

Greening *the* Economy *with* Agriculture



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Greening the Economy with Agriculture

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Working Paper 1

GEA - AVAILABILITY

Food availability and natural resource use in a green economy context

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Working Paper 2

GEA - ACCESS

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Working Paper 3

GEA - STABILITY

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Working Paper 4

GEA - UTILIZATION

Improving food systems for sustainable diets in a green economy

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Greening the Economy with Agriculture (GEA)





Introduction

The United Nations General Assembly (UNGA), through Resolution 64/236 of 24 December 2009, decided to organize the United Nations Conference on Sustainable Development, Rio de Janeiro, 3 to 6 June 2012 (UNCSD, also referred to as Rio+20). The two main stated themes decided by the UNGA for UNCSD are: a green economy in the context of sustainable development and poverty eradication; and the institutional framework for sustainable development. The preparatory process foresees three sessions of the preparatory Committee and three inter-sessional meetings.

The Second Preparatory Committee of UNCSD, held in March 2011, has invited “Member States, the relevant United Nations system organizations, and relevant stakeholders to provide their inputs and contributions in writing by 1 November 2011 for inclusion in a compilation document to serve as basis for the preparation of the zero-draft of the outcome document”.

Since May 2010, FAO’s active contribution to the preparatory process of UNCSD has resulted in the inclusion of food security among the priority areas under consideration. FAO is particularly contributing to shaping the green economy agenda of UNCSD by providing elements pertaining to its mandate. To this end, an analysis has been carried out on the interactions between the green economy and the food and agriculture sector, including opportunities and constraints. The Greening the Economy with Agriculture (GEA) Initiative seeks to contribute to the definition and implementation of the green economy, with a particular emphasis on food security. As part of this initiative, FAO organized broad stakeholder consultations through an FAO/UNCTAD/Biovision side event in New York on 8 March 2011, and a joint FAO/OECD Expert Meeting on Greening the Economy with Agriculture in Paris, France, 5 to 7 September 2011. An informal seminar was held with Permanent Representatives to FAO on 4 November 2011 to brief them on progress made thus far.

GEA aims to promote a dialogue between the agriculture, forestry and fisheries constituencies and other partners, on sustainable development strategies, as well as the overall participation of food and agriculture stakeholders into the Rio+20 process and beyond, with a view to facilitating their access to the resources and institutional arrangements that will be put in place in order to effectively move towards sustainable development. By taking a proactive role in international, regional and national debates



for Rio+20 and beyond, the GEA Initiative would create bridges among different types of stakeholders and between constituencies, notably between agriculture and the environment, while strengthening the overall resilience of countries to exogenous shocks, either macroeconomic or ecological.

Concepts and definitions

Although UN Member States have not yet come to an agreement on the definition of the green economy, they recognize that an efficient, functioning economy is a precondition for addressing the environmental and social pillars of sustainability. Therefore, the green economy is seen as a key implementation tool for sustainable development. UNEP defines the green economy as one that results in “improved human well-being and social equity, while significantly reducing environmental and ecological scarcities”.

GEA refers to ensuring the right to adequate food, as well as food and nutrition security – in terms of food availability, access, stability and utilization – and contributing to the quality of rural livelihoods, while efficiently managing natural resources and improving resilience and equity throughout the food supply chain, taking into account countries’ individual circumstances.

GEA can be achieved by applying an ecosystem approach to agriculture, forestry and fisheries management in a manner that addresses the multiplicity of societal needs and desires, without jeopardizing the options for future generations to benefit from the full range of goods and services provided by terrestrial, aquatic and marine ecosystems. Therefore, GEA strives to:

- achieve food and nutrition security through an appropriate balance between domestic production and trade;
- contribute to achieving the right to adequate food for all;
- ensure decent rural livelihoods;
- use traditional and scientific knowledge to maintain healthy ecosystems that integrate food production and respect natural resource constraints.



Greening the Economy with Agriculture

GEA means that the entire food supply system needs to become resilient to the harmful effects of climate change and macro-economic shocks in the face of growing global population and food demand, which will require fundamental shifts in the approach to the food and nutrition systems.

No green economy without food and nutrition security

The agricultural sector - including crops, livestock, forestry, fisheries and food processing - will play a vital role in the transition to a green economy. Croplands, pastures and forests occupy 60 percent of terrestrial land, agriculture uses 70 percent of globally withdrawn freshwater, and the sector as a whole provides livelihoods for 40 percent of the world's population. The agricultural sector depends heavily on natural resources for its production processes and can both cause environmental harm and provide environmental benefits. While current practices contribute to over one third of global greenhouse gas emissions, good management practices can result in an almost carbon-neutral sector, as well as the creation of environmental services and the generation of renewable energy, while also achieving food security. The agricultural sector can also be an engine for economic development and the creation of millions of green jobs, especially in the poorest countries. Consequently, there can be no green economy without the agricultural sector. At the same time, food and nutrition security will have to be achieved as an integral part of the green economy. This is because food and agriculture systems are threatened by climate change, resource degradation and poverty – the same problems that the green economy is designed to tackle. Only an economic system that results in improved human well-being and social equity, while significantly reducing environmental risks and ecological scarcities, will be able to deliver food security for over nine billion people, by 2050, in a resource-constrained world.



Green jobs for smallholders

Small rural households, which still constitute two-fifths of humanity, are increasingly under pressure and agricultural employment and opportunities have to be increased in a green economy. Out-migration from rural areas is expanding urban slums, with concurrent inability of these poor urban dwellers to access food and water. Support to smallholders is essential to both achieving food security and preserving natural resources. Farming, forestry and fisheries operations in both developed and developing countries play a fundamental role in the provision of landscape management and the provision of ecological and cultural services. More diverse food systems and off-farm diversification - such as value addition, rural-urban food networks, agri- and eco-tourism, small-scale forest-based enterprises - offer livelihood opportunities in employment-scarce settings (especially, but not only, in least developed countries), while improving land stewardship.

Sustainability through nutritious diets

In a world facing increasing competition for scarce resources (e.g. water), resource degradation (e.g. soils), increased uncertainty (e.g. climate change), volatility (e.g. fuel and food prices), conflict (e.g. land tenure) and wastage (e.g. one third of all food is lost during post-harvest handling and retailing), food and nutrition security has become an issue of efficiency, resilience to shocks and distributional equity. The problem of under-nourishment, with roughly one billion people going hungry, is super-imposed by the problem of micronutrient malnutrition, with roughly 1.7 billion people¹ overweight and obese. At both ends of the spectrum, individuals are not deriving sufficient nutrition from their diets. Improving nutrition through better diets can also reduce the ecological impact of dietary choices. A shift to more sustainable diets would trigger upstream effects on the food production (e.g. diversification) and processing chain. Improved diets, in terms of micro-nutrients density and quality will be more sustainable, resulting in substantial gains for both the environmental and public health.

1 WHO, 2011. Fact Sheet n. 311



Accounting for environmental and social impacts through full-cost pricing of food

Making the transition to GEA will require reflecting the true costs—economic, environmental and social—of different systems in the price of products. This entails internalizing external costs associated with resource depletion and environmental degradation and setting of incentives that encourage sustainable and resilient practices that create positive externalities (e.g. payments for environmental services). Markets and trade will play an important role to create a level playing field, especially for poor producers in developing countries. Scaling-up social protection systems will be needed to protect vulnerable groups from adverse effects of changes in relative prices.

Inclusive implementation through cross-sectoral cooperation

There are various food and agriculture models that can deliver the multiple objectives of food security, environmental conservation and social and economic development as synergies, rather than trade-offs. They will involve an ecosystem approach to production systems, fairer trade, and more equitable access to natural resources and livelihood opportunities, as advocated by the Voluntary Guidelines to Support the Progressive Realization of the Right to Adequate Food in the Context of National Food Security. This transition process involves both large and small holdings, whereby sustainable systems are supported equitably. They also need to be facilitated by more sustainable food demand and consumption patterns and well-functioning markets. Although the long-term benefits are clear, making the transition will require new policies, investment and research. Financing and supporting this transition will require cooperation across multiple sectors, not just limited to food, agriculture, fisheries or forestry, but also including energy, water, the environment, health, education and economic development.



Working Paper 1

Food availability and natural resource use in a green economy context





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Executive summary

In a green economy, agriculture will be characterized by activities that are increasingly low carbon, resource efficient and socially inclusive. In terms of food security, this raises questions as to the world's capacity to ensure food availability in coming decades, in relation to growing uncertainty over climate change and increasing socio-economic pressure on natural resources.

Looking towards 2050, the issue of food availability is not confined only to balanced global supply and demand. Food availability also reflects overall resilience to both expected and unexpected environmental and macro-economic shocks, as well as equity within society and across regions. Indeed, a number of studies reviewed herein suggest that, regardless of the specific socio-economic and technological settings analyzed – whether business-as-usual development paths or green development paths – food production and its underlying socio-economic and natural resource base will continue to be able to meet projected global food demand, even though regional food availability problems will still exist.

At the same time, in a world with natural and socio-economic resources becoming increasingly stressed, maintaining business-as-usual scenarios will result in production systems that are significantly less resilient to regional shocks and less socially equitable than greener development scenarios. This, in turn, will also result in more acute regional food insecurity. Green scenarios contribute to virtuous cycles: by favouring a much more rational use of available resources, and focusing on respecting ecosystems and communities, green development will further reduce pressures in the future. To this end, this paper identifies specific technological options and funding mechanisms, including trade agreements and climate funding, which are consistent with the implementation of greener development paths in agriculture.

Specifically, trends for 2050 suggest growing scarcities of agricultural land, water, forest, marine capture fishery and biodiversity resources, as well as limitations of bio-available nutrients and non-renewable energy supply. As a result, some regions will face insufficient water and agricultural land for their growing populations. The geographically uneven distribution of resources, and the strong dependency on and interconnectedness of scarce natural resource and risk thresholds linked to environmental limits (such as those imposed by climate change), will define food availability to households in the future.



The FAO AT2030/50 projection for 2050 anticipates that, similarly to today, global resources will be available for the food production growth necessary to match future food demand, but that the required growth will occur in developing countries. Whereas several alternative scenarios find it plausible that higher average food consumption should be attainable globally, the question is whether this equilibrium will have continuity or resilience in the face of poorly understood, and often unexpected, natural resources dynamics. Regional imbalances will continue to result in regional food insecurity. The extent and the distribution of hunger will depend, as it does today, on geopolitical, socio-economic, agro-climatic and technical conditions – but with added negative pressures from climate change. All these conditions will affect the resilience of regional equilibrium between food supply and demand. In particular, climate change introduces a significant new level of uncertainty.

Several scenarios indicate that the consequences of shocks in resource availability will be higher in the future, particularly in South and Central Asia, the Near East and North Africa. When anticipated demand for food is matched with potential scarcities by geographical region and by food type, it becomes evident that there are critical food producing systems at risk due to the gradual degradation of their own ecosystem integrity and services. Reducing the risk of ruptures in overall food availability requires a transition to more efficient and sustainable production systems. Attaining these systemic efficiencies requires a stronger integration of the patterns and socio-economic drivers of utilization of land, water, nutrients and hydrocarbon resources. It will also require the broad-scale application of knowledge-rich agricultural practices, with a focus on respecting the balance of ecosystems and society.

In making the conversion towards “greener” food and agriculture systems, management options will need to include gradual shifts in focus from fossil fuel-based and synthetic agricultural inputs towards a more informed use of ecosystem goods and services and green inputs. Scaling-up such alternative systems will require continued investments in improving ecological knowledge generation and dissemination, and upfront financing to sustain transition phases.

Trade is essential to ensuring food availability, especially where there are local or regional scarcities of natural resources and inputs. The mix of domestic production and imports depends on the availability of natural resources and related inputs and, thus, on the comparative advantage of specific crops and animals at a specific time and place. Hence, food trade will increasingly be determined by efficiency in natural resource use.



The green economy brings opportunities for ameliorating the world population's use of environmental goods and services, such as water, biodiversity and carbon, within a context of more equitable distribution of benefits.

Climate change funding should be used to facilitate the transition to the natural resource management systems identified in this work, based on the fact that they all contribute to creating more resilient systems that minimize climate change risks and lower greenhouse gas emissions. Recognizing that green agriculture practices generate a host of often intrinsically bundled ecosystem and social benefits, future climate funding needs to be much more broad-based than the current mechanisms that are based largely on carbon. Therefore, it is argued that novel markets and public funding are necessary, and should be structured around pooled benefits, rather than single commodities. By going beyond carbon markets, these new mechanisms could be used to more efficiently pay for some of these ecosystem and social services, provided they function within wider international mandates. In particular, public and private climate funding for agriculture could continue to reward adaptation and mitigation benefits, but only if a host of other benefits is included, especially biodiversity, water, soil, food security, alternative income opportunities and rural development.

Greening the economy with agriculture is a daunting but essential task, requiring knowledge and management skills more than only new technologies. It also requires more effective governance that will lead to a shift in mind-sets and the re-allocation of financial and other resources to activities that generate public goods. It is more about investing in making a qualitative leap in production and consumption patterns, rather than a quantitative leap to increasingly unsustainable production levels. This will be possible through improving producer stewardship of the land and increasing consumer awareness of the impact of their choices on the future of food availability.



Purpose and scope of this paper

The term “food security” encompasses four dimensions that cut across the supply chain: food availability, access to food, stability of food supply systems regarding availability and access, and food utilization. This paper addresses the food availability dimension of food security.

Food availability is defined as adequate quantities of food of appropriate quality, supplied through domestic production or imports, including food aid. The green economy concept recognizes that an efficient, properly functioning economy is a precondition for addressing the environmental and social pillars of sustainability.

In a green economy context, the food availability dimension is closely coupled with the availability and use of natural, human and economic resources, especially scarcity of natural resources. Coping with food and agricultural resource scarcities without reaching environmental limits presents a major challenge for the years to come. In addition, food availability also is closely coupled with food stability.²

This paper describes the challenges for continued availability of food and agricultural inputs, in the face of ecosystem and natural resources constraints. It reviews production and trade options for meeting the demands of current and future generations. First, it assesses the availability of natural resources for food and agriculture systems. Second, it analyzes food perspective studies for 2050, pointing out the preponderance of uncertainties. Third, it assesses the characteristics of food, fibre and fuel production systems and of management performance in terms of efficiency and resilience in the future context of a green economy. Fourth, it offers trade considerations aimed at ensuring an appropriate and sustainable balance between self-sufficiency and self-reliance. Finally, the paper calls for fundamental changes and adjustments, including green technologies and investments for scaling-up ecological intensification of food and agriculture production systems.

2 For further discussion, refer to Working Paper 3 on Stability.



Status of natural resources availability for food security

Planetary boundaries and natural resource limits

Since the onset of the industrial revolution, human activities have had an ever-growing impact on natural resources (Steffen *et al.*, 2007). In recent decades, a tremendous intensification of these activities has taken place, threatening to alter the earth's ecological functioning in a way harmful to many regions in the world (Rockström *et al.*, 2009a). In advance of the Copenhagen Climate Council in 2009, Rockström *et al.* (2009a) developed the concept of “planet boundaries”, a framework that identifies the thresholds for indicators that monitor different earth system processes. In other words, it establishes a safe operating space for humanity. Thus, in order to secure a safe scope of action in the future, humanity has to limit the impact of its activities, recognizing that crossing these planet boundaries may lead to abrupt changes in earth systems that can negatively affect ecosystems and impair the further development of humans.

According to the authors, the earth system processes for climate change, the rate of biodiversity loss and the nutrient cycle for nitrogen have crossed their boundaries, while global freshwater use, the nutrient cycle for phosphorus, land use change and ocean acidification will soon reach theirs, as they attempt to meet demands for a projected global population of about nine billion by 2050 (Rockström *et al.*, 2009a). However, these planetary boundaries are not fixed. In terms of development, they reflect the physical efficiency with which the earth's resources are utilized. As such, they are strongly associated with land, water and agricultural management and sustainability of production technology.

Population and income growth are the principal drivers of demand for food production. Meeting these levels of demand can be mediated by the management of supply through the application of knowledge and technology. Critically, this offers a point of intervention, focused on the ability of ecological systems to meet demand within planetary boundaries, if the appropriate management structures can be brought to bear.

Under the current management systems, the planetary boundaries for the aforementioned earth system processes have already been reached, or will be reached soon, as human demand for natural resources is far from decreasing. Business-as-usual



scenarios for the current and prospective resource use show an even stronger pressure on resources, such as land, biodiversity, energy and nutrients for the coming decades, which will extend actual scarcities even further.

“Scarcity” as used in this working paper, follows the definition used in the EU Standing Committee on Agricultural Research’s (SCAR) 3rd Foresight Exercise (2011). It refers to a multiple set of constraints to using resources, including physical and biological shortages, as well as political, economic and social obstacles. In the future, natural resources scarcities will be aggravated by the environmental limits set by planet boundaries (SCAR, 2011). In this section of the paper, the *status quo* of resources and their scarcities are discussed in relation to their physical limits of supply and availability, as well as their environmental limits that result from, for example, pollution, biodiversity loss and climate change impacts.

Scarcities of resources, such as nutrients, water and agricultural land, vary widely on a geographical level. A resource also can be scarce in certain regions of the world, while in others, the excessive use the same resource can cause pollution. For nutrient cycles (phosphorus, nitrogen), in particular, significant imbalances exist over large regional scales. It should be noted that large regional imbalances naturally occur even under equilibrium. The carbon cycle is characterised by large differences between the northern and the southern hemispheres and between winter and summer seasons. The major challenge is to bring cycles back into states of equilibrium from the current situation that has become characterized by the wholesale degradation of agricultural systems at risk (FAO, 2011b).

Status and trends in natural resource availability

Agricultural land

Today, 1.6 billion hectares, or 12 percent of the global land area, are used for agricultural crop production and 3.4 billion ha are used for pasture (FAO, 2011d; FAO, 2010b). This land is cultivated by a mix of farmers, ranging from pastoralists and smallholders to large commercial farms. Of the world’s 455 million farms, 387 million have less than 2 ha of farmland and only two million are larger than 100 ha (von Braun, IFPRI).

Looking to the future, the need for agricultural land will be driven by increased productivity on the one hand, but also by demand pressures from changing dietary habits and the demand for biofuels on the other hand. In addition, agro-ecosystems will have to provide certain ecosystem services, such as biodiversity, clean groundwater and carbon sequestration.



Biofuels are expected to play an important role in the future global energy mix, leading to up to a ten-fold increase over current levels by 2050 (IEA, 2011). To minimize the tension between food and fuel, good practices, such as agro-ecological zoning, integrated food energy systems and fair contract farming, can be applied.

In terms of food availability, it has been estimated that a 60 to 70 percent increase in global agricultural productivity is going to be needed to cope with world population growth, expected to reach nine billion by 2050 (UN, 2010) and with the rise in daily calorie intake, projected to reach 3 130 kcal per capita per day (FAO 2006a). During the last fifty years, the fact that agricultural production increased between 2.5 and 3 times, while agricultural land expanded only by 12 percent, indicates that productivity increases resulted mainly from increases in input-intensive agriculture and irrigation (FAO, 2011d). Since 1960, agricultural output has grown about 2 percent each year, with stronger growth in developing countries than in developed ones (IAASTD, 2006). However, this growth is slowing, and is projected to slow even further in coming years: on average, annual crop yield growth rate over the projection period would be above (0.8 percent) its historical growth (1.7 percent) (FAO, 2009c).

Economic development typically leads to changes in dietary habits, as consumers move from plant-based to animal-based diets. Indeed, livestock production has increased in the last decades in many countries and, today, 34 percent of the world's arable land is used for the production of feed grains or related products (FAO, 2006a). About half of the global grain production is for feed, rather than direct human consumption. In the future, global meat production is expected to rise further, from 229 million tonnes in 1999–2001 to 465 million tonnes in 2050 (FAO, 2006a). This trend will put additional pressure on land and water systems, as more land and water is needed to produce meat than to produce plant-based products of the same nutritional value (FAO, 2011d).

In addition to the currently cultivated land, FAO estimates that an additional 2.7 billion hectares have some crop production potential (Bruinsma, 2009). Most potential land for rainfed crop production is located in sub-Saharan Africa and Latin America. By contrast, the Near East, North Africa and South Asia have virtually no land left for additional farming activities, as all land suitable for cultivation is already farmed (Bruinsma, 2009) and/or at various degrees of degradation. Even with the uneven geographic distribution, the fact that large land reserves exist in sub-Saharan Africa and Latin America might indicate that, on a global level, physical scarcity of agricultural land is not a critical issue (SCAR, 2011).



However, much of this land would have lower productivity and most would come from conversion of forest and grasslands, further aggravating negative effects on climate change and biodiversity losses (Bruinsma, 2003). Even in those regions where land is abundant, a great diversity exists in terms of quantity and quality (Bruinsma, 2009). In order to keep to environmental limits, Rockström *et al.* (2009a) propose that no more than 15 percent of global ice-free land surface should be converted to agricultural land and, to stay within planetary boundaries, cropland should be allocated to the most productive areas, rather than bringing external inputs to sustain production in less than optimal lands.

There is a risk that intensification strategies in agriculture disregard the integrity and multifunctionality of agro-ecosystems. Although all agricultural systems rely on ecosystem services, they vary in the extent and nature of the ecosystem services they use and provide. Ecosystem services may be altered to the worse due to agricultural intensification, land degradation or land use change (e.g. from pasture to crop land).

Expansion of cultivated land and intensification of agriculture often correspond to other scarcities. For example, the worldwide increase in meat production has led to further expansion of pasture and cropland for feed into formerly natural ecosystems, accelerating losses of biodiversity and carbon, and increasing greenhouse gas emissions. Pasture development and soybean cultivations are among the major drivers of deforestation (FAO, 2006a). Surpluses in N and P derived from agriculture, as well as their deficits, may result in eutrophication (Rockström *et al.*, 2009a) or land degradation, respectively. Even more important, absolute scarcities of resources exist that limit agricultural activities, such as regional water scarcities.

Unsustainable agricultural practices and land use change are the most important drivers of land degradation that result in the loss of ecosystem services, yield decreases and the abandonment of former agricultural land. This, in turn, induces further expansion of agriculture in natural ecosystems. According to the Land Degradation Assessment in Drylands, land degradation refers to the reduction in the capacity of the land to provide ecosystem goods and services over a period of time for its beneficiaries (webpage of GEF/LADA project 2006-2010).

The main issues surrounding land degradation include the loss of soil organic matter, soil physical degradation, and carbon and nutrient depletion. Globally, only half of the nutrients removed from the soil by agricultural production are replaced by fertilizers (FAO, 2011d). On-site soil erosion, another aspect of land degradation, leads to loss of nutrients,



organic matter and water-holding capacity, thereby affecting ecosystem services, such as water retention, soil organic matter protection, carbon sequestration and soil biodiversity preservation (FAO, 2011d). On a global scale, FAO estimates that about 34 million hectares, which represent 11 percent of the earth's irrigated land, are negatively affected by salinity, and an additional 60–80 million hectares of land are affected to some extent by waterlogging and related salinity intrusion (FAO, 2011d). Desertification refers to land degradation in arid, semi-arid and subhumid regions and is caused by human activities and variations in climate. The same source estimates that about 250 million people are directly affected by desertification and about one billion are at risk (UN Convention to Combat Desertification). The effects of climate change are likely to accelerate land degradation even further (IPCC, 2007). In addition, extensive poorly-managed livestock systems particularly contribute to land degradation and ecosystem changes by accelerating desertification in arid areas and by favouring woody encroachment (as woody vegetation is not consumed) which changes the species composition of savannahs and grasslands (Steinfeld *et al.*, 2010).

In addition to direct effects on agricultural land, current land-use management activities contribute to eutrophication (Carpenter and Bennett, 2011) and to the accumulation of pesticides in aquifers. This has consequences for downstream users of water and related biodiversity, including fish resources (FAO, 2011d).

Water

The state of global water resources in relation to agriculture has been summarized in two recent reports, the Comprehensive Assessment of Water Management in Agriculture (CA, 2007) and the State of Land and Water (FAO, 2011d). The mean annual global freshwater resource cycle on land has a volume of around 42 000 km³. Of this, about 3 900 km³ are withdrawn for human use from rivers and aquifers, of which 70 percent (some 2 710 km³) is for irrigation, 19 percent for industries and 11 percent for the municipal sector. About half of withdrawals (1 280 km³) returns to the atmosphere through evaporation and plant transpiration, and half to local hydrological systems by return flows to rivers or groundwater.

Human use of the terrestrial water cycle is dominated by agriculture but the terrestrial circulation of water and the atmospheric circulation of water vapour also feed back to coastal and marine ecosystems through water quantity, quality and sediment transfers.



Global freshwater circulation is the principal agent for cycling nutrients and introduced chemical compounds. For this reason, the acceleration of hydrological processes through agricultural land use management accounts for the accumulation of eutrophication (Carpenter and Bennett, 2011) and increased levels of evapotranspiration, particularly when non-renewable groundwater is exploited.

Although irrigated areas have doubled over the last 50 years, total water withdrawals still represent only a small share – about 9 percent – of internal renewable freshwater resources (IRWR). However, this average masks large geographical discrepancies. The rate of withdrawal varies greatly by country or region. Europe withdraws only 6 percent of its internal resources and just 29 percent of this goes to agriculture. By contrast, the intensive agricultural economies of Asia withdraw 20 percent of their internal renewable resources, of which more than 80 percent goes to irrigation. In many of the low rainfall regions of the Near East, Northern Africa and Central Asia, most of the exploitable water is already withdrawn, 80–90 percent of it goes to agriculture, and thus rivers and aquifers are depleted beyond sustainable levels.

On the assumption that renewable water resources maintain long term means to 2050, the projected increases for agricultural water withdrawals to meet global demand for agriculture is expected to reach almost 3 000 km³. This may be below the planetary boundary assessed by Rockström *et al.*, (2009a), but in fact the regional picture is bleak, as indicated in Table 1. Already Northern Africa and most of Asia are using more than 40 percent of their annually renewable circulation – the point at which water scarcity among all competing sectors becomes critical. In other semi-arid regions, national aggregated data can mask local scarcity, particularly when the flows of large river basins sourced in tropical zones are taken into account. The FAO AT2030/50 projections to 2050 still anticipate upward demand for water from the agricultural sector.

In terms of physical water scarcity, meaning the available supply does not meet demand, it is estimated that, on average, a withdrawal rate above 20 percent of renewable water resources represents substantial pressure on water resources; anything near 40 percent is critical. In some regions, particularly in the Near East, North Africa and Central Asia, nations are already withdrawing in excess of critical thresholds, with resultant stresses on the functions of ecosystems increasingly apparent. It is now estimated that 45 percent of the world's rural population lives in river basins that are physically water scarce.



Table 1. Annual long-term average renewable water resources and irrigation water withdrawal 2006/2050 (FAO, 2011a)

CONTINENT REGIONS	PRECIPITATION (mm)	RENEWABLE WATER RESOURCES* (km ³)	WATER USE EFFICIENCY RATIO ** (%)		IRRIGATION WATER WITHDRAWAL (km ³)		PRESSURE ON WATER RESOURCES DUE TO IRRIGATION (%)	
			2006	2050	2006	2050	2006	2050
AFRICA	678	3 931	48	53	184	222	5	6
Northern Africa	96	47	69	81	80	95	170	204
Sub-Saharan Africa	815	3 884	30	32	105	127	3	3
AMERICAS	1 091	19 238	41	41	385	438	2	2
Northern America	636	6 077	46	46	258	244	4	4
Central America and Caribbean	2 011	781	30	33	15	23	2	3
Southern America	1 604	12 380	28	29	112	171	1	1
ASIA	827	12 413	45	48	2 012	2 073	16	17
Western Asia	217	484	47	56	227	251	47	52
Central Asia	273	263	48	50	150	133	57	50
South Asia	1 602	1 766	55	58	914	889	52	50
East Asia	634	3 410	37	42	434	458	13	13
Southeast Asia	2 400	6 490	19	21	287	342	4	5
EUROPE	540	6 548	48	48	109	100	2	2
Western and Central Europe	811	2 098	43	43	75	81	4	4
Eastern Europe and Russian Federation	467	4 449	67	67	35	19	1	0
OCEANIA	586	892	41	41	19	25	2	3
Australia and New Zealand	574	819	41	41	19	25	2	3
Pacific Islands	2 062	73	-	-	0.05	-	-	-
WORLD	809	43 022	44	47	2 710	2 858	6	7
High income	622	9 009	45	45	383	317	4	4
Middle income	872	26 680	39	42	1 136	1 330	4	5
Low income	876	7 332	50	52	1 191	1 212	16	17
LOW INCOME FOOD DEFICIT	881	13 985	48	51	1 813	1 992	13	14
LEAST DEVELOPED	856	4 493	28	31	190	263	4	6

* Refers to internal renewable water resources, it excludes "incoming flows" at the regional level.

** The water use efficiency ratio is the ratio between the irrigation water requirement and the amount of water withdrawn for irrigation.



Attaining higher levels of water use efficiency and preventing otherwise wasteful losses and associated pumping costs remain important objectives for ameliorating water scarcity and energy inputs to agriculture. A combination of increased productivity of water (more production per unit of water use) and, in some cases, of increasing efficiency of water use (the ratio between water effectively used by crops and water withdrawn from its source) is seen as an imperative for management of the global water cycle (CA, 2007; FAO, 2011d). These measures can be expected to lengthen the period for which the global hydrological cycle can be exploited (De Fraiture and Wichelns, 2010).

Forest

Forest cover, estimated at just over 4 billion hectares in 2010, represents 31 percent of the global land area. Primary forests cover 36 percent of the forested area, other naturally regenerated forests 57 percent, and 7 percent are planted forests (FAO, 2010d). Currently, 13 percent of world forests are legally protected in order to preserve biodiversity or protect soil and water reserves or cultural heritage (FAO, 2010d). Tropical forests are hotspots in biodiversity richness, home to 50–90 percent of the terrestrial plant and animal species but covering less than 10 percent of global land area (Shvidenko *et al.*, 2005).

The rate of deforestation is slowing – decreasing from 16 million ha per year in the 1990s to 13 million ha per year in the decade from 2000 to 2010 – yet still poses a serious threat to many forest ecosystems. The large-scale planting of trees has significantly reduced the net loss of forest area globally to -5.2 million ha per year, down from -8.3 million hectares per year in the period 1990 to 2000 (FAO, 2008c and FAO, 2004b).

Land use change from forest to agriculture is still the most important driver of deforestation. Primary forests have decreased by more than 40 million ha since 2000 (FAO, 2010d). Between 1980 and 2000, deforestation was particularly severe in the tropics: 55 percent of new agricultural land was derived from primary forests and 28 percent from disturbed forests across the tropics (Gibbs *et al.*, 2009).

Forests are a direct source of industrial roundwood, fuelwood and non-wood forest products, such as fuelwood, bamboo, rattan, fodder, palm fibres and resins, which can be used to build shelter, support livelihoods or be sold at local markets. In addition, they provide food and cash income for almost one billion of the world's poorest people, by providing a wide range of food items such as wild tubers, bush meat, edible insects, fruits, leaves, mushrooms, nuts, honey and medicinal products. In 2005, the total value of forest



product removals was USD 121.9 billion, of which about 71 percent was from industrial roundwood, 15 percent from non-wood forest products and 14 percent from fuelwood. Considering that informally and illegally removed wood, especially fuelwood, is not usually recorded, the actual value of wood removals is undoubtedly higher. In the future, a key challenge for feeding the rural poor in developing countries will be to increase the production of food items in forests (FAO, 2010d).

Production and consumption of key wood products and wood energy are expected to continue rising, largely following historical trends, until 2030. The most dramatic change will be the rapid increase in the use of wood as a source of energy, particularly in Europe, as a result of policies promoting greater use of renewable energy. The highest growth rates will continue to be in Asia though, as the major producer and consumer of wood-based panels, paper and paperboard. Industrial roundwood will be increasingly likely to come from planted forests in the future (FAO, 2009f). Already in 2005, the potential industrial wood production from planted forests was estimated at 1.2 billion cubic metres or about two-thirds of the overall wood production in that year (Carle *et al.*, 2008).

In addition, forests support food security by providing fodder, browse for livestock, fuel for cooking and food processing, and ground cover for the protection of crops, erosion control and the restoration of agricultural soils. Forests play an important role in sustaining ecosystem functions, including the conservation of biodiversity and genetic pools of wild relatives of cultivated species, the regulation of hydrological cycles and carbon sequestration (Shvidenko *et al.*, 2005). Halting expansion of agricultural land into forest ecosystems and reducing forest degradation are key for the reduction of greenhouse gas emissions, in addition to sustainable management, planting and rehabilitation of forests to increase carbon stocks.

Fish resources

In 2008, capture fisheries and aquaculture together delivered 142 million tonnes of fish, 46 percent of which was derived from aquaculture. Of this, 115 million tonnes were used for human consumption, equalling 17 kg per capita – the highest annual per capita consumption of fish ever recorded. Fish supplied roughly 16 percent of the world population's intake of animal protein and 6 percent of the total protein intake. A large proportion of human population depends heavily on fish protein: 1.5 billion people derive 20 percent of their animal protein intake from fish, and another three billion derive 15 percent.



Aquaculture continues to grow rapidly, from 1 million tonnes per year in the 1950s to 52 million tonnes per year in 2008. Aquatic plant production by aquaculture, primarily seaweed, reached 15.8 tonnes in 2008. Most aquaculture production is located in Asia. This dominance is mainly because of China's enormous production, which accounts for 62 percent of global production in terms of quantity and 51 percent of global value. Several aquaculture systems, such as those that farm salmon and shrimp, rely significantly on fish-based feed, primarily from marine fishery resources, such as small pelagics processed into fish meal or low-value fish bycatch. While technological developments have reduced the fish contents of feed for both aquaculture and livestock, global fish and meat consumption expected to continue to grow strongly in the decades to come, so the demand for feed derived from marine fishery resources is expected to remain high.

Global capture fisheries extracted 90 million tonnes of fish in 2008 – some 90 percent from marine waters and the remainder from inland waters (FAO, 2010d). The number of overexploited, depleted or recovering marine fish stocks increased in 2008 to 32 percent, the highest in history. In addition, about half of the marine fish stocks are estimated as fully exploited, which means there is no possibility to expand catches in a sustainable way. For the ten species that have the highest share in catches, most of the stocks are overexploited. The overuse of fish resources endangers livelihoods, especially for small-scale fishers in developing countries.

Inland fisheries are important and contribute significantly to the livelihoods and nutrition of many living in major delta areas. However, pollution, drainage of wetlands, construction of dams, water extraction, habitat loss and irresponsible fishery practices all contribute to declines in inland captures and quality of fish. As inland fisheries are particularly important for food security, this warrants further attention (FAO, 2010g).

Marine ecosystems also face degradation, but from different drivers, including overexploitation, excessive nutrient inputs, pollution, invasive species and climate change. Due to a combination of these pressures, 60 percent of the world's coral reefs are predicted to be lost by 2030 (TEEB, 2008). Climate change, unsustainable use of marine resources and growing pollution are threats to marine food production (FAO, 2010g).

Biodiversity

Biodiversity provides the basic material for food production, including genetic resources, but also essential ecosystem services which provide productive, regulatory, supporting and cultural services. For food and agriculture, it is important to maintain biodiversity



variety at all levels: genetic, species and ecosystem. Many production systems are also important for biodiversity conservation, providing habitats for *in situ* conservation of genetic resources and maintenance of ecosystem services.

At the genetic level, diversity in plants and animals is particularly important for adaptation to a range of farming conditions and environmental stresses, such as temperature extremes, drought, soil salinization, pests and diseases, and water quality. The availability of a broad pool of genetic resources also contributes to breeding of crop and animal varieties for improvements in productivity. It is essential to conserve genetic diversity within each species. Modern agriculture has encouraged many farmers to adopt uniform high-yielding types of plant or animal. But when food producers abandon diversity, valuable traditional varieties and breeds may die out, along with their specialized traits. For the poorest farmers, the diversity of life may be their best protection against starvation. Here, farmers' knowledge plays a critical role in the management of genetic resources. This is reflected, for example, in their knowledge of seeds and the use of local seed systems. Consumers also benefit from diversity, because having a wide choice of plants and animals contributes to a nutritionally balanced diet, which is particularly important for rural communities with limited access to markets.

At the species level, the diversity of organisms in ecosystems contributes to important ecosystem functions, and the production of a diverse range of species contributes to livelihoods. A rich variety of cultivated plants and domesticated animals is the foundation for sustainable production. Yet most people depend on just 14 mammal and bird species for 90 percent of their food supply from animals. And, in industrialized societies, just four species – wheat, maize, rice and potato – provide half of our energy from plants. However, over 250 species of aquatic species are cultured and used as food.

At the ecosystem level, resilience is dependent on biological diversity to reduce environmental, economic and social vulnerability, and enhance the adaptability of ecosystems to changing environments and needs. Biological diversity in agricultural ecosystems also contributes to wide ecosystem services, such as biological control, pollination, the maintenance of water quality, soil health, erosion control, and carbon sequestration and climate change control. Biological diversity at the ecosystem level also contributes to recreational and cultural functions, such as educational and spiritual values, aesthetics and ecotourism. The role of farmers in safeguarding and managing ecosystems is unique and this role can be enhanced through systems that establish payment for ecosystem services schemes.



In addition to its critical role in ensuring global food security, biodiversity can also be a major contributor to reducing poverty and improving livelihoods and food and nutrition security. Poor people often depend on the direct use of biodiversity for their livelihoods and diets, and are its primary custodians. Yet, they are also the first to suffer when these resources are degraded or lost.

Biodiversity is closely related to other scarcities, such as the availability of agricultural land. Land use changes, habitat loss, excess discharges of N and P to freshwater and marine ecosystems, and overexploitation are main drivers of biodiversity loss, but climate change is becoming the dominant factor (Mace *et al.*, 2004; Rockström *et al.*, 2009b).

Certain ecosystems with a high level of biodiversity, such as the Amazon rainforest and Pacific coral reefs, are highly vulnerable to the direct and indirect effects of climate change and human activities, such as land use change. After a certain threshold is crossed, a new equilibrium is reached with unforeseeable consequences for biodiversity (CBD, 2010). Despite the 2009 Copenhagen Accord objective of keeping increases in global temperatures to below 2 °C, the current trends in GHG emissions indicate the 2 °C temperature limit is unlikely to be met (IEA, 2010a). This means biodiversity loss may be accelerated to even higher rates which could destabilize ecosystems and put ecosystem resilience at stake (Rockström *et al.*, 2009b; SCAR, 2011).

Biodiversity is essential for ensuring the long-term productivity of agricultural systems by, for example, providing genetic resources, contributing to soil fertility, providing pollination and pest predation. However, input-intensive agriculture, an over-expansion of agricultural land into natural terrestrial ecosystems (forests, savannahs, grasslands, shrublands), land degradation and high loads of agriculture-derived nutrient inputs in marine and freshwater ecosystems seriously accelerate biodiversity loss (CBD, 2010; Mace *et al.*, 2005; Stoate *et al.*, 2001).

For domestic species, the maintenance of genetic pools for breeds and cultivars and their adaptation to changing environments provides the basis for future breeding approaches and makes agricultural systems less vulnerable to a changing environment (FAO and PAR, 2011).

To maintain this adaptability, a pool of different breeds and cultivars is necessary. In addition, genetic intra-species diversity has to be ensured which requires sufficient numbers of individuals of each breed or cultivar. Currently, the extension of intensive high-input agricultural systems contributes to the erosion of genetic pools for livestock



breeds and plant genetic resources. The increase in intensive livestock systems focuses on a few globally successful breeds at a large scale and, in turn, reduces local breed diversity (FAO, 2007c). The loss of plant genetic resources is triggered by the replacement of local cultivars, land clearing, overexploitation, population pressures, changing agricultural systems, environmental pressures, overgrazing, and inappropriate legislation and policy, as well as by invasive species, diseases, pests and weeds (FAO, 2010f).

Energy

In 2008, the total global primary energy supply amounted to 12 267 million tonnes of mineral oil equivalents, with oil, coal and gas being the most important sources (IAE, 2010). Fossil energy sources are distributed unevenly on a global scale. In 2009, the major crude oil producers were the Russian Federation, Saudi Arabia and the USA, the main gas producers were the USA, the Russian Federation and Canada, and the major coal producers were China (with half of the world's production), the USA and India (IEA, 2010b).

Projections assume that fossil fuels will remain the main energy source until 2035. Depending on the scenarios (reduction of fossil fuel consumption by use of renewable energy and energy saving) global “peak oil” will be reached between 2020 and 2035 (IEA, 2010a). Energy consumption will rise further though, with China and India as major players. According to IEA (2010a), crude oil prices are expected to rise from USD 60 in 2009 to USD 113 in 2035. Unconventional oil sources (oil sands, extra heavy oil, oil shale, gas-to-liquid and coal-to liquid) are expected to play a larger role in the future (IEA, 2010a). Reserves of coal are predicted to last for 120 years at the current rate of production (World Coal Association, 2011). However, the major restriction in using this energy source or any other fossil fuel sources is the need to limit emissions of GHG gases to prevent runaway climate change.

The continued use of oil as the primary energy source of the future, together with rising price levels, has two important implications for agriculture:

- Modern agriculture is highly dependent on fossil fuels for transport, fertilizer, irrigation, on-farm machinery use and pesticide production. As they become more expensive with rising oil prices, farmers may have to reduce or abandon their use, which could lead to yield reductions and in turn increase food insecurity, including for the urban poor, because it will increase overall food prices.



- Rising oil prices together with subsidies for the cultivation of bioenergy crops and increasing demand for biomass triggers competition between food and fuel and reduces food availability. Fan *et al.* (2011) warn that a combination of expanding bioenergy production and rising oil prices, in combination with US dollar depreciation, export restrictions and panic purchases will trigger a new food crisis. The production of feedstock for bioenergy is also clearly coupled with scarcities of land, water and biodiversity.

In 2008, about 12 percent of the world energy consumption was derived from renewable energies, about 10 percent from biomass and 2.3 percent from hydropower, while geothermal, wind, solar and ocean derived energy sources had very small shares (Edenhofer *et al.*, 2011). Fuelwood is the most widely used bioenergy source that is traditionally burned in developing countries, usually for heating and cooking (SOLAW, 2011). Of the energy derived from biomass, 10 percent is derived from agriculture, animal wastes, energy crops and other agricultural biomass (Edenhofer *et al.*, 2011). Driven by subsidies and other policy incentives, the use of energy crops has steadily increased in some countries, especially in Europe (SCAR, 2011) and the USA where 40 percent of its corn production is currently used for ethanol production. According to several estimates, a significant increase of renewable energy in the global primary energy mix will occur in the coming decades, and could triple between 2008 and 2035 (IEA, 2010a).

Renewable energies, especially solar energy, are not scarce, but to change from the current energy systems that rely strongly on fossil fuels to renewable ones will require major economic efforts, fundamental infrastructure changes and strong political support. The expansion of biomass production for energy uses within agricultural systems will require improved management systems and a better understanding of the related environmental, social and economic implications. As food and agriculture systems are major producers of biomass and repositories of organic residues and waste, tremendous opportunities exist for the sector to generate its own energy needs. Projections foresee 25–30 percent of bioenergy feedstock coming from residues in 2050 (IEA, 2011). However, these estimates have to be handled carefully because by-products also are used for animal feed, animal bedding or soil amendment, which diminishes their availability for energy use (Sims *et al.*, 2007). To ensure the long-term functioning of agro-ecosystems and food systems, shifting to renewable energies and increasing energy efficiency in agriculture will be a central issue for the next decades.



Pathways to resource availability

The issues surrounding access to food are also a critical aspect of the availability of food at a global scale (see Working Paper 2 on Access). These include the broad infrastructure issues, such as the need for effective road networks and transport links to supply areas that are non-productive (including many urban areas), as well as the more localized issues of transport and effort which impact upon community provision and market access. Roads are generally the most used method of accessing markets in developing countries and, therefore, they are often to be linked with decreased levels of poverty and increased agricultural productivity and household incomes (IFAD, 2002; Lokshin and Yemstov, 2005; Platteau, 1996; Windle and Cramb, 1997). Inputs, such as fertilizer and pesticides, which can increase production, are often used more in areas with easier access to markets (Von Oppen *et al.*, 1997). Roads effectively reduce the costs of commercial inputs, such as fertilizers, pesticides and higher yielding seed varieties, which can then result in increased uptake and increases in farm employment (Fan and Hazell, 2001; IFAD, 1999), and the commercialization of farm activities in general³.

Global carbon and nutrient cycles: status and scarcities

Carbon and greenhouse gases

The global carbon (C) cycle is intimately intertwined with global climate, and its disturbance by fossil fuel use may confront human societies with severe changes. For the last 11 000 years, the concentration of CO₂ in the atmosphere was relatively stable with small deviations of < 20 ppm (Joos and Prentice, 2004). Human activities in the last 200 years have led to the emission of 400 Pg C through the burning of fossil fuels and land conversion to agriculture (Sabine *et al.*, 2004), increasing the concentration of atmospheric CO₂ from pre-industrial levels of 280 ppm to 379 ppm in 2005 (IPCC, 2007) and 392 ppm today. In fact, the current atmospheric concentration of CO₂ is higher than any time during the last 420 000 years (Petite *et al.*, 1999; Kawamura *et al.*, 2003, as cited in Joos and Prentice, 2004). The rise in atmospheric CO₂ concentrations accounts for most of the expected global warming from the total anthropogenic emissions of GHG.

3 For further discussion, see Working Paper 2 on Access.



Agriculture plays a major role in the carbon cycles, typically leading to a loss of soil carbon stocks in the conversion of land to agriculture. Depending on agricultural management, agricultural activities can change the role of biomass and soil from sink to source and back again. Soils in general account for a major proportion of the world's carbon pool but many agricultural soils are depleted of their soil organic carbon (SOC) (Lal, 2011). This SOC depletion is strongly linked with land degradation and decreased yield levels. World agricultural soils are estimated to have a sequestration potential of 1.2 to 3.1 billion tonnes per year (Lal, 2011).

Importantly, GHG emissions from agriculture are dominated by non-CO₂ gases, specifically methane (CH₄) and nitrous oxide (N₂O). In terms of GHG emissions, agriculture accounts for 10 to 12 percent of the global GHG emissions, most of them derived from CH₄ and N₂O (Smith *et al.*, 2007). CH₄ is a strong GHG: its global warming potential is 25 times higher than that of CO₂ (Forster *et al.*, 2007). In 2005, 50 percent of the global anthropogenic CH₄ emissions were derived from agriculture (Smith *et al.*, 2007). The main emission processes are enteric fermentation of ruminants, manure storage and paddy rice production (Mosier *et al.*, 1998 in Smith *et al.*, 2007); among them, CH₄ from livestock production is the greatest, setting free 2.1 Pg carbon equivalents per annum (Steinfeld, 2010). Rising meat consumption patterns will therefore increase CH₄ emissions from agriculture (Smith *et al.*, 2007).

The rise of atmospheric CO₂ occurs on a global scale, although the associated human activities differ widely on a regional scale. For industrialized countries, combustion of fossil fuel is the dominant source, while land use change accounts for most of the CO₂ emitted by developing countries (Romero Lankao, 2004). Here, deforestation plays a major role accounting for approximately 12–20 percent of all annual GHG emissions, with CO₂ being the most important GHG (Van der Werft *et al.*, 2009). This is particularly important as only 10.5 percent of the tropics is used as crop land (West *et al.*, 2010), but natural tropical vegetation stores about 340 billion tonnes of C (Gibbs *et al.*, 2007). In addition, wetlands, temperate grasslands and high latitude/altitude peatlands are important C sinks. Extensive livestock grazing systems contribute strongly to CO₂ and CH₄ emissions. CO₂ emissions, which take place via deforestation of tropical forests for pasture land and the desertification of arid grasslands, together with methane emissions, in extensive livestock systems account for 3.2 Pg CO₂ equivalents per year (Steinfeld *et al.*, 2010).



The higher the carbon storage in a natural ecosystem, the higher the emissions in case of land use change. Land use change from tropical forest to agricultural land emits twice as much C as land use changes in temperate regions. The global anthropogenic CO₂ budget fails to account for emissions from peatlands in Southeast Asia, which are increasingly being deforested and drained for agriculture (SCAR, 2011). In 2006, these 12.9 million hectares of degraded land emitted an additional 0.1-0.2 Pg C per year through peat decomposition (Hooijer *et al.*, 2010) and fires, making these areas a global hotspot for carbon vulnerability.

Future strategies needed to limit or reverse C losses and GHG in agriculture should seek C sequestration through sustainable management techniques and the introduction of cropping systems that include perennials and build soil biomass, as well as by halting land use change in ecosystems with large C stocks. At the same time, in order to recognize the dominant role of non-CO₂ GHG in agriculture, a major effort needs to be directed at reducing direct CH₄ and N₂O emissions from agricultural practices, such as improved fertilizer management, rice cultivation practices and, especially, the development of more effective livestock management systems.

Nitrogen

In the last decades, humans have significantly influenced the global nitrogen (N) cycle through the release of nitrous oxides from fossil fuel burning, soil emissions of agricultural lands fertilized with inorganic fertilizers, the production of N fertilizer and, to a lesser extent, by the cultivation of plants that perform biological nitrogen fixation. Through these activities, 150 million tonnes of N₂ per year are transformed to fertilizers based on reactive N. This is more than all N transformed in natural terrestrial processes together (Rockström *et al.*, 2009b). Before the current human interference, the global nitrogen cycle balanced N-fixation and denitrification processes by transferring available N to non-reactive N₂ gas (Ayres *et al.* in Galloway *et al.*, 2003).

Currently, about 75 percent of reactive N set free by humans is related to food production (Galloway, 2003). Unfortunately, agriculture is currently not very efficient in using N, especially in intensive agriculture systems, where excessive quantity or inappropriate timing of nitrogen application on crop fields can cause leaching and pollution of water bodies, the atmosphere or other ecosystems. Besides agricultural activities themselves, land use change is also a driver for modification of the natural N cycle.



N is a major plant nutrient and indispensable for agricultural production. The availability of cheap inorganic N fertilizers accounts for a large proportion of the yield increases of the last decades, including those of the Green Revolution of the 1970s. However, large regions in developing countries have poor access to inorganic N fertilizer and can barely afford to purchase it. With the growing demand for food, N fertilizer consumption is expected to continue, supporting increased crop production for human and livestock systems alike, with some projections indicating a doubling of inorganic N supply by 2050 (Tilman *et al.*, 2001). Such a large increase will need to cope with both economic (due to the foreseen increase in prices for fossil fuels) and environmental barriers, as planet system boundaries for N already may have been reached (Rockström *et al.*, 2009b).

On a global scale, differences in N budgets in agriculture are huge. In wide regions of the world, cropping systems are N-limited with related soil N depletions. At the same time, in other regions large surpluses of N are applied to soils, causing significant environmental problems through leaching. For example, in some Eastern and Southern African countries, N depletion is as high as 47 kg per hectare annually (FAO, 2011d), while surpluses in European countries can reach 223 kg of N per hectare per year (Hoang and Alauddin, 2010).

Deficiencies in N (and P) supply in crop production lead to low yields, accelerate land degradation and may lead to agricultural expansion and land use. On the other hand surpluses of N can cause serious pollution of watersheds and aquifers with severe impacts on some ecosystem services. N from agricultural sources accounts for 50–80 percent of nitrates entering Europe's waterways (SCAR 2008). Reactive N in the environment is linked to many other scarcities – the production of synthetic N fertilizers is very energy intensive, and fertilizer prices are coupled to energy prices. On the excess side, increased levels of N in natural ecosystems lead to excess emissions of nitrous oxides in the atmosphere, and significant losses through leaching lead to polluted waterways and estuaries, as well as the loss of biodiversity through eutrophication (Rockström *et al.*, 2009a).

The third most important GHG emitted from agricultural activities, one unit of N₂O has a global warming potential of 298 times that of CO₂ (Forester *et al.*, 2007). In 2005, agriculture was responsible for 60 percent of the global N₂O emissions, in total 2.8 Gt CO₂ equivalents per year (Smith *et al.* 2007). N₂O in agriculture is mainly derived from nitrogen fertilization (mineral fertilizer, manure, biological N-fixation). Livestock production plays



an important role in the alteration of the N cycle. While extensive livestock production systems are main drivers of CH₄ emissions, intensive livestock production is responsible for changes in the N cycle. Sixty percent of the global ammonia emissions result from livestock husbandry and also contribute to the acidification of ecosystems via acid rain. A large proportion of N pollution in ground and surface water is derived from intensive animal production (Steinfeld *et al.*, 2010).

Improvement of N efficiency in agriculture is key to achieving decreased N losses to the environment and to optimizing N use in crop production. Balancing the uneven N budgets on a global scale will be a key issue for improving future food security. Even though enhanced N use efficiency can be achieved, the reduction challenge posed by the planetary boundary threshold is such that N use in agriculture production needs to be fundamentally revised (SCAR, 2011).

Phosphorous

P is similar to N, in that it is an essential element in crop production. However, contrary to N, there are no bacterial processes that can transform organic forms of P into the inorganic forms that can be taken up by plants. In this respect, P is a non-renewable resource. Thus, in all terrestrial ecosystems, P is often the ultimate limiting nutrient for plant growth, which makes the use of P fertilizers indispensable for agriculture. A large part of yield improvements of the last decades can be attributed to the use of easily soluble synthetic P and N fertilizers. Other sources for P in agriculture are manures and waste materials.

P for fertilizer production is derived from P ores. Globally, 80 percent of the mined P is used for agriculture (Van Vuuren *et al.*, 2010). Changing dietary habits and a growing world population are projected to increase P demand by 50–100 percent (Steen, 1998; EFMA, 2000, in Cordell *et al.*, 2009) with the highest growth rates of such demand in East and South Asia, Eastern Europe, Central Asia and Latin America (FAO, 2008a). In Western Europe, P fertilization is projected to decline due to already excessively high P levels in agricultural soils and environmental concerns (FAO, 2008a; Cordell *et al.*, 2009).

Large imbalances of P fertilizer use exist on a regional scale. Asian farmers apply almost 54 percent of the globally available P fertilizer while only 3 percent is used in Africa (Lott *et al.*, 2009, in SCAR, 2011). Especially in regions with intensive livestock production, such as the Netherlands, large amounts of excess P accumulate from imported feed and the use of P fertilizers (Smil, 2000).



As phosphate rock is a non-renewable resource, the availability of P ores may limit the ability to sustain current agricultural production methods, but when this will happen is an ongoing debate. Some studies set ‘peak phosphorus’ for the next 33–100 years (Runge-Mezger, 1995; EcoSanRes, 2003; Steen, 1998; Cordell *et al.*, 2009), while more recent studies suggest much larger global phosphate rock resources than previously thought, which may last at current production rates up to 300–400 years (IFDC, 2010; Van Vuuren *et al.*, 2010). Even if this is the case, high-grade P ores may be depleted much earlier, threatening P supply and increasing fertilizer prices. Recognizing this, P scarcity is likely to affect food availability and turn into a critical geopolitical issue (SCAR, 2011).

In addition to the threat of irreversible depletion of phosphate rock sources, P scarcity also has environmental limits. Excess P in natural ecosystems, together with excess N, lead to eutrophication, anoxic events in coastal waters and biodiversity loss (Rockström *et al.*, 2009b) and to the loss of water quality and fish resources. For instance, today, the share of P derived from fertilizer that ends up in marine ecosystems is already about eight times the natural background rate of P influx (Rockström *et al.*, 2009a). Livestock husbandry is a major driver for P pollution of the environment: P via farm animal excrement is estimated to exceed that in human excrement by seven to nine times (Steinfeld *et al.*, 2010).

To solve these problems, the efficiency of P use in agriculture has to be improved with the consequent reduction of P loads into aquatic ecosystems. In addition, trying to increase efficiency in the use of P and to become less dependent on P ores is extremely important for the future. Urban areas are particularly at risk, and cities are becoming ‘P hotspots’ as the regional P cycles back to the countryside are interrupted (Cordell *et al.*, 2009). This includes the influx of materials (food, feed, etc.) to cities, whereby faeces and degradable garbage accumulate without being transferred back to their area of origin in order to close nutrient cycles. With increasing urbanisation and rising population in the mega cities, this becomes a major problem, as waste materials are in most cases either discharged to rivers, burnt or disposed of in unregulated open landfills. And while this happens, rural areas continue to lose essential nutrients.



Food production scenarios towards 2050

Per capita food availability is expected to increase, despite natural resource limits. The key driving forces of this improvement will be per capita GDP increase from the demand side, and yield increase from the supply side. Is this evolution due to the fact that thresholds on natural resource availability will not limit agricultural production in 2050, or is it due to a limited accounting of the impact of natural resources on food prospects?

This section reviews existing scenarios for future food security which, for the most part, are ‘business-as-usual’ expert projections of the current and expected trends in socio-economic and technology variables. It examines how they take natural resources into account, and analyses the potential consequences that different assumptions on the underlying natural, economic and social resources could have on the scenarios’ outcomes. Given the increasing pressures on natural resources and increasing risks for food availability that have been identified in different ways in many scenarios, this section considers the broad principles of a ‘green scenario’, focusing on a more efficient and more resilient use of land, water and agricultural inputs for food production.

Scenario assumptions do not build on explicit dynamics of future natural resources use because resource dynamics, such as land and water availability, fertilizer prices, disease spread, and trade policy impact on resources and bargaining power, are not fully understood. Therefore, it becomes important to offer explicit considerations of these dynamics in order to anticipate their potential impact on food availability. A few scenarios have made a step in this direction.

The International Food Policy Research Institute (IFPRI) has developed three more or less optimistic scenarios, based on policy and technology assumptions, which discuss food security in relation to climate change in particular, as well as water availability and oil prices. The United Nations Environment Programme (UNEP) and the Agricultural Research Centre for International Development (CIRAD) and the National Institute for Agricultural Research’s (INRA’s) Agrimonde have designed scenarios that simulate different aspects of a greener agriculture. FAO and the International Institute for Applied Systems Analysis (IIASA) have designed alternative future scenarios combining the global circulation model and emission scenario in order to assess the impacts on agro-climatically attainable yield, suitability and productivity for 2020, 2050 and 2080 using the Global Agro-Ecological Zone (GAEZ) framework.



Before analyzing the implications of the scenarios in detail, it is worth noting that they focus on average food availability more than on its continuity or its resilience. This means that they do not consider interannual or interdecadal variability due to sudden weather or socio-economic events. Including such variability is at the centre of the state-of-the-art development in these models, but such scenarios are not yet available, even though large-scale food crises in the last two centuries have resulted precisely from unexpected events, such as drought, plant disease and war, and not from an average trend in food availability per person. This would indicate that analyses of sources of ruptures (discontinuity) in food availability should be given more importance along with the yearly average equilibrium when analysing food availability under these scenarios.

Nevertheless, existing scenarios provide important information on potential regional tensions. For instance, South Asia is expected to cultivate 98 percent of its potential usable land and to increase yield by more than 50 percent, but it will still import more food than today. A higher level of food availability per capita is expected, but the consequences of a food crisis will also be more important, making the population more vulnerable to climatic damage or price shocks. This means that the average production level can be increased using fewer resources, but this should not happen at the expense of the resilience of production systems. These elements are at the core of green scenarios.

The challenge for 2050 is not represented by the need to raise production by 60 to 70 percent on average (Bruinsma, 2009), but rather to sustain this production level in vulnerable areas in a context of increased scarcity of many natural resources and increasing risk of ruptures in food availability (FAO, 2011b; FAO, 2011d).

FAO AT2030/50 projections

Methodological aspects

The FAO projections to 2030 (Bruinsma, 2003) and subsequently to 2050 (Bruinsma, 2006; 2009) were developed to contribute to projecting likely futures. These projections are presented and discussed together with related studies in Conforti (2011). Based on an analysis of current trends and past data, they infer future trajectories of yields, consumption and land use. There is no simple scientific method for this inference, so these projections rely on experts' knowledge and judgement of plausible evolutions.



The evolution of some variables follows a more or less business-as-usual trend, such as yields which are assumed to increase at a decreasing rate in all regions after 2000. Some variables have a different pattern, such as the per capita GDP growth rate in African countries which is expected to increase until 2050 at an average rate of 2.8 percent per year, whereas it was decreasing in the 1990–2000 decade at a rate of -0.5 percent per year. Similarly the number of undernourished people in sub-Saharan Africa is expected to decrease between 2000 and 2050, although it has been increasing thus far.

The FAO projection for 2050 is meant to be “policy neutral”, meaning that no explicit assumptions are made on policies in 2050, which is contrary, for instance, to the IFPRI scenarios which are defined by different policies. This policy neutrality is actually questionable, considering that since data used for projections have been influenced by policies that are likely to be subject to change. For instance, production in Europe has been dramatically encouraged by the Common Agricultural Policy (CAP), which has been progressively reformed since 1992. The Green Revolution in Asia was encouraged by subsidies and public investments. Policies have been extremely important in food production and in all data in FAOSTAT that scenarios based on these historical data probably should not be considered as policy neutral.

FAO used the Supply Utilization Account method to ensure equilibrium between food production and food use patterns (Bruinsma, 2003). The per capita GDP growth rates are the key assumptions from the demand side, since they determine food demand. Assumptions on yields in 2050 – fixed by experts for each type of production for each country and then aggregated into regions – are the key assumptions from the supply side. The global equilibrium is reached through an iterative adjustment between demand and production. Therefore, the food availability at equilibrium does not represent the food production that would be sufficient to feed people.

The state of the world described by the FAO scenario does not indicate how much production is needed (or the yields needed) to guarantee food security. Rather, it looks at how much production is expected. Therefore, one should not indicate that a 70 percent increase in food production would be sufficient to feed the world. A more rigorous statement is that a 70 percent increase in food production globally balances demand and supply, while decreasing the number of undernourished to 290 million, given prevailing assumptions on food distribution between and within countries. Such projected hunger



decrease, however, is sharper as compared to today, if the incidence of hunger (absolute number of hungry divided by total population) is considered.⁴

Assumptions from the demand side

The world population which was 6.07 billion in 2000 is projected to grow to around nine billion by 2050 (UN, 2010). At the same time, the world's average daily calorie availability is projected to rise from 2 789 kcal per person per day in 2000 to 3 130 kcal per person in 2050, a 12 percent increase.⁵ As the result, overall food consumption increases (including projected changes in both diets and population size) are projected to be 65 percent globally between 2000 and 2050 with maximum increases of 220 percent in sub-Saharan Africa, 112 percent in the Near East and North Africa, and 105 percent in South Asia (Table 2).

This consumption growth results from the projected fast-growing GDP per capita, which these scenarios assume to be in line with World Bank projections (World Bank, 2005; World Bank, 2006). Compared to a business-as-usual perspective, these GDP prospects can appear optimistic,⁶ in particular in sub-Saharan Africa, where the per capita GDP growth rate was -1.1 percent between 1980 and 1990, -0.5 percent between 1990 and 2000, and the projected growth rate is 1.6 between 2000 and 2030 and 2.8 between 2030 and 2050. Other regions projected progression is presented in Table 3.

As a result of increasing GDP per capita and increasing consumption, the number of undernourished people is expected to decrease dramatically, from 811 million in 2000 to 290 million in 2050 (4 percent of the developing countries' population). This evolution will require an important change in food security patterns, particularly in sub-Saharan Africa and South Asia where the number of undernourished people is currently increasing (Table 4).

Moreover, this projected decrease of malnourished people between 2000 and 2050 has not taken into account crisis that will most likely emerge in the next decades, such as the effects that were seen with the 2008 food price crisis which suddenly increased the number of hungry to almost one billion.

4 See also Grethe *et al.*, 2011, for a discussion on methodological aspects of FAO prospect.

5 The amount of meat in this daily availability has a great importance on the crop production needs (see Keyzer *et al.*, 2005).

6 See Hillebrand, 2011, for a complete discussion.



Table 2. Consumption (availability) prospect (Bruinsma, 2006)

	CONSUMPTION/CAPITA (kcal per day)			POPULATION (millions)			TOTAL CONSUMPTION
	2000	2050	GROWTH RATE (%)	2000	2050	GROWTH RATE (%)	GROWTH RATE (%)
World	2 789	3 130	12	6 071	8 919	47	65
Developing countries	2 654	3 070	16	4 731	7 509	59	84
Sub-Saharan Africa	2 194	2 830	29	607	1 509	149	221
Near East/North Africa	2 974	3 190	7	392	774	97	112
Latin America and the Caribbean	2 836	3 200	13	515	762	48	67
South Asia	2 392	2 980	25	1 340	2 208	65	105
East Asia	2 872	3 230	12	1 877	2 256	20	35
Industrial countries	3 446	3 540	3	905	1 019	13	16
Transition countries	2 900	3 270	13	411	343	-17	-6

Table 3. Expected economic growth (Bruinsma, 2006)

	PER CAPITA GDP GROWTH RATE FROM 1990 TO 2000	EXPECTED PER CAPITA GDP GROWTH RATE FROM 2030 TO 2050
World	1.2	2.7
Developing countries	–	4.0
Sub-Saharan Africa	-0.5	2.8
Near East/North Africa	1.0	3.1
Latin America and the Caribbean	1.6	3.1
South Asia	3.2	4.9
East Asia	6.3	5.0
Industrial countries	1.8	2.4
Transition countries	-1.8	4.3

Table 4. Expected under-nourishment (Bruinsma, 2006)

	PREVALENCE OF UNDER-NOURISHMENT (millions of people)		
	1989	2000	2050
Developing countries	823	811	290
Sub-Saharan Africa	170	201	88
Near East and North Africa	24	39	29
Latin America and the Caribbean	60	55	20
South Asia	291	299	90
East Asia	277	216	64



Assumptions from the supply side

It is estimated that world agricultural production needs to increase by 70 percent between 2005 and 2050 to meet future projected food demands (Bruinsma, 2009). Crop production is expected to increase by 66 percent, while meat is expected to increase by 85 percent.

This increase will be principally in regions with increased demand, namely sub-Saharan Africa and South Asia. Sub-Saharan Africa has a projected agricultural production increase of 224 percent between 2000 and 2050 (Bruinsma, 2006), including a 150 percent increase between 2005 and 2050 for crop production (Bruinsma, 2009). In South Asia, agricultural production is to increase by 141 percent (Bruinsma, 2006), including a 77 percent increase for crop production (Bruinsma, 2009).

These assumptions, established by experts, are meant to be plausible and sufficient to satisfy expected consumption (given assumptions on imported and exported food products). According to these assumptions, average food production will grow every year in each region (Table 5). At the world level, crop production is assumed to increase by 1.1 percent per year, which is slower than the rate of production growth in the 1961–2007 period, which averaged 2.2 percent per year. Production will grow at a lower rate in particular because fertile land is becoming rarer, and because yields are getting close to their maximum physiological level. Production will also slow because the demand increase will slow.

The expected production growth is essentially met through intensification of current production. Between 2005 and 2050, 91 percent of crop production increase can be attributed to yield and cropping intensity, and 9 percent to land expansion (Bruinsma, 2009).

Table 5. Expected annual crop production growth (Bruinsma, 2009)

	CROP PRODUCTION GROWTH RATES, PERCENT PER ANNUM (food and non-food crops)	
	1961-2007	2005/07-2050
World	2.2	1.1
Sub-Saharan Africa	2.5	2.1
Near East and North Africa	2.6	1.4
Latin America and the Caribbean	2.6	1.8
South Asia	2.6	1.3
East Asia	3.5	0.8
Industrial countries	0.9	0.7



Although production costs are not specified in the study, it seems that the increased difficulty of improving yields will imply increasing production costs and increasing food prices. This would be consistent with other studies that forecast a food price increase (IFPRI, 2010). If this is true, this would be an important change as compared with the twentieth century, when real food prices were on a slowly declining trend, indicating that the costs of further intensification could be higher than the cost of the previous steps of intensification, especially if input prices increase as several experts expect (IFPRI, 2010; Msangi and Rosegrant, 2009).

In order to improve and enhance such projections, therefore, it would also be necessary to pair projections of average food supply with economic cost analysis, as well as to specify technologies needed, including deployment times and required research and development efforts. Finally, as discussed, impacts of interannual variability should be further analyzed.

The natural resources scarcity in the FAO AT2030/50 projections

Land. At the global level, the cultivated area is projected to increase from 38 to 40 percent of the total area that is to some degree suitable for crop production. Therefore, at the global level, the resource of cultivable land should not limit the world production increase. However, cultivable land is becoming scarce in Asia, the Near East and North Africa where needs are expected to grow rapidly.

If these regions aim at regaining self-sufficiency, the availability of cultivable land will be a limiting factor as the shortage of cultivable land will cause an increase in the price of land and consequently in the price of food. At the same time, the current population growth that these regions are facing will make it unlikely for them to reach a goal of self-sufficiency in a short-time horizon.

Furthermore, the remaining 60 percent of land suitable for agriculture is currently used for other purposes or provides other non-food ecosystem services (such as GHG mitigation and biodiversity conservation). This may further reduce land available for food production in the future. The conflict between use for food production and non-food ecosystem services is not always so marked, given that the land devoted to cultivation often has different ecological characteristics than land suitable to preservation of non-food ecosystem services.



Table 6. Total arable land: past and projected (Bruinsma, 2009)

	TOTAL LAND SUITABLE (millions ha)	ARABLE LAND IN USE (millions ha)	ARABLE LAND IN USE (% of total suitable)	ARABLE LAND IN USE (millions ha)	ARABLE LAND IN USE AS (% of total suitable)
				2005	2050
Developing countries	2 782	966	35	1 086	39
Sub-Saharan Africa	1 031	236	23	300	29
Near East and North Africa	99	86	87	82	83
Latin America and the Caribbean	1 066	203	19	255	24
South Asia	220	206	94	212	96
East Asia	366	235	64	237	65
Industrial countries	874	388	44	364	42
Transition countries	497	247	50	223	45
World	4 188	1 602	38	1 673	40

Water. The use of freshwater for irrigated agriculture will increase, putting more pressure on water. As for land, agriculture will not use 100 percent of the available water in 2050, but water scarcity has already led to visible impacts on food security. While water availability in a normal year can be estimated, water availability in exceptionally dry years is already known to be insufficient for food security in several areas. Boundaries on water resources in the Sahel or East Africa are already limiting factors for food security.

Fossil nutrients and nutrient cycles. FAO projects an increase in fertilizer use in each region at a decreasing rate, reaching a maximum of 266 kg per hectare in East Asia in 2030 (figures are not available for 2050). As the price of fertilizers (and more generally of inputs) is an important component of the price of food, an increase in fertilizers cost would generate an increase in production costs and, in turn, higher food prices. As resources become scarce, sharp price increases are more likely to occur and to be more severe. For now, the hypothesis that technological progress and resource substitution will help make fertilizers more available at a lower price cannot be excluded. However, neither can the contrary hypothesis, which predicts more expensive fertilizers, be excluded. This could be the case, for instance, because of the non-renewable sources of phosphorus held by a small number of countries.



Table 7. Fertilizer consumption per hectare (Bruinsma, 2003)

	1962-63	1997/1999	2030
Sub-Saharan Africa	1	5	9
Latin America and the Caribbean	11	56	67
Near East/North Africa	6	71	99
South Asia	6	103	134
East Asia	10	194	266
Industrial countries	64	117	–
World	25	92	–

Accounting for uncertainties

Looking towards 2050 with respect to natural resource use and sustainability thresholds, the focus is on regional rather than global perspectives. The FAO scenario highlights a paradoxical situation. On one side, yield will further increase, people will be richer and the number of undernourished people will decrease, and in a “normal” context, the above projections seem robust (Alexandratos, 2009). On the other side, the pressures on resources used in agriculture will increase, even though this risk is very difficult to measure.

For instance, the important yield increases projected in sensitive areas such as Africa and South Asia are reassuring because they show that experts believe there can be improvement, and they seem reasonable when compared with past trends. However, at the same time, this improvement looks fragile when put in relation to the increasing pressure on natural resources and the increasing reliance on imports.

For instance, if the growth rate of cereal yield increase in South Asia is 0.9 percent instead of 1 percent per annum and if the consumption is kept as in the FAO scenario (Bruinsma, 2006), the necessary imports in 2050 will double. This means expected import of 60 million tonnes instead of 30 million tonnes, compared with 1 million tonnes imported in 2000.

The global image of improving food security may be due in part to the focus on annual averages, rather than an analysis of instability of yield (climate, diseases) or of import access (prices shocks, restrictions). In a “normal” year, the situation could look like the average picture described by above figures, but it is not easy to describe what a “bad” year would look like.

The 2008 crisis raised awareness that food shortages can occur in a region even when food is available at the world level. This can be caused by climate impacts on food producing



systems (FAO, 2011d) or because of speculative movements on commodity prices. Such shortages or price increases also could occur because of armed conflicts, or many other reasons linked to natural resources.

Therefore, it may be wise to anticipate scarcities of natural resources because their effects on food availability may be sudden and unpredictable. Several famines in developing countries as well as in developed countries have occurred unexpectedly in a trend of greater food availability at the global level (Griffon, 2006).

The substitution between resources is an important factor in adjusting to their relative prices, or enhancing their productivity. But some key resources (water, N, P, K) are not really substitutable. Therefore, it would probably be interesting to design modern farming systems and city infrastructures that can recycle rare resources, such as phosphorus or water, before their scarcity can be signalled through market prices.

It is equally important to anticipate and manage the strategic behaviour of exporting countries before these countries consider restricting exports. This could be done at the WTO, and is probably as urgent as the prevailing tradition of focusing on market access, domestic support and dumping.

Alternative scenarios

The following section synthesizes the outcomes of quantitative prospects for food availability at global level in 2050. Among the increasing number of prospects exercises⁷, the ones summarized below provide contrasting views on agriculture in 2050: three scenarios from IFPRI (2010), two from UNEP (2011b), and two Agrimonde scenarios from CIRAD (Paillard *et al.*, 2011). UNEP and Agrimonde AG1 put forward several characteristics of a green scenario for agriculture, including an improved eco-efficiency (defined as output per unit of input coming from natural resource) and improved resilience (defined as decreased risk of shortage).

7 Many important prospect studies could have been reported here, including the Millennium Ecosystem Assessment scenarios (Millennium Ecosystem Assessment, 2005), the UK prospect (UK Government Office for Science, 2011; UK Secretary of State for Environment, Food and Rural Affairs, 2005), the scenarios from the Social Ecology Institute in Vienna (Erb *et al.*, 2009), the European Commission Standing Committee on Agricultural Research (Freibauer *et al.*, 2011), or the OECD/FAO prospect (OECD/FAO, 2009). An overview of quantitative prospects is provided by Even and Laisney (2011) and Even and Vert (2011).



IFPRI scenarios

Methodological aspects. IFPRI's projection has important differences from the FAO baseline scenario. IFPRI considers three possible scenarios: optimistic, pessimistic and baseline. In each, policy is a driver and the economic equilibrium is derived from a General Equilibrium Model (IMPACT model). This scheme highlights the consequences of policy choices that can be made. The IMPACT global equilibrium model is an efficient way to ensure a quantitative consistency between different assumptions within a scenario. If a parameter on the demand side is changed, the supply side automatically reacts in order to ensure the equilibrium. This standard way to model food equilibrium does not, however, put the emphasis on the problems of food availability.

In such a framework, the food security problems do not arise from the fact that producers would be “unable” to feed the world, but from the fact that poor people lack the means to purchase enough food.

Key assumptions and outcomes. The supply side of the model specifically requires an assumption on yield growth which includes productivity growth rates. These productivity growth rates will increase slightly over the next 10–15 years and then decline gradually to 2050. They are adjusted in each scenario to account for the effects of climate change and producer responses to changes in prices. Technologies and farming practices used in 2050 to reach expected yields are not fully explicit and do not tell, for instance, how much input will be used for each unit of output. This does not mean that expected yields are unlikely, but that it is not possible to describe in sufficient detail the farming practices that will be associated with the 2050 yields.

The three IFPRI scenarios are quite contrasted. For instance, calorie availability decreases in all regions in the pessimistic scenario and increases in the optimistic scenario. But a key feature of IFPRI's scenarios is projected increase in prices in all scenarios, which is mainly attributed to the effect of climate change on productivity, thus “signalling the existence of imbalances in supply and demand and growing resource scarcity” (IFPRI, 2010). The likely price increase ranges from 31 percent for rice (in the optimistic scenario) to 100 percent for maize (in the baseline scenario). With perfect mitigation of climate change, these price increases would range from 18.4 percent for rice in the optimistic scenario to 34 percent for maize in the pessimistic scenario. Although a 20 to 100 percent



price increase might not appear spectacular, overall, the IFPRI scenarios show that producing food in 2050 becomes more and more difficult and a larger part of people's income will be devoted to purchase of food.⁸

UNEP scenarios

Methodological aspects. UNEP uses the Threshold 21 World Model, an integrated modelling platform based on systems dynamics. The evolution of environmental quality and its contribution to the economy is at the core of the model, making it particularly suitable to simulate scenarios of the green economy. The key principle is that investment in environment helps maintain natural capital that is necessary to economic growth. The economics of agriculture, forestry, fisheries or energy are positively influenced by the availability and the quality of natural resources. In the end, GDP and population well-being increase with the quality of environment and the availability of natural resources. This framework in principle overcomes the difficulties for general equilibrium models to describe effects of resource scarcities on productivity. At the same time, it is legitimate to wonder if the positive relationship between green investment and increasing GDP is fully an outcome of the model or partly an assumption of this integrated model.

Key assumptions and outcomes. UNEP designed two variants of a green scenario (G1 and G2) based on the expenditure of 1 percent for G1 and 2 percent for G2 of the GDP in green investments, and two corresponding variants of a business-as-usual scenario.

In the agriculture sector, the additional investment reaches respectively USD 118 billion per year in G1 and USD 198 billion per year in G2 on average between 2011 and 2050. It is allocated to more extensive use of organic fertilizer, agricultural research and development, pest control and food processing. In these scenarios, the volume of crop production is projected to increase by 11–17 percent in 2050 compared with business-as-usual. This is mainly due to higher yield per hectare (15–22 percent higher than business-as-usual). The empirical description of farming systems in 2050 is not specified – making it difficult to better understand if the UNEP-projected green agriculture produces more than business-as-usual only through the underlying additional investments, or through a general evolution toward more environmentally-friendly or eco-efficient systems.

⁸ See also Msangi and Rosegrant (2009) and Delgado *et al.* (1999) for a detailed analysis of IFPRI's prospect on animal products.



A similar rationale is applied to other sectors. For instance, the energy sector includes a large part on renewable energy in the green scenario, such as water use benefits from investment for management and desalination.

The green scenarios G1 and G2 point to a higher level of food consumption. By 2050, the overall nutrition level is projected to rise by 9–13 percent relative to business-as-usual, with 3 250 kcal (G1) and 3 380 kcal (G2) being consumed per person per day. Employment in the agriculture sector will increase up to 1.6 to 1.7 billion in 2050 in the green cases, well above the business-as-usual levels. In the green scenarios, while investments support the transition to a lower carbon and more resource-efficient economy, they generate higher GDP, as well as greater energy and water demand than would have been the case otherwise.

Agrimonde scenarios

Methodological aspects. The balance between production and consumption in the scenario is made through a simplified supply utilization account, expressed in calories. Production is converted into calories per hectare, and waste, feed, trade and non-food uses are expressed in calories (calories from food plants and those from animal production are aggregated separately).

Key assumptions and results. Agrimonde describes two very contrasting scenarios: a trend scenario inspired by the Millennium Ecosystem Assessment Global Orchestration (AGO) scenario, and an exploratory scenario where both supply and demand strongly differ from a business-as-usual scenario (AG1). The demand in AG1 is driven by health and equity principles (at a very simplified level) and production follows the principles of ecological intensification.

The average diets in AG1 are supposed to be composed of different food products around the world, but the total of plant food product available per person per day is 2 500 kcals in all regions and the total of animal food product available is 500 kcal in all regions. In OECD countries, this supposes a decrease in food intake (a decrease in “over-consumption”) and a decrease in waste of food by end users.

The production assumptions are based on ecological intensification, which consists of improving yields by using the ecological and biological functionalities of ecosystems to the greatest possible extent. This can be achieved in five main ways: (i) ecological approaches to soil fertility, (ii) water management of an entire ecosystem, (iii) integrated management



of major biogeochemical cycles such as the carbon cycle and the nitrogen cycle, (iv) integrated control of pests and diseases, especially through organic management, and (v) use of biodiversity (Griffon, 2006).

AG1's yields should be understood as the minimum production level that is sufficient to meet the world demand in 2050 according to the above principles. The average yield increase between now and 2050 is calculated at 7 percent (much less than all other systems). According to AG1, reaching a sufficient level of production with green agriculture is feasible (Paillard *et al.*, 2011).

Food availability in 2050

All food scenarios produced to date agree on the future ability of agriculture to match projected demand with enough food production globally. However – even without considering the fundamental additional risks that these scenarios neglect by ignoring effects of interannual fluctuations in agro-climatic and socio-economic resources – significant issues remain open in two key areas. First, in any given scenario, projected demand will reflect projected levels in people's means of accessing food. Hence, low demand may simply mean a world where many people lack sufficient economic resources to purchase sufficient food and, thus, even if demand and supply will balance in that scenario, such cases will correspond to high numbers of malnourished. Second, a global balance of demand and supply does not imply regional balance everywhere. In fact, all scenarios consider increased pressures on resources regardless of the global positive potential.

For IFPRI, even in its optimistic scenario, food prices will rise, due largely to climate change and, hence, mitigation is highlighted as a priority. This can be interpreted as a resource boundary impacting food security. In fact, weather-induced shocks causing a 5 percent decrease in grain yields would increase grain price by 25 percent (OECD/FAO, 2011). For the UNEP scenarios, agricultural productivity in the current trend is threatened and investing in environment, including the farming sector, is key for long-term increased productivity and wealth. In the Agrimonde scenarios, green agriculture, defined in terms of ecological intensification, is technically feasible and sufficient to produce enough food.



Modelling potential productivity under climate change and variability

FAO and IIASA have designed the Global Agro-Ecological Zone (GAEZ) framework to assess the impacts of climate change on agro-climatically attainable yield, suitability and productivity for current and alternative future climate scenarios (for the years 2020, 2050 and 2080), based on IPCC emission pathways and the climate projection of the global circulation model. GAEZ provides information on agroclimatic yields, yield constraints and crop calendars, and actual and potential production estimates for a large number of crops and crop subtypes subdivided into land utilization types at three basic levels of inputs and management: high, intermediate and low. Productivity estimates are made respectively for rainfed production, rainfed production with water conservation, and gravity, sprinkler and drip irrigation systems.

The outputs derived from the GAEZ framework include impacts of climate change and variability on the prevalence of environmental constraints to crop agriculture; climate variability and the variability of rainfed cereal production; changes in suitability of potential agricultural land; changes in environmentally suitable crop production patterns and multi-cropping conditions; and the impact of climate change on cereal production potential (Fisher *et al.*, 2002).

Several uncertainties limit the accuracy of these projections including the degree and rate of temperature change and its geographic distribution, associated changes that are likely to occur in the precipitation patterns that determine the water supply to crops, and evaporative demand imposed on crops by the warmer climate.

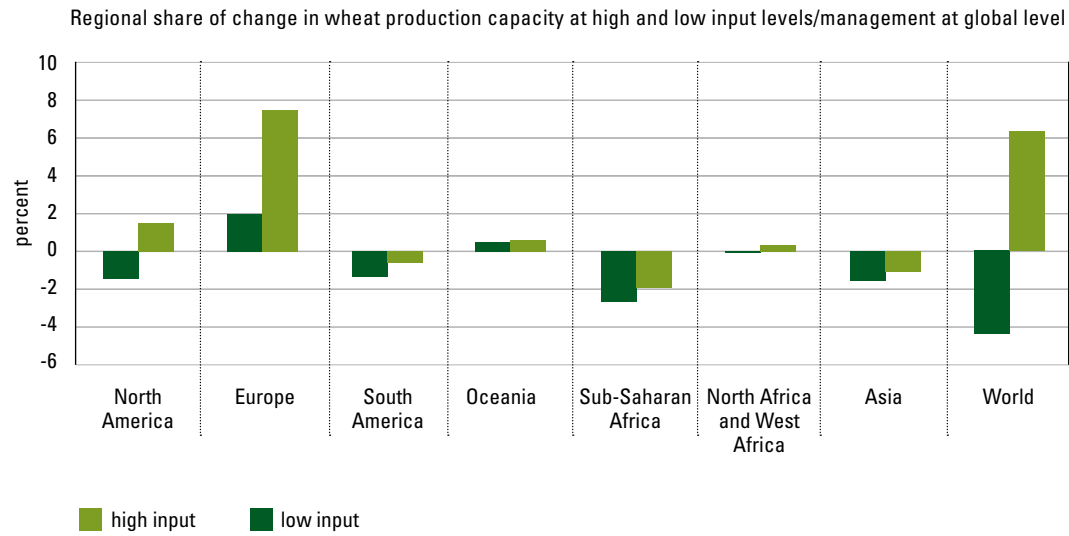
Figure 1 presents an example of the outputs derived using the GAEZ modelling framework to estimate changes in wheat production capacity due to reference⁹ and future climate projections for current rainfed cultivated land under low and high input levels by region. The current wheat production capacity estimate is based on the GAEZ crop productivity assessment for reference climate (1961–1990) data. The wheat production capacity estimate for future climate (2050) is based on IPCC HadCM3 A2¹⁰ and includes CO₂ fertilization effects. The estimated change in wheat production capacity for current

9 Reference climate data is calculated based on the time series for the years 1961 to 1990.

10 HadCM3, Hadley Centre Coupled Model, version 3, a coupled atmosphere-ocean general circulation model developed at the Hadley Centre in the United Kingdom, one of the major models used in the IPCC Third Assessment Report. The A2 scenario is based on the assumptions of a very heterogeneous world.



Figure 1. Regional share of change in global wheat production capacity in current cultivated land for rainfed cultivation at a global level at high and low input levels/management based on future climate projections (HadCM3-A2 model for 2050s) relative to reference climate data (1961–1990)



rainfed cultivated land is expressed as a percentage of the relative change by region. The chart shows the regional share of change in wheat production capacity in current cultivated land at global level. It indicates that climate change impacts on production capacity are projected to vary considerably across regions under both input levels. It also indicates that aggregated regional impacts are sensitive to the assumed level of input and management.



Regional scarcities, regional food needs and modalities for greener systems

For all the above reasons, it is reasonable to believe that agriculture in 2050 will be shaped by natural resource scarcities much more than is the case today.¹¹ Based on global and regional scarcities and food needs, farming systems will need to be more eco-efficient and risk resilient. This working paper identifies such regional scarcities and suggests key properties of future greener food production systems based on these scarcities. Production systems *per se* are described further in this document.

Sub-Saharan Africa. Sub-Saharan Africa is expected to encounter a very large demand increase, especially for animal products which will have a fourfold increase in present consumption. Land is available in many countries and yields are currently far below their agronomic potential, because input use is likewise very low. If GDP growth rates are as high as expected, there is a high potential for agriculture development, based on increased intensification, especially in tropical areas, and an increasing contribution of livestock to soil improvement, especially in dry areas. Water management will be a critical factor in dry zones, in the Sahel and East Africa in particular.

Middle East and North Africa. In North Africa, the expected demand increase is almost as high as in sub-Saharan Africa, but water and land scarcity are very significant limiting factors. If per capita GDP actually increases as expected, it is likely that precision agriculture may develop to increase the eco-efficiency in water and nutrient use. As in all dry areas, all techniques that would increase water conservation, such as mulch and organic matter accumulation, would increase the potential for intensification, while increasing the efficiency of input uses. Yet import increases are expected in virtually all scenarios.

Asia. Asia should also encounter a very high increase in food demand, but land is already scarce in many countries and yields are already high. Although intensification has to increase further, the resilience of the production system has to be improved.

¹¹ See also UNEP, 2009.



This includes resilience to input price increase, to climate events and, in particular, to spreading pests and diseases. Nutrient recycling, such as the rice-fish-duck systems practiced in many countries, seems to be a promising and necessary solution. The economic growth in Asia could contribute to significant technological improvement towards eco-efficiency.

Latin America. Latin America, although very diverse, is often considered to have the largest potential for intensification and surface expansion simultaneously (as can be observed now). Suitable land for cultivation is potentially available (although this potential land should not be considered “vacant”), labour is available, and capital and technologies are available. Several forms of conservation agriculture and an expansion of organic agriculture are good candidate technologies for greener production (Buckles *et al.*, 1998).

Industrial countries. Expected food demand in industrial countries hardly increases, land availability increases in several countries and production factors and capital are available. The demand for quality products (such as organic products) and the pressure for environmental improvement will continue to favour greener farming systems, with lower inputs and improved animal welfare and plant-animal integration.

Table 8. Summary of regional needs and constraints (Bruinsma, 2003 and 2009)

	TOTAL CONSUMPTION GROWTH RATE (%)	MEAT AGGREGATE CONSUMPTION (GROWTH RATE (%))	LAND IN USE (% of potential in 2050)	FERTILIZER USE/HA (2030)	PRESSURE ON WATER RESOURCES DUE TO IRRIGATION (% in 2050)	TRACTOR (% of area cultivated with tractor in 2030)	LABOUR (% of area cultivated by hand in 2030)
World	65	104	-	-	-	-	-
Sub-Saharan Africa	221	371	29	9	2	25	45
Near East / North Africa	112	291	83	67	62	75	10
Latin America and the Caribbean	7	128	2	99	2	70	15
South Asia	105	439	96	134	39	70	15
East Asia	35	120	65	266	9	50	25
Industrial countries	16	29	42	117 (in 2000)	-	-	-



From modelling average availability to risk prevention

Reaching a sufficient level of overall food availability should not be as much a problem as sustaining a sufficient level of crisis prevention as natural resources become scarce, more expensive and more strategic. This represents the overriding challenge of food production systems moving towards 2050.

Although the rate of deforestation, population growth and the required yield growth is decreasing, there is still but because of resource boundaries, this level of greater availability could be reached at a higher cost and with more uncertainties. Even though they are not technically focused on the evaluation of risks and inter-annual variability, the reviewed scenarios provide signals of such risks due to resource boundaries. FAO projections anticipate higher food availability but identify sources of tension on food availability due to natural resources, in spite of important per capita improvement in developing countries. IFPRI considers different levels of food availabilities, but forecasts higher food prices resulting mainly from climate change. UNEP finds that green investment in resource conservation yields a higher long-term outcome than business-as-usual. Agrimonde finds that ecological intensification together with a healthy and equitable diet yield a sufficient level of farm products with a much lower pressure on natural resources.

For these reasons, greener food and agriculture systems are proposed as viable means to use natural resources sustainably, improve the eco-efficiency of nutrients (OECD, 2011; UNEP, 2011b) and decrease the risk of food crises due to unpredicted tensions between natural resource availability and food demand (Conway, 1997; McNeely and Scherr, 2002; Griffon, 2006; Pingali and Rosegrant, 1994).



Options for greening food and agricultural systems

Methodology

This section analyzes the performance of most food and agriculture systems according to their different levels of input and management. It builds on the base information presented in the sections above, which looked at the current state and possible future scenarios of natural resource availability for food security. It deals with a number of sustainability issues relevant to the resource scarcity problem, as most increases in food production are projected to come from intensification in zones where land and water are already scarce.

As shown in the previous section, most experts agree that food production will have to increase substantially by 2050. Looking towards the future, establishing guidance in support of ecological intensification of food and agriculture systems is a major issue. The ultimate objective is to decrease the ecological footprint of production systems and, thus, move towards a greener economy.

Each production system has functional and structural properties (see Figure 2). Structural properties – including diversity, coherence and connectedness – are similar to a car’s engine: they determine the functional responses of the system. Functional properties – including efficiency and resilience – are similar to car’s dashboard display: they can be used to monitor agro-ecosystem sustainability (but they are not useful in explaining the underlying mechanisms). These system properties are particularly relevant to understanding the mechanisms that govern agro-ecosystem functional performance, or to designing targeted adjustments that aim to improve performance of the system or to innovate it (Groot and Pacini, 2010).

Why choose this conceptual model to assess food and agriculture systems? The FAO (2011b) flagship publication “Save and Grow” states that the Green Revolution in agriculture saved an estimated one billion people from famine. Thanks to high-yielding crop varieties, irrigation, agrochemicals and modern management techniques, farmers in developing countries increased food production from 800 million tonnes to more than 2.2 billion tonnes between 1961 and 2000. Those achievements came at a high cost though. In many countries, decades of intensive cropping have degraded fertile land and depleted



groundwater, provoked pest upsurges, eroded biodiversity and polluted air, soil and water. As the world population rises to a projected nine billion in 2050, we have no option but to further intensify crop production. However, the average yield rate per area of major cereals is declining and farmers face a series of unprecedented, intersecting challenges: increasing competition for land and water, rising fuel and fertilizer prices, and the impact of climate change. The present paradigm of intensive crop production cannot meet the challenges of the new millennium.

“Save and Grow” details farming practices for sustainable intensification based on an ecosystem approach. This section aims at putting the ecosystem approach into the practice of current and innovative food and agriculture systems. As clearly stated in “Save and Grow”, a paradigm shift is needed and can only be enforced at the global level if all the food and agricultural stakeholders (including farmers, technicians, researchers, policy-makers, input producers, consumers, workers and advocacy groups) are provided with the improved production practices and tools needed to assess both current and future choices.

In any decision process involving food systems, farmers and fisherfolk are those that assume the available production practices and shape farming, forestry and fisheries systems on the ground. The consequences of their choices impact all other stakeholders and future generations. A consensus needs to be found among all the actors while respecting land property rights, other private interests, national sovereignty and other public interests.

All actors need to fully engage in the process of “greening” food and agriculture systems, while guaranteeing food and nutrition security. Some food systems will need to become greener, while others that already use green technologies will need to become more productive; all food systems will need to become more resilient. It is not possible to enforce a paradigm shift without taking on board considerations on inter-relationships among diverse cropping and livestock systems; pedo-climatic conditions, fauna and flora; inter-relationships among diverse economic, social and environmental processes within food production units; and inter-relationships between food production units and both the immediate and global societies.

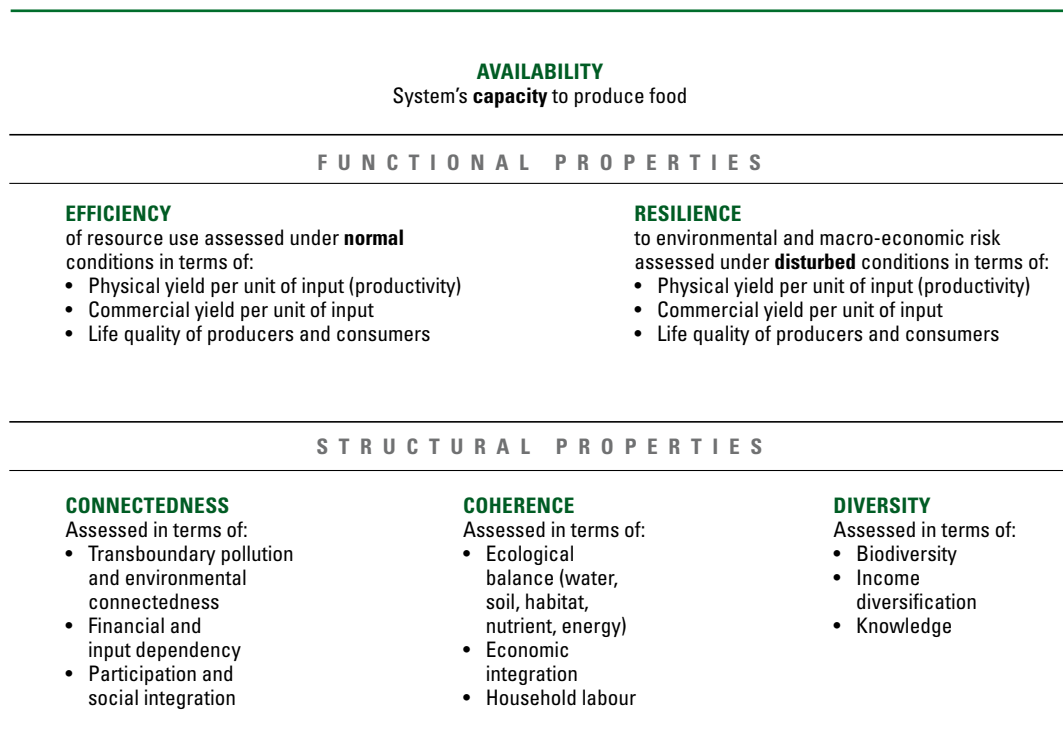
The aim of the conceptual framework based on structural and functional properties used in this document is to support a common ground for shared sustainability visions and assessments and to help decision-makers in finding their own way to analyse the



reality of food systems and guide their perceptions of related impacts. The conceptual framework is inspired by an ecosystem approach. While the level of detail of properties and relevant indicators, the communication ability and the way in which the framework is applied can be criticized and re-adjusted, we believe that this framework can support proactive assessments of food systems under an ecosystem approach perspective.

Figure 2 illustrates agro-ecosystems’ functional and structural properties and lists some representative indicators that could guide the analysis of the different agriculture, forestry and fisheries management options. Indicators included under each property are indicative of the type of information to be researched, but for reasons of brevity, reporting is not exhaustive in terms of covering all possible performances related to corresponding properties.

Figure 2. Agro-ecosystems’ functional and structural properties and indicators





Classification of different food and agriculture systems

Modern food and agriculture systems have modified natural ecosystem properties to increase productivity by substituting ecosystem services with anthropogenic activity. This includes using synthetic inputs, such as replacing insect predation with pesticides. This has led to a majority of intensive production systems that are clearly unsustainable due to unbalanced nutrient and energy flows.

For a green economy, ecosystems used by agriculture, forestry and fisheries need to shift back from heavily anthropogenized systems to semi-natural systems, without trading-off productivity.

This can be achieved by combining a reasonable decrease in the use of "hardware-like" technologies, such as mechanization and synthetic inputs, with an increased adoption of "software-like" technologies, such as agro-ecology-based knowledge and management. Any balance in the combination of these two types of technological approaches has to be coherent with two equally important objectives: (i) guaranteeing food security today, and (ii) guaranteeing the ability of future generations to meet their own food needs and therefore maintaining the health of agricultural, forest and water ecosystems and their ability to continue providing adequate food and nutrition.

Intensification can be achieved either through the intensification of external input use or intensification of ecosystem services for enhanced system performance, or a combination of both. Hence, the high, intermediate and low input intensity production systems in this review are categorized in terms of the degree of substitution of natural resource processes by "hardware-like" technologies. Ecology-based knowledge-intensive farming systems are defined herein as those that tend to rely on the observation and knowledge of ecosystem services much more than high-external-input systems.

In general, the further the distance of a production system from a stable ecosystem (e.g. natural biocenosis), the more external energy and inputs are required to maintain it. So, intensively cultivated annuals take the most energy, mixed farming systems with pastures take less, and forest gardens still less. Similarly, monocultures or single species production specialize in achieving high outputs, at the cost of significant applications of external inputs. Multi-trophic aquaculture, which supports the ecosystem approach to fish production, is a viable option for improvement. In capture fisheries, the Maximum Sustainable Yields approach has demonstrated its limit. Current management options rely



on the ecosystem approach where multi-species interactions are the focus of attention. The general tendency is to improve understanding (and mimic) the complexity of ecological interactions and, thus, ensure sustainable use of terrestrial and aquatic ecosystems.

The three categories hereby defined for food and agriculture systems parallel Global Agro-Ecological Zone Assessment input levels, as defined by IIASA and FAO (2010):

- **High-external input systems** are characterized by (i) commercial market orientation; (ii) use of improved high-yielding varieties; (iii) mechanization with low labour intensity, based on capital and knowledge-intensive technologies; and (iv) almost complete reliance on external synthetic inputs (e.g. fertilizers, pharmaceuticals). These systems are designed to produce the highest output at the lowest cost, usually using economies of scale, and global trade for financing, purchases and sales.
- **Intermediate input systems** are characterized by (i) partial market orientation, with both subsistence and commercial sale focus; (ii) use of improved varieties; (iii) medium-high labour (both manual and mechanization) and agro-ecological knowledge-intensive management and practices; and (iv) use of both fertilizer and chemicals, and on-site nutrients.
- **Low external input systems** are characterized by (i) largely subsistence focus and less market orientation; (ii) use of traditional cultivars; (iii) high labour and agro-ecological knowledge intensive management; and (iv) no or very little application of external nutrients, no use of synthetic chemicals for pest and disease control, but high emphasis of on-site nutrient cycling.

Of course, the on-the-ground reality is never as schematic as the classification above. More often than not, defining management level is case-specific, as the different levels of implementation depend on producers' personal objectives, knowledge and market possibilities. For instance, organic agriculture is very often an intermediate input system. However, small-scale farmers mostly practice it as a low external input system, and large-scale farmers as a high external input system (although to meet standards, the external inputs must be organically certified).

In the same way, practices such as conservation agriculture, integrated pest management and precision farming could also qualify, on a case-by-case basis, as intermediate or high-external input systems. The same is true for fisheries and forestry practices – with small-scale subsistence coastal fisheries and small-scale aquaculture being low input systems, and bottom trawling or large-scale aquaculture being high-external input systems, depending on specific cases.



Performance of food and agriculture systems

There are different management options identified for agriculture, forestry and fisheries, ranging from high to low input systems, including the entire spectrum of food and non-food production types, such as biofuels, fibres and timber. Current systems range from those ones which provide for most global food availability to emerging systems that have little or no significance to food availability today but which may develop within the context of a green economy and future population dynamics (i.e. urbanization).

Production systems in agriculture, forestry and fisheries include: high external input cropping systems; high external input livestock systems; genetically modified organism-based systems; conservation agriculture; integrated pest management; precision farming; sustainable rice intensification; urban and peri-urban agriculture; mixed rice-fish systems; mixed crop-livestock systems; organic agriculture; grasslands and forage crops; traditional polycultures; agroforestry systems; perennial grain polycultures; permaculture; biodynamic agriculture; forestry systems; mountain systems; capture fisheries and aquaculture.

The relevance of agriculture, forestry and fisheries management options could be evaluated in terms of area used, share of world food supply, labour employment and ecosystems services supplied. Each production option has different impacts on diversity, coherence, connectedness, efficiency and resilience and could be analyzed considering their potential for food production through the lens of ecological intensification.

The review of the different natural resources management options (from low to high external input systems) needs to be considered in terms of implementation potential in a green economy context. This would inform the adoption of policies that can tackle scarcities. Scaling-up any management option is challenging, with different levels of opportunities and constraints, depending on local natural resources assets, capital investment and socio-political contexts.

The process of greening the economy with agriculture will inevitably be iterative; production systems will have different intensities of green. The ultimate objective is to move from trade-offs to synergies by establishing more efficient and resilient food and agriculture systems that are able to cater to a growing population while drastically reducing the environmental footprint and enhancing ecosystem services.



Low-External Input systems (LEI). The options under this category are practiced by a small percentage of farmers and on a small scale. These systems are often as low-production farming methods. Poor farmers most often do not have access to inputs and markets to trigger improvements. Also, scientists have hardly studied forest gardens and perennial polyculture systems because of their complexity. However, there are many examples, for instance, from organic agriculture, tested under most agro-climatic zones, that point to a high potential in productivity, dietary diversity, income generation, maximization of returns given low levels of technology, carbon sequestration and a low environmental footprint. Increasing community awareness of environmental issues, combined with rises in the cost of energy, water and food are likely to lead to expansion in permaculture, perennial grain polycultures and other LEI innovative options. LEI improvements and up-scaling depend on improved agro-ecological knowledge, a public good that will hardly meet the interest of agribusiness, which by contrast tends to invest predominantly in HEI promotion. So far, LEI awareness and dissemination has taken place chiefly through bottom-up initiatives by civil society groups, non-governmental organizations and charities, and some research institutes. This may no longer be enough: public incentives and other rewarding mechanisms (such as Payments for Environmental Services) are necessary for the fast up-scaling of performing LEI systems in order to strengthen the resilience of food systems before natural resources scarcities create unforeseen crisis situations. Furthermore, this also requires the re-creation of local markets for the dozens of “new” products produced in such diverse systems.

Intermediate External Input systems (IEI). Intermediate external input systems constitute the bulk of food and agriculture systems and will most likely continue to be so in the medium-term. Their performance is location- and scale-specific, depending on the local endowments (environmental, social and economic). Continuous improvements are necessary to make such systems as conservation agriculture, and urban and peri-urban agriculture less dependent on external inputs, while maintaining a reasonable degree of stability in productivity. Agro-ecological knowledge, as in the case of LEI systems, is required, as well as green inputs. The transition towards greener systems within this category and scaling-up will most likely be triggered by consumer demand. This transition, however, could be greatly accelerated by financially supporting targeted conversion costs, as is the case for conversion to organic agriculture in most developed countries and, increasingly, some developing countries.



High External Input systems (HEI). HEI systems are more likely to remain options for the well-endowed producers (in terms of natural resources and financial flows) in the years to come. They have been easily scaled-up in the last decades due to the interest of private input producers, as well as public subsidies for synthetic inputs, favourable market conditions particularly for cash crops, and receptive attitudes by farmers in some regions. The increasing cost of inputs, such as energy and water, will most likely lead to a loss of economic efficiency of such systems, especially in the face of environmental shocks. Scarcity risks may become a major constraint to HEI expansion, especially if environmental externalities are considered in production costs. Given the capital availability of HEI systems, and the necessity of keeping up with food production to meet market demand in 2050, more investments will be needed from the public and the private sector to progressively move towards green inputs (including, for example, inputs for low carbon and biodiversity-safe technologies, mechanization, biological and integrated pest and weed management) in order to prevent risk of massive failure and pandemics.

As emphasized above, agro-climatic, socio-economic and cultural contexts dictate different approaches and different options for up-scaling management options. The successes and failures of low and high external input systems provide important lessons to learn and apply for all systems to improve. Three commonalities do exist in choosing future pathways, besides ensuring productivity: (i) taking into account the demands and needs of local communities; (ii) reducing fossil-fuel based inputs; and (iii) contributing to the conservation and enhancement of natural resources (i.e. land, water, biodiversity) and functional ecosystem services on which production strives.



Trade issues of relevance to food availability

Balance of food availability through production and imports

Food availability encompasses the issue of where food is produced which, in turn, determines key dynamics of imports versus local production. For individual countries, how much of the food it consumes is produced domestically or imported is a significant issue.

Clearly, not all countries can produce all types of necessary foods. The appropriate balance of production and imports depends on several factors, such as whether the country has sufficient or suitable climate conditions, land, water and other resources and capacity to grow food in sufficient quantities for its population, and its cost of production. It also depends on how high a priority the country places on achieving a critical ratio of self-sufficiency, based on the uncertainties or disadvantages of being too dependent on imported food and resilience to crisis, and the importance of the food and agricultural sector as a source of livelihoods.

Many developing countries once sought food self-sufficiency, but this objective was gradually tempered, starting in the 1970s, by a perception of economic efficiency that recognized the advantages of importing food at cheaper cost, so long as there was sufficient foreign exchange to pay for the imports. In several developing countries, especially in Africa, the change in attitude, to a significant extent, resulted from structural adjustment policies that promoted import liberalization and the withdrawal of government investment support to agricultural activities. More recently, the implementation of the World Trade Organization Agreement on Agriculture has contributed to some countries further liberalizing their agricultural trade.

Food imports have taken an increasing share of the domestic market in many countries, giving consumers access to cheaper food. However, there were drawbacks, including a decline or stagnation in domestic food production and adverse effects on small farmers' livelihoods and rural development. Paradoxically in some cases, the imports were foods that were heavily subsidized by developed countries (FAO 2011f).

The situation has changed in recent years because of the sharp rise in world prices of many food items, especially since the 2008 food price crisis which raised the prices of imports and food in local markets. It also led to shortages or restrictions on exports by some exporting countries, leaving several countries facing uncertain availability of certain food items. The inflation and shortages led to street protests in many countries. A climb in world food prices in 2011 has again put food importing countries in an uncertain and insecure position.



Because of this situation, a number of developing countries have announced plans and measures to achieve higher self-sufficiency in selected food commodities. For example, the Minister of Agriculture in Egypt plans to increase the local production and self-sufficiency rate for wheat (Egyptian Gazette, 2011); the President of the Philippines has targeted full self-sufficiency in rice (Aquino, 2011); the Philippine Minister of Agriculture announced a policy to minimize dependence on food imports (Alcala, 2011); Mali launched a Rice Initiative for developing local production following the 2008 rise in grain prices (Mali, Cabinet du Premier Ministre, 2008); and the Venezuelan government initiated support to agriculture production aimed at greater food self-sufficiency (Schiavoni and Camacaro, 2009).

It is increasingly recognized that there is a short-term need to ensure availability of food for countries currently dependent on imports, but a long-term solution is also needed to increase local food production in developing countries where the conditions are suitable. At the G8 Summit held in Italy in July 2009, leaders committed USD 20 billion in agricultural aid to boost the long-term capability of African countries to produce food. At the Summit's closing press conference, USA President Barack Obama said "there is no reason that Africa cannot be self-sufficient when it comes to food" (Wintour and Elliott, 2009).

Trade policies supportive of local production

While there are many factors involved in increasing local agricultural production, an appropriate trade policy framework is one of the most important requirements. At the international level, there is need to reduce further the trade distortions caused by the large domestic subsidies provided by developed countries. These domestic subsidies, sometimes accompanied by export subsidies, enable the export of agricultural products at artificially lowered prices, sometimes below the cost of production. These agricultural support policies associated with relatively high tariffs, particularly on processed food products in developed countries have both hindered export market access of agriculturally-efficient countries. By contrast, during the 1980s and 1990s, many net food importing poor countries reduced their applied agricultural tariffs to low levels, often significantly below the rates that are bound at the WTO. For example, many African countries have applied agricultural tariffs of 10–20 percent, compared to their bound rates of 80–100 percent (WTO, 2010). This has facilitated the entry of



cheaper imports, often making local production less viable and reducing the share of local produce in the domestic market.

A key difficulty that faces many developing countries is the inability of their producers to cope with rapid increases in levels of food imports and subsequent reductions in domestic market prices. Termed “import surges”, such instances of increased imports into the developing countries with limited ability to implement trade safeguard measures, have been well documented and analysed in a series of FAO studies (FAO, 2000, 2011f). According to one analysis, there were 12 167 cases of import surges in 102 developing countries between 1980 and 2003, involving coarse grains, cereals, meat, milk and vegetable oils (FAO, 2006d).

Most research concludes that import surges have been of increasing concern to developing countries, with food crops experiencing a great number of import surges, and some fibre crops are also vulnerable. According to FAO (2006d), “import surges may fulfil an important role in supplementing shortfalls in domestic supplies or contributing to longer term economic growth, but many countries fear that the opening-up of their markets as a result of trade liberalization may expose them to disruptive import surges that can damage otherwise viable domestic industries”. A more recent set of case studies (FAO, 2011f) confirms many of these concerns, but importantly, finds that the causes of many instances of import surges are not directly related to the extent to which a country has liberalised but are due to other factors such as events which have reduced domestic supply or domestic policy and institutional constraints to increased productivity, particularly where growth in domestic demand is strong.

At the national level, developing countries should therefore calibrate their degree of trade liberalization to be in line with their objectives and national realities (Morrison and Sarris, 2007). Countries that do not have the potential or intention of producing certain foodstuffs may have low or no tariffs, in order to enable their population to obtain imported food at the lowest cost. Those countries that intend to increase food production can take advantage of the flexibilities allowed in the WTO, and set their tariffs at the appropriate levels to have a viable domestic food sector, as long as the applied tariffs do not exceed the bound rates. Also, those developing countries with an export interest should be given the opportunity to expand their export earnings through improved market access.

Developing countries with a more efficient agricultural sector would be able to have higher export earnings if there were a reduction in existing restrictions to their market access, especially to developed countries. These countries have been in the forefront of



attempts to liberalize global agricultural trade through the WTO's Doha negotiations. There is a tension between these countries and the majority of developed countries that have tried to retain sizable agricultural supports and relatively high tariffs, as well as with developing countries which want to defend the livelihoods of smallholders from import surges. Indeed, some agriculturally-efficient countries have been advocating restrictions in the use of a special safeguard mechanism for developing countries arguing that their own farmers would be affected by any resulting restrictions on imports (WTO, 2010).

In addition to the establishment of tariff policy, governments also can boost agricultural activities through subsidies, credit, establishