

Food prices and oil prices are linked increasingly closely, and higher oil prices will tend to contribute to higher food prices.

Access to finance

In the two decades preceding the recent spike in food prices, the slump in commodity prices resulted in a drastic decline in aid and government spending on agriculture. The amount spent on agricultural research and development fell dramatically too. There is widespread consensus on the need to reverse these trends, from the FAO, the UN and the World Bank, even though estimates of how much money is required vary widely: from 5 billion dollars now and 9 billion dollars medium term to 30 billion dollars a year.[61] The recent G8 summit in l'Aquila also highlighted the need for more funding.

Public investment in agricultural research and development (R&D) is particularly important for research focused on the needs of poor countries and poor farmers: indeed, this research tends to be associated with longer time-horizons and more uncertain outcomes. By contrast, profit-driven private-sector R&D tends to focus on a few major high-value crops and profitable markets.[62]

The issue of financing for individual farmers is discussed in 3.3.

Technological innovation

Given demand growth and resource scarcity, the agriculture industry faces the challenge of producing more and better food with fewer resources. Globally the average hectare of arable land supported 2.4 persons in 1960, 4.5 persons in 2005 and, according to some estimates[63], is required to support over 6 persons by 2050. But the

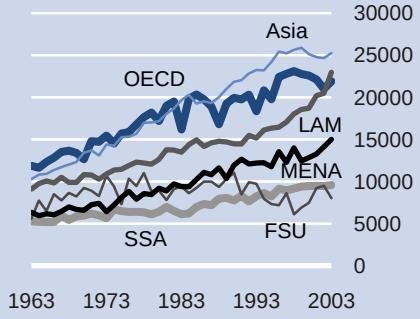
Agriculture: the neglected child of aid donors and developing countries' governments

- Proportion of official development assistance aid going to agriculture:
- 17% in 1980, 3% in 2006
- Total amount of aid spent on agriculture in real terms: -58%, between 1980 and 2006
- Proportion of public spending for agriculture in Africa: 4.5% in spite of an African Union target of 10% by 2008
- Budget of the Consultative Group on International Agricultural Research (CGIAR), key coordinating body for public investment in agricultural R&D: -50% over the past 15 years

Source: UN, 2008; Evans, 2009

Uneven yield increases products

Plant food production per ha of cultivated land, kcal/ha/day



Source: B. Dorin, based on FAO data (Inra-Cirad, 2009) 22

[57] See, for instance, Dorin and Gitz (2008).
[58] World Bank (2007).
[59] Fachagentur Nachwachsende Rohstoffe.
[60] Inderwildi (2009).
[61] World Bank (2008).
[62] Evans (2008), Toennissen (2008).
[63] IASSTD (2009).

rate of growth in agricultural productivity is declining: from 2.3% a year since 1961 to 1.5% up to 2030, forecast at 0.9% between 2030 and 2050[64].

R&D had a key role in the Green Revolution's success, and was then focused on input intensity. Now, the approach to innovations tends to be knowledge-intensive.[65] Future prospects in agricultural R&D fall into two categories.

Yield improvement through life sciences and biotechnology

It is not clear how much further the yield potential of the world's main cereal crops – wheat, rice and maize – can be raised. However, in the fields, crop yields rarely reach their theoretical potential, because of constraints such as water, nutrients, imperfect adaptation to local environments, and pests, diseases and weeds.[66] Biotechnology has potential to deliver in this area, in three forms.[67]

The Green Revolution (1): successes and limitations

- Three central elements: (i) new high-yield seed varieties, (ii) fertilisers, and (iii) irrigation – also building on the mechanisation of agriculture, which started a few decades earlier
- Astonishing result: global aggregate food production has kept pace with population growth, which more than doubled between 1960 and 2009.
- Major drawbacks: environmental degradation and pollution, unequally shared benefits, and diminishing returns.

(1) Began in Mexico in 1943, as a new venture was set up by the country's Ministry of Agriculture and the Rockefeller Foundation

Tissue culture, marker-aided selection and genetic engineering

Tissue culture allows the rapid dissemination of improved varieties of crops which traditionally have low multiplication ratios (e.g. cassava, sweet potato and banana). Based on scientists' ability to detect specific DNA sequences, marker-aided selection is useful in breeding particular traits such as: improved resistance of crops to weeds and pests, greater root depth and vigour, or higher drought tolerance. Genetic engineering is a collection of techniques enabling scientists to move genes from one organism to another, including between species. For instance, it is applied to produce vitamin A-enriched golden rice, or crops resistant to chewing and boring insects. For the next generation of genetically modified (GM) crops, R&D is focusing on traits like allowing crops to cope with too much or not enough water, extremes of temperature, salinised or acidified soils. These advances have the potential to improve both the resilience of crops (to climate change and land degradation) and their sustainability, if they are more efficient in their use of water.

GM foods highly controversial, due to uncertainties, in terms of

- safety
- environmental impact
- access and intellectual property
- ethics

At the same time, they bring about the risk of pests and weeds evolving that will be resistant to GM technologies. The experience of the Green Revolution has shown how real this risk is: in 1993, excessive application of new insecticides and herbicides meant that 700 pests, 200 pathogens and 30 weeds had already developed resistance to agrochemicals.[68] The safety of GM products is currently a highly controversial topic, particularly since there is no way of knowing the long-term impacts. An additional crucial issue associated with genetic engineering is the challenge of intellectual property rights (IPR). It is important that farmers be allowed to save and replant seeds, since poor farmers cannot afford to purchase new seeds for each planting.[69] This area is too critical to be left exclusively to the private sector, given its interest in maximising shareholders' profit.

Substituting information for resources: precision agriculture and mobile phones

Information and Communication Technology is increasingly used in large-scale agriculture in order to fine-tune sowing density as well as chemical and water usage. Precision farming relies on Global Positioning Systems (GPS), sensors and sometimes aerial images to understand in-field variability, with expected benefits in terms of yields, costs and the environment. Less high-tech mobile phones

[64] IASSTD (2009).
[65] For more on closing the production gap, see Kahn and Zaks (2009).
[66] Evans (1998).
[67] Toennissen *et al.* (2003).
[68] Thacker (1993).
[69] Toennissen (2008).

have however proved very useful in accessing timely data on input prices, environmental conditions or weather, thus contributing to cost reduction and yield increases.

Ecologically integrated approaches

From input intensity to knowledge intensity, with two approaches to increased yields, crop resilience and sustainability

- High-tech through life sciences and biotechnology, or
- Focus on whole systems rather than individual crops

Rather than working just with individual crops, the resilience and resource use of crops may also be improved through working with whole systems[70]: for instance, through integrating natural biological and ecological approaches (soil regeneration, predation and parasitism) into food production. Examples of integrated approaches include

- Integrated pest management (pest control through natural predators and parasites),
- Integrated soil fertility management (soil fertility improvement through combined use of chemical fertilisers and organic approaches: composts, manures and nitrogen-fixing plants)[71],
- Conservation agriculture (minimising soil disturbance by reducing tillage and ploughing, maintaining permanent organic soil cover and ensuring proper crop rotation, all of which result in healthier soil, enhanced carbon sequestration, as well as reduced water, energy and workload),
- More sustainable water use (through overhead sprinkler irrigation, drip irrigation or water “harvesting”) and
- Livestock management (through converting manure into biogas, for instance).[72]

Another dimension of the two approaches: equitability

- Top-down for high-tech
- Participative for ecologically integrated approaches

The two approaches described above can be differentiated along another dimension: the extent to which they contribute to equity and poverty reduction. In the pure life-sciences approach, knowledge is heavily concentrated upstream, in the laboratories of biotechnology companies and seed companies. It then moves downstream to the farmers, who apply the technologies in their fields. They are dependent on biotech companies for future crop plantings, if the engineered crop strains do not produce new seed, or if these companies do not allow the farmers to sow those new seeds.

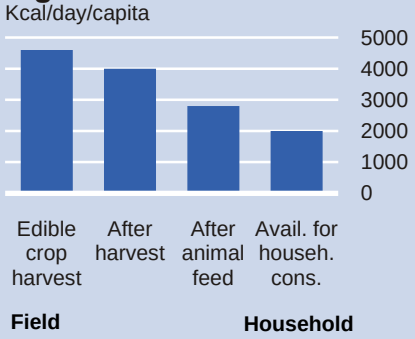
In contrast, the ecologically integrated approaches are more participative, replacing investment in chemicals and pest-surveillance systems by investment in people. They distribute power and autonomy outwards, to individual farmers.[73]

Creating the right environment for new technology adoption and multiplier effects: innovations in organisations, institutions, policies

Generally, a cross-sectoral approach to agricultural research is key, integrating specialists in agronomy, pathology, genetics, nutrition, as well as economists and sociologists. And for effective transfers, it is best to involve farmers from the beginning.[74] For lasting improvement, it is indeed important to link technological progress with other kinds of innovations.[75] (i) Organisations covering research, input supplies, marketing, education or extension[76] benefit from innovations in the areas of capacity strengthening, strategic planning, financing and evaluation. For instance, extension is undergoing broad organisational reforms in the areas of

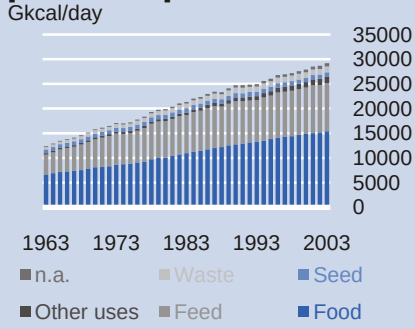
[70] Hawkens (1999).
[71] This is the approach used by the Alliance for a Green Revolution in Africa: see Toennissen et al. (2008).
[72] Evans (2009), BirdLife (2009).
[73] Hawken (1999), Evans (2008).
[74] Riba (2008).
[75] Asenso-Okyere et al. (2008).
[76] Extension refers to agricultural advisory services: supporting farmers in obtaining knowledge, skills and technologies.

Food losses: A gross estimate
Kcal/day/capita



Source: United Nations Environment Programme **23**

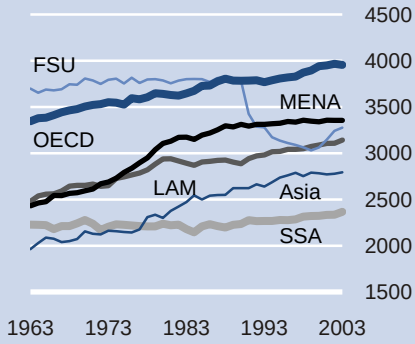
Utilisation of the world plant food production
Gkcal/day



Source : B. Dorin, computed from FAO data, Inra-Cirad, 2009 **24**

Waste as a resource

Total calories available for food
Kcal/day/capita



Source: B. Dorin, computed from FAO data, Inra-Cirad, 2009 **25**

decentralization, privatisation, outsourcing. (ii) Innovations for institutions (defined as the system of rules: laws, regulations, traditions etc. constituting the environment in which innovation occurs) refer particularly to the roles of public-private partnerships, social networks and participatory research. Their benefits are knowledge and risk-sharing advantages, economies of scale and potential synergies. (iii) Policies also need to be monitored and evaluated, in order to rectify faulty programmes. For instance, subsidising fertiliser may be desirable, but care must be taken that such action does not distort the market and lead to excess demand.[77]

Food waste: To be reduced or recycled

Food supply is not only a function of production, but also of food energy efficiency. Not all food produced is available for human consumption: this is the case for only an estimated 43% of the cereal crops produced, as a result of harvest, post-harvest distribution losses and use of cereal for animal feed.[78] Additionally, households do not consume all that reaches their home. In Europe, consumers throw away considerable amounts of food that could be eaten, up to 30% of all food purchased, according to the European Commission. The average British household throws away food worth hundreds of pounds each year.[79]

The impact of food waste is not just the decrease in food availability and associated financial losses. It is also environmental: wasteful use of water, chemicals and fuel for transportation, and more methane emissions through food rotting.[80]

Apart from reducing waste, food energy efficiency can be increased by recycling waste. With new technology, waste along the human food supply chain could be used as a substitute for cereal in animal feed. Additional cereal would then be available as food rather than feed, and this without additional pressure on natural resources. Recovering energy from agricultural waste is already done small-scale in some countries (countless households in India produce biogas out of manure for their cooking needs), and it is becoming increasingly feasible at the industrial production level. Investment in technology enhancement and innovation for waste management systems is called for to support renewable energy, an expanding green economy.

2.3 Access to food

Food security is achieved when "all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life."

1996 World Food Summit, Rome – UN Food and Agriculture Organization.

The reason why almost one billion people go hungry today is not a global lack of food (over one billion people are actually overweight, mostly due to over-eating). Rather, poor people lack access to food.

[77] See for instance Dorin and Landy (2009).
[78] UNEP (2009).
[79] Cabinet Office UK (2008).
[80] The UK-based WRAP (Waste and Resource Action Programme) estimates the contribution to global warming of food going to landfills: if food were not discarded this way, the level of GHG abatement would be equivalent to removing 1 in 5 cars from the road.

We will discuss in this section the issue of food prices, trade and concentration in the agribusiness.

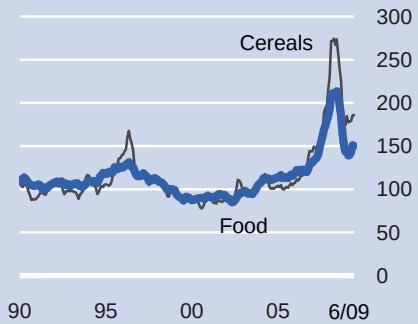
Another critical driving force of access to food is beyond the scope of this paper: social protection, allowing recipients to afford more or better food. This includes emergency safety nets but also, most importantly, systems which chronically protect poor people from a food crisis. They can be growth-promoting and have a transformational political impact. Recent innovations in social safety nets focus on improved targeting and an increased impact on capital creation – for instance through conditional cash transfer schemes and interventions, which are linked to conditions such as school attendance, working or accessing healthcare.[81] This is a sure incentive for the recipients to help themselves, thus benefiting beyond the cash transfer. In addition to the intrinsic value of the transfers in creating a fairer society, these social protection programmes have an instrumental function in promoting economic growth.

Food prices: Balancing supply and demand, and beyond

The changes in supply and demand have led to imbalances and drastic price changes. Income and population growth, rising energy prices, and subsidised biofuel production have contributed to surging consumption of agricultural products.[82] At the same time, productivity and output growth have been impaired by natural resource constraints, underinvestment in rural infrastructure and agricultural science, farmers' limited access to agricultural inputs and weather disruptions. Speculation has also contributed to price increases.[83] The consumption of cereals has been consistently higher than production in recent years, which has reduced stocks.

2000-2006: World demand for cereals increased by 8% (mostly for industrial processes, such as biofuel production), cereal prices by 50%

Source: FAO, 2008



26

And agricultural supply responds modestly (and with a time lag) to price changes: typically, aggregate agricultural supply increases by 1 to 2% when prices increase by 10%, with significant differences between crops.[84] This is partly due to imperfect competition along the supply chain, from producer to consumer (see discussion on the corporate food system below): increased demand translates into higher prices for the consumer, but the farmers often do not experience these higher prices[85], which limits their incentive to increase supply. Market entry barriers and high costs (of fertilisers, seeds, energy or additional land) also impede their ability to boost supply in the short term. In the long term, though, high prices may trigger investment in technology or reforms (of property rights, for instance), which potentially lead to higher output.

The major food crisis of 2007-2008 …

The price of nearly every agricultural commodity sharply increased in 2007 and 2008, creating a global food price bubble. At their peaks in the second quarter of 2008, world prices of wheat and maize were three times higher than at the beginning of 2003, and the price of rice was five times higher. Dairy products, meat, palm oil, and cassava also experienced sharp price hikes. The prices of butter and milk, for example, tripled between 2003 and 2008, and the prices of beef and poultry doubled.

… is alleviated by the global financial crisis …

The unfolding global financial crisis and economic slowdown have now pushed food prices to lower levels by decreasing demand for

[81] Alderman and Hoddinott (2007).
[82] See for instance FAO (2008) or IFPRI (2007).
[83] See for instance Miguel et al. (2009) and von Braun (2007).
[84] Von Braun (2007).
[85] Dorin (2008).

agricultural commodities for food, feed and fuel. Prices for most agricultural commodities have dropped significantly and swiftly in recent months (even if some are on the increase again, like oil and sugar prices).

… but the structural factors remain

At first sight, lower prices are good news for the global food system. Falling prices have benefited from recovering global supplies but they are being driven downwards mainly by slowing demand. Even with the abundance of the latest cereals crop and stocks being replenished, the world's food problems have not been fixed, in view of the longer-term challenges. The increase in food commodities prices leading to the 2007-2008 food crisis was driven by new and ongoing forces as discussed above. These fundamental, longer-term issues are still relevant.

Little benefit of high prices to poor producers

The impacts of high food prices have been felt by poor people worldwide, including in many middle and even upper-income countries. The benefits of higher prices have not accrued to many smallholder farmers in developing countries for several reasons. First of all, the poor subsistence producers tend to be net food buyers. Higher prices of key agricultural inputs such as fertilisers, seeds and energy also made it more difficult for all farmers to step up production. Moreover, export taxes (e.g. in Argentina) and restrictions meant that high international prices were not always and not fully transmitted to domestic markets. This was an extra burden even for commercial farmers confronted with higher costs and stagnant output prices.

Food prices on a long-term upward trend for structural reasons

Food prices, on the whole, have dropped since June 2008, but still remain above 2006 levels (see chart 26). They remain problematic for low-income import-dependent countries and poor people worldwide. As discussed in 1.1, the FAO expects an additional 100 million hungry people in 2009. In the medium and longer term, technological progress and trade liberalisation are expected to affect food prices downwards. But the long-term resource scarcity trends discussed above (of land, water and energy, exacerbated by climate change) combined with increasing demand point towards a rise in food prices.

Trade and globalisation

Significant impact of food prices

The policy response to soaring food prices has been wide-ranging, from reducing grain import tariffs to imposing export controls. Agricultural trade has been significantly impacted by rising food prices, particularly through export restrictions (in the form of bans, quotas or taxes), in particular for rice and wheat. Governments of at least thirty countries had implemented export restrictions by July 2008[86] as a means to promote domestic food security.

The gap between economic theory (free trade is best for all) …

Although export restrictions may bring some short-term relief to selected domestic consumers, economic analysis clearly shows that their overall impact on the domestic economy as well as on the rest of the world is negative.[87] A more open trade regime would benefit developing countries in general. Significant economic gains would be achieved by improving market access between the OECD and developing countries, and among developing countries, even if large advances in poverty reduction were only to occur in rare cases and over a longer time span.[88]

[86] World Bank (2007).
[87] Mitra and Jostling (2008), von Braun (2007) among others.
[88] Bouet (2007).

… and political reality …

The political reality, however, is that after the recent shock to the system, increased dependency on overseas suppliers is likely to be an unattractive option for importers, unwilling to take the risk. Poorer countries are likely to be aware of the fact that, in a scarcity context where food supply falls further behind demand, a liberalised trade regime would put them at a disadvantage if richer countries are simply able to outbid them. These concerns must be taken seriously and integrated into trade rules as much as possible in order to avoid an uncoordinated lapse into protectionism: poor countries would stand to lose out heavily.[89]

… is exacerbated by biased agricultural trade rules

In fact, existing agricultural trade rules are primarily focused on the problems of exporters and have largely ignored the importers' main problem, which is unreliability of supply. The World Trade Organization (WTO) is designed to resolve arguments about market access and dumping – disputes expected in a long-term buyers' market, which prevailed until recently. Lately, trade in food has become a sellers' market, and supply concerns – both security of supply and unfair suspensions of supply – have to be built into trade reform. One way is through pushing forward with existing development priorities in agricultural trade, for instance in the EU Common Agricultural Policy.

"The current global agricultural trade system structurally favors production among wealthy countries and disadvantages producers in poor developing countries: redressing that balance needs to become a strategic priority in the years ahead"

The Center for Strategic and International Studies

Currently, developed-country trade barriers discriminate against imports from developing countries, and subsidised developed-country exports to developing markets have been called "dumping" (including through food aid). Policy-makers need to examine options to create buffers in the international trade system in order to make it more resilient to shocks and stresses.[90] The option to create a physical, public, globally managed grain reserve is discussed in Section 4.

Multilateral discussions toward further trade liberalisation and the integration of developing countries into the global economy are currently deadlocked, due to divisions and lack of political commitment. In reaction to the lack of progress of the Doha Round, many countries are increasingly engaging in regional and bilateral trade agreements.

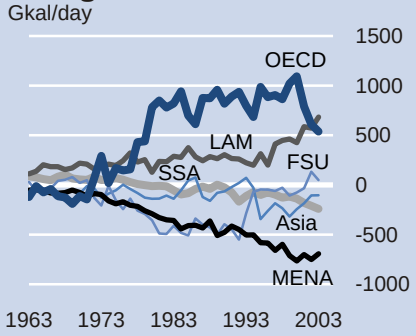
A few data on trade

- International trade in agriculture represents 10% of world trade
- 25% of the world's food production is traded globally (for industrial goods: 50%), most of which is processed food
- Between 2000 and 2007, the agricultural exports of developing countries to the developed grew by 11% per year, in the opposite direction by 9%
- The world's trade-weighted average industrial goods tariff is about 8%, in agriculture it is 25% (with peaks up to 1000%)

Sources: UN, 2008; Evans, 2009

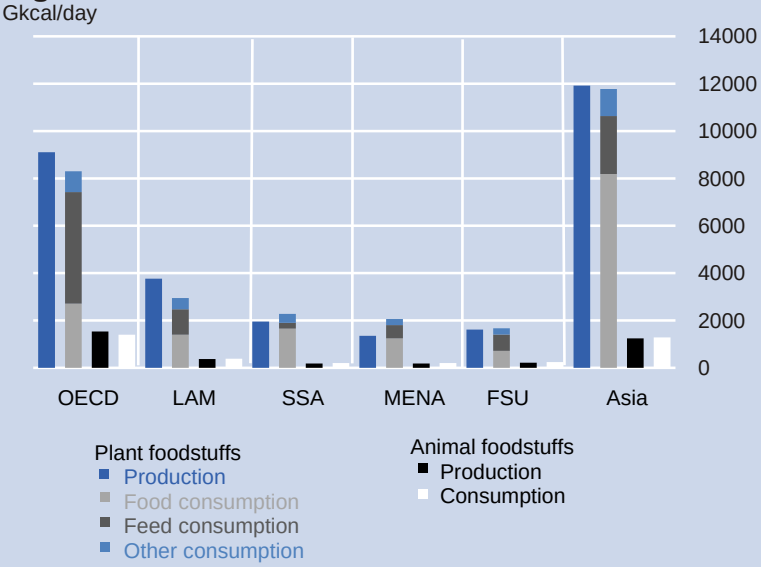
Developed countries still dominate world agricultural exports, but middle-income countries have been gaining ground. Latin America, in particular, stands out as a large and fast-growing net agricultural exporter (see chart 27). The epicentre of global agriculture is expected to further shift from the OECD towards developing countries. Both consumption and production are growing faster in developing countries for all products except wheat. By 2017, these countries are expected to dominate production and consumption of most food commodities, with the exception of coarse grains, cheese and skim-milk powder.[91]

[89] Sprissler (2009), Evans (2009).
[90] Evans (2009).
[91] FAO (2008c).

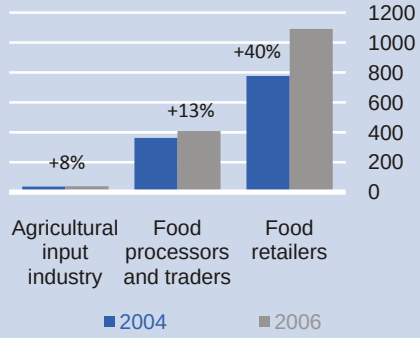


Source: B. Dorin, computed from FAO data, Inra-Cirad, 2009 **27**

In terms of volume, increased trade in agricultural commodities and food products is anticipated given the limited availability of arable land per capita in the key demand-growth markets, particularly in Asia. At the same time, international trade is expected to be constrained in a context in which climate change is being carefully addressed: if mitigation involves a systematic consideration of the environmental footprint of all activities, transport may be reduced.



Source: B. Dorin, based on FAO data (Inra-Cirad, 2009) **28**



Source: IFPRI **29**

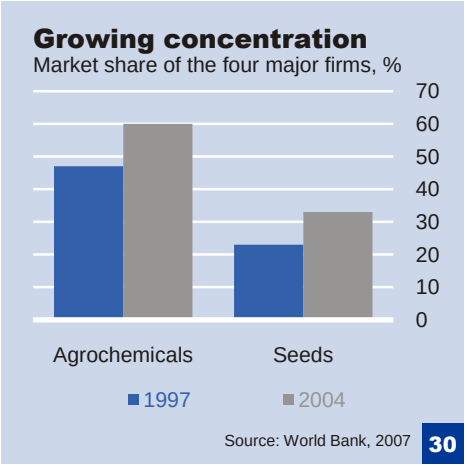
The corporate food system

Driven by gains from economies of scale and globalisation of the food chain, multinational companies increasingly dominate the food sector along the value chain. National, regional, and global supply chains are being radically altered, bypassing traditional markets where smallholders sell to local markets and traders. Supermarkets control 60 to 70 percent of food sales in Argentina and Brazil, and are expanding rapidly in China, India and urban Africa.[92] Independent grocers continue to dominate the market in Vietnam (85% of retail sales) and India (77% of retail sales).[93]

Consolidations all along the value chain have concentrated the market power and leverage of large international corporations, transforming the opportunities for small producers.[94] Better prospects and access to markets have however also come with new requirements in terms of food safety and quality standards. Whereas this is positive for consumers, it sometimes creates a barrier to entry for small agricultural producers, especially in developing countries, until they get organised (as cooperatives or public-private partnerships).

Sales along the corporate food chain have increased in the past years. Most noticeably, the sales of the top ten retailers grew by more than 40% between 2004 and 2006 (see chart 29). The

[92] World Bank (2007).
[93] Euromonitor (2007).
[94] More on this in Dorin (2008).



corresponding increases for food processors and agro-input industries rose by 13% and 8% respectively.

Horizontal consolidation in the agricultural-input industry (agrochemicals, seeds and equipment) continues globally (the top three companies account for about half of the total market). In contrast, the market share of the top five retailers does not exceed 13%, with wide regional differences (57% in Venezuela, 4% in Indonesia).[95] For biotechnology patents, the market share of the four largest firms was 38% in 2004. In some subsectors, global concentration is much higher – in 2004 one company had 91% of the worldwide transgenic soybean market.[96] Vertical integration of the food supply chain is taking place, increasing the synergies between agricultural inputs, processing and retail. In the future, a few multinational companies are expected to dominate the market. Retail chains are likely to increase their influence on the whole value chain.

Key role of policies

In this Section 2, we have reviewed various factors driving the food situation, in terms of demand, production and access to food. One driver – already discussed and elaborated on below – overlaps these three categories: policies. Policies play a crucial role in driving the food situation. For example, they have already had an important impact in the areas of food production (most obviously with the implementation of quotas), trade or biofuel development (with impacts on land availability and GHG emissions).

3. Future food landscape

In Section 2 we discussed the various forces shaping the global food landscape. What major challenges can be expected from this evidence? We summarise below the major issues surrounding global food security in the 21st century and discuss some ways to tackle these challenges.

3.1 A scarce environment

Scarcity issues are expected to plague world food and agriculture over the next few decades: competition for land and water, high energy prices and climate change all mean that the world has to produce more with less.

The interconnected challenges of water, land, energy and climate change

The magnitude of the upcoming scarcity is next to impossible to forecast. Indeed, there is a high degree of uncertainty across all issues, be it land or water availability, energy issues (oil prices, biofuel production) or the effects of climate change. Moreover, these issues are highly interconnected, which adds to the uncertainty: food production is both part of the problem and part of the solution when it comes to climate change and energy. Additionally, water availability depends on energy inputs, thus contributing to climate change, which in turn affects water availability. “Future interactions between scarcity issues will be shaped by complex feedback loops and by human attempts to mitigate them, making it difficult or impossible to predict how these linkages will play out in future.”[97] What is clear is that scarcity issues are here to stay, long term, and are a challenge to innovation.

[95] Euromonitor (2007).
[96] World Bank (2007).
[97] Evans (2009).

The challenge is particularly acute in developing countries

These scarcity issues are poised to affect poor countries more seriously. Water scarcity and climate change on one hand, population growth on the other hand, are more acute in their geographical areas. This will further affect developing countries' capacity to adapt to scarcity, and to adopt some Green Revolution approaches (mechanisation, irrigation, fertilisers) where needed.

More uncertainties

Other sources of uncertainty in assessing future food security include on the supply side technological advances in food production as well as impacts of pests and diseases; on the demand side actual versus predicted population growth (also potentially affected by major disease outbreaks in humans) and human behaviour, in terms of food preferences, ability to adapt to changing conditions of food supply, as well as the degree of commitment to more equitable distribution of resources. Catastrophic events may also affect both sides of the equation, such as major wars, earthquakes, droughts, floods or volcanic events.

3.2 Sustainability: A must

Resilience, sustainability and equity

We need sustained growth in the agricultural sector to feed the world, to enhance rural livelihoods, to stimulate economic growth. We also need to meet food safety standards – all this in an environmentally and socially sustainable manner. While it is critical to boost food production, the world's systems for producing and distributing food will also need to change along three lines: more resilience – to help mitigate the impacts of shocks and stresses (such as extreme weather events or spikes in oil prices), more sustainability (more considerate use of resources), and more equity, to enable access and entitlement to food.[98]

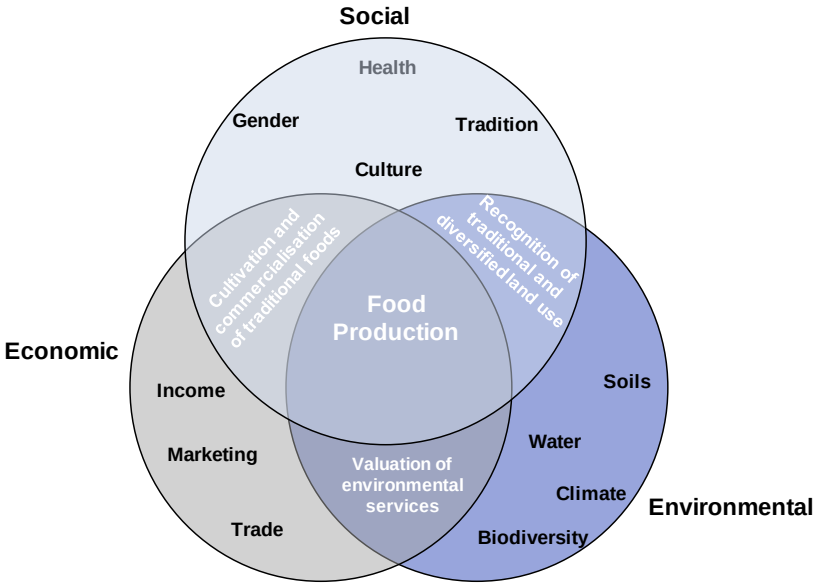
Farming must change

"Increased attention needs to be directed towards new and successful existing approaches, to maintain and restore soil fertility and to maintain sustainable production, through practices such as low-input resource-conserving technologies based on integrated management systems."

Source: IAASTD, 2009

Farming must change to feed the world. There is no one-size-fits-all farming method, as each region has its own optimal (green) ways to boost food production. In Africa, for instance, the Alliance for a Green Revolution in Africa (AGRA) focuses on boosting the production of small-scale farmers with better agricultural technology through Integrated Soil Fertility Management: choice of improved varieties, judicious use of chemical fertiliser together with locally adapted organic fertiliser and appropriate combinations of crops (e.g. cereal-legume, like maize-soybean).[99] Another stream promotes organic practices (e.g. use a cover crop like spring onions as natural pest control, use of composts etc.), that can be as productive as industrial farming, but far more sustainable. While organic farms require more labour, they save in commercial nitrogen, insecticides and herbicides, with net savings, especially in Africa where labour is cheap and capital scarce.[100] In Africa, organic farming is especially well-suited for high-value commodities to export.

[98] World Bank (2007), Evans (2009).
[99] Toenniessen et al. (2008).
[100] Organic farms also have a positive effect on farm workers' health. in India's Darjeeling region, hospital admissions for respiratory diseases have drastically reduced since tea plantations started moving to organic production.



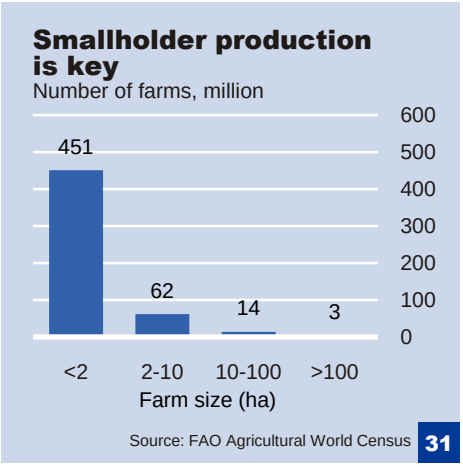
The different roles and functions of food production and their inescapable interconnectedness

Source: IAASTD, 2009

3.3 From subsistence farming to commercial farming

"The potential of agriculture to contribute to growth and poverty reduction depends on the productivity of small farms."

World Development Report 2008



About two-thirds of the 3 billion rural people in the world live off the income generated by farming less than two hectares.[101] These 500 million small farms have a crucial role to play when it comes to equity and poverty reduction.[102] Indeed, agricultural growth that includes smallholders boosts food availability and incomes, and thus generates demand for locally produced goods and services, resulting in broad-based socio-economic development in rural communities. Small farms are also particularly resilient: their size makes them more flexible, and their farmers can react to changes more readily. Even if larger farms are usually considered more efficient in terms of land or crop productivity, small farms can be very productive when productivity at large (total factor productivity) is considered – including labour and capital.[103] So what are the conditions for smallholder farming to grow successfully?

Land reform: a key to land and water access

Access to assets (land, water, machinery) is an obvious prerequisite for farmers. Land is a basic asset, and equitable land distribution has been shown to go together with economic growth.[104] In practice, however, small farmers' access to land is often undermined by insecure property rights or corruption leading to illegal seizures of land. This is a particular problem for women.[105] Land reform can be beneficial in providing access to landless people, and in encouraging farmers to look at the long-term sustainability of their land management practices. Similarly, equitable access to water, in a sustainable way, requires effective governance mechanisms.[106]

[101] World Bank (2007).
[102] See for instance Hazell et al. (2007).
[103] See for instance World Bank (2007).
[104] Quoted in Green (2009).
[105] World Bank (2007).
[106] Evans (2008).

Developing markets for poor farmers in a changing landscape: new challenges, and opportunities …

Access to functioning markets for both staples and high-value commodities (such as vegetables, fruits, fish, nuts, spices and flowers) is a key requirement for smallholders to move from subsistence farming to commercial farming. In many developing countries, smallholder participation is often constrained by:

— a lack of infrastructure (roads and storage facilities);

— poor market information;

— inadequate and poorly enforced grades and standards and

— poor farmer organisation for bulk marketing.[107] With the advance of globalisation, the sales channels are changing: less through traditional markets, more through multinational food companies and supermarkets. This increases both the need to address the above constraints and the challenges associated with them.

… especially through cooperative behaviour

Smallholders can benefit from these changes, if they are able to respond with the volumes and quality standards usually required by big companies. Well-managed cooperatives or public-private partnerships can be good enablers, at the same time reducing marketing costs. Farmer organisations, the government or private companies can also play a useful role in disseminating price and other marketing information, with internet and mobile phones replacing radio and newspapers. As discussed above, another aspect of market access for small farmers is ensuring that they do not have to compete with highly subsidised exports from developed countries.

Access to knowledge is also key to farmers' success, especially in the context of limited land resources. Many small-scale farmers of the developing world have benefited little from past innovations originating from scientists or other farmers. Governments and the private sector have a role to play in supporting the transfer of knowledge and technology to smallholders, as well as the sharing of best practice among them.

Dominance of informal credit lenders

Access to affordable credit is insufficient for the majority of small-scale producers. On top of allowing them to use the basic inputs, appropriate financial arrangements can help them to be more productive by allowing them to invest in technology and innovation. Rural households in developing countries are still largely reliant, for their financial needs, on informal providers. They include rotating savings and credit associations[108], money lenders, pawn-shops, businesses that provide financing to their customers, and friends and relatives. The dominance of informal lenders as credit source is even greater among poor rural households. For instance, in Pakistan and Cameroon, less than 5 per cent of the amount borrowed by poor rural households in 1998 was obtained from formal lenders, including banks and microfinance institutions[109].

A (historical) gap to be filled

Public-sector bodies used to play a key role in providing access to markets, credit and knowledge during the heyday of aid investment in agriculture, even if they were often corrupt and inefficient. In many developing countries, they were rolled back or abolished under structural reform programmes mandated by international institutions in the 1980s and 1990s. Their role is beginning to be filled by private companies, public/private partnerships or NGOs.

The root of the problem is that transaction costs are particularly high in rural areas because of the greater spatial dispersion of production, lower population densities and lower-quality infrastructure. Additionally, risks associated with financing in agriculture are high due to the seasonality and often high covariance of rural production activities (e.g. due to a common set of weather risks or same periods of project gestation). Lenders tend to offer only a limited menu of products, mainly with heavy collateral

[107] FAO (2008a).
[108] A group of individuals agreeing to meet over a defined period of time in order to save and borrow together.
[109] United Nations (2008).

requirements. Wealthier farmers can obtain larger loans at lower cost from formal lenders because they can credibly pledge assets or future cash flows. Asset-poor households are limited to considerably smaller loans at much higher rates because they have to turn to lenders who must substitute costly monitoring for collateral.

Reshaping financial services for smallholders: Microfinance institutions, potentially in partnership with a bank, reformed state-sponsored lenders, cooperatives or correspondent or mobile banking

Innovations are required to permit more flexible forms of lending while guaranteeing that borrowers repay loans. Microfinance institutions[110] offer various contracts with new arrangements that substitute for collateral, for instance standing crops. They often have guidelines to favour groups excluded from borrowing through other channels, particularly women. Partnerships between formal finance institutions and informal organisations can also effectively join forces (supplying credit and sharing the risk for the former, monitoring and recovering loans for the latter). For instance, in India, ICICI Bank, the country's second largest commercial bank, has successfully partnered with a leading microfinance institution (owned by India's largest tractor manufacturer). Reformed state-sponsored lenders have also been successful in several countries. Self-help groups and financial cooperatives provide other financing options with reduced transaction costs. Another way to increase access to agricultural capital is financial intermediation through agents in the value chain (input suppliers or output processors). They are in a good position to cost-effectively monitor on-farm behaviour and enable financial institutions to accept crops as collateral.[111]

Weather-index based insurance

Information technologies offer a broad array of ways to extend financial services to rural areas, through the use of mobile phones, or branchless banking, using "correspondents": post offices, stores, petrol stations and input providers.

Access to risk management mechanisms is also necessary to mitigate price volatility and production volatility. Weather-indexed risk management products represent an innovative alternative to the traditional crop insurance programmes for smallholder farmers in developing countries. Payments are linked to a weather proxy for crop losses like rainfall deficit, eliminating the need for monitoring actual losses.[112] The farmers benefit directly through steadier income, which in turn unlocks credit facilities. Pilot programmes conducted in several developing countries have proved the feasibility and affordability of weather-index-based insurance products.

4. Actions

Food security, development, environmental and social sustainability must all be important goals of agricultural policy. We attempt here to summarise key points of action for the various stakeholders: governments, international institutions, the food and financial industries, as well as consumers.

In developing countries

Adequate spending, right investments, access to the basics, especially for small-scale farmers

1. Spend more on agriculture (both developed-country donors and developing-country governments).
2. Invest in increasing yields, especially through ecologically integrated approaches. More funding for public R&D is required.

[110] For more on microfinance see Dieckmann (2007).
[111] World Bank (2007).
[112] Auer (2003), Bryla and Syroka (2007).

3. Ensure farmers in developing countries, especially small-scale farmers, have access to key resources: education, knowledge, assets, credit, markets, as well as social protection.
4. Educate and empower women and give access to voluntary family planning to slow down population growth.
5. Promote healthy diversified diets.

Farm technology has to be transferred to small-scale farmers in a responsible, sustainable way. Governments, public research institutions, non-governmental organisations and corporations need to devise new ways of doing business and of forming partnerships: to accommodate both the interests of the majority of the world's people located in developing countries and the concerns of the technology providers and consumers in wealthy countries.[113]

Internationally

Reforming agricultural support, food aid, trade and support regimes for biofuels

1. Push ahead with agricultural liberalisation in developed countries

— By exporting food whose production has been subsidised, developed countries reduce the capacity of developing countries' agricultural sectors to compete. Reforming agricultural support is essential (in the EU and the US).

— It is also beneficial to consider food aid in cash rather than in food: the latter often indirectly subsidises producers in the donor country while being detrimental to the recipient country's capacity-building. This is not just a question of obligation, developing countries' progress is a long-term asset for the world at large.

— Given their impact on food security, support regimes for biofuels need to be further reviewed to promote the move towards second-generation biofuels.

2. In principle, liberalise trade in agricultural goods, but ensure that domestic supply is not critically reduced, by introducing clear rules (export suspensions, for instance) in order to avoid a lapse into protectionism. Ideally, harmonise trade rules to some degree with environmental and social rules in order to guarantee a true level playing field for all producers. Also ensure fair competition through international anti-trust policy (particularly important in the developing world).
3. Examine the possibility of more global governance mechanisms for food safety. One alternative, if realistic, could be a global system of food reserves in order to cope with emergencies and shocks.[114]
4. Technical assistance needs to be available to developing countries for negotiating fair deals on long-term agreements (food purchase agreements, land leases or purchases in other countries) and may be financed by aid.
5. Promote sustainable water use. Implementing water pricing (at least with token prices, and by rebalancing subsidies rather than the increasing costs to farmers) is potentially effective for reducing volume of water used for irrigation (through increased

The Common Agricultural Policy (CAP)

EUR 55 bn (42% of 2008 EU budget)

Major milestones

1950s: subsidizing farmers to counter war-induced **shortages**

1980s: EU self-sufficiency reached, with almost permanent **surpluses** of basic commodities
→ CAP increasingly used for export and storage subsidies, with a series of reforms to tackle surplus and sustainability

1992: to **limit rising production**, move towards freer agricultural markets: "set-aside" payments to withdraw land from production, limit stock levels, measures to encourage retirement and afforestation

1999 → 2 pillars: production support and **rural development** (trade, tourism, biodiversity)

2003: to **prevent over-production and waste**: subsidy payments decoupled from production (allocated e.g. according to land size rather than production volume), conditional to meeting certain environmental, food safety and animal welfare standards

Since 2008: "Health Check" to streamline and better respond to the market and new challenges (like climate change): phasing out milk quotas, further shifting money from direct aid to rural development, investment aid for young farmers

Source: EurActiv

[113] Toennissen (2003), Toennissen (2008).

[114] See von Braun and Torero (2008), Evans (2009)
IFPRI suggests a system where participating countries would commit funds to intervene in the grain futures markets to help smooth out fluctuations in food prices. This could be managed by a disinterested expert international agency (such as the World Food Programme).

irrigation efficiency or selection of less irrigation-demanding crops).

In Europe

Sustainable use of natural resources (soil, water and biodiversity) and maintenance of healthy agro-systems are key to preserving EU agricultural productivity and long-term food security.

1. Review the CAP in line with the above.
2. Re-examine the beneficiaries. Most of current spending is still untargeted and severely biased in favour of the most competitive and intensive sectors and farmers.
3. Address the environmental problems caused by current unsustainable production: soil degradation, biodiversity loss, water over-extraction and pollution and GHG emissions. Direct more support towards traditional farming, which uses little chemical input and is typically associated with high levels of biodiversity: reward farmers for good land stewardship.
4. Tackle GM food production: accelerate research on capabilities and potential impacts on health and the environment.
5. Review intellectual property rights in order to regulate corporate control.
6. Address EU enlargement, ironing out the huge payment disparities between countries. Reducing market distortions is essential.

Sustained cooperation between various areas of public policy is vital: agriculture, environment, innovation, health, education, consumption etc.

For the financial industry

Financing agriculture

Alliances between formal finance institutions and informal organisations can be very successful as the partnership between India's ICICI and a microfinance institution has shown

Farmers need increased access to financial services, such as credit, savings, insurance, mobile cash transfer systems and new risk-mitigation instruments. There is a shortage of credit services currently available, partly due to poor loan repayment rates. The following items have proved to be key for success in financing agriculture.[115]

Non-farm share of rural income (1998) in

— Africa	42%
— Asia	32%
— Latin America	40%

Sources: CGAP/IFAD, 2006

1. Repayments are not linked to loan use. Lenders assess borrower repayment capacity by looking at all of a household's income sources, not just crop sales. The variety of income-generating activities provides relatively steady cash flow for many farming households. It makes weekly loan payments possible over the course of the year. Borrowers understand that they are obliged to repay whether or not their particular use of the loan is successful. Microfinance has an income-smoothening role which is particularly important for farming households subject to extreme income volatility during the course of the year. For the lender, treating the household as one financial unit increases repayment rates.
2. Character-based lending techniques are combined with technical criteria in selecting borrowers, setting loan terms and enforcing repayment. Lending models combine reliance on character-based mechanisms (group guarantees or close follow-up on late payments) with specialised knowledge of crop production

[115] CGAP/IFAD (2006).

techniques and markets for farm goods. This decreases credit risk.

3. Adapt to the highly cyclical cash flows in farming communities by adjusting loan terms and conditions (promoting flexible repayment options) to track the cash-flow cycles more closely.

Investments[116]

Moving subsistence farmers towards commercial agriculture production will require significant investment in the following sectors:

1. Efficient irrigation systems
2. Storage and transportation
3. Optimised fertiliser use
4. Funds to stimulate research and innovation (e.g. second-generation biofuels)
5. Access to markets and distribution channels
6. Farmers' education

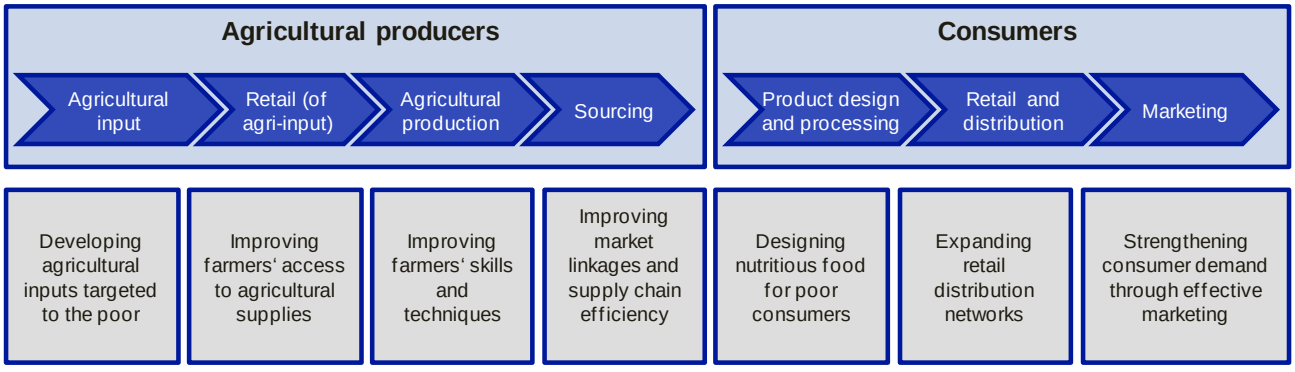
For the agricultural and food industry

Increased demand requires greater deployment of scarce agricultural resources. The global food and agribusiness is set to undergo significant changes in the coming years, with a likely shift of the industry's value proposition on the upstream and midstream segments of the value chain. Even if opportunities continue to exist in the downstream (in the areas of retail and food services), tremendous growth potential is first expected in agricultural inputs and equipment, crops, animal proteins (meat and dairy) and food processing ("new age" consumer preferences).

Other industries such as transportation, energy, telecommunications (to provide market information) and education are also important enablers along the food-value chain.[117]

New processes of value creation have a role to play here: often temporary and global, and above all highly collaborative, based on commitment, openness and broad cooperation potentially spanning all functions, from innovation to marketing. These are the principles of the project economy, expected to deliver an increasing share of value creation.[118]

Business solutions for producers and poor consumers along the food chain



Source: World Economic Forum, 2009

116 For more on investing in agriculture, see Kahn and Zaks (2009).
117 For more on this, see wef (2009).
118 For more on the project economy, see Hofmann et al. (2009).

Implications for all

Consumers' choice: watching what we eat …

The impacts of the food system on human, ecological and animal health are ultimately a consequence of consumption decisions. Our choices can support forms of agriculture that are destructive to human, ecological and animal health – such as the factory farm approach to raising livestock[119] – or they can support practices that are better for people, animals and the planet. The composition of our diet is decisive, even more important than how and where food items are produced.[120] Consuming locally grown, seasonal (organic) food when possible is still beneficial.

Evidence on health and the balance of environmental analysis suggest that a healthy, low-impact diet would contain less meat and fewer dairy products than we typically eat today. Western diets – full of meat and dairy products – are massively inefficient in terms of water, energy and grain use, and produce more greenhouse gases as well. More sustainable livestock management (improved nutrition, converting manure into biogas etc.) can help reduce the environmental impact.

The move towards a lower-impact and healthier diet can be facilitated by raising awareness and educating people to make smarter decisions. Pricing in the social and environmental costs (through carbon tax, for instance) may be the solution.

… and what we waste

Making a conscious effort to reduce waste can also go a long way. Wider implementation of collection processes for recycling the food left behind (especially from restaurants, canteens, hospitals etc.) or soon to perish (from supermarkets and other stores) could benefit the poor. Burning food waste for fuel is an additional way to increase food energy efficiency. Here too, governments can help to change the perception of "waste is to be disposed of" to "waste as a commodity". Promoting technological innovation and transfer, providing agricultural extension to farmers and support policies fostering the recycling of agricultural or food waste into animal feed or fuel are all part of the solution.

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[119] It may be argued that bigger farms, where cattle are raised intensively, are more likely to afford taking care of environmental issues (monitoring their impact, recycling waste, etc.), but on balance the damage is probably still greater.

[120] Cabinet Office UK (2008).

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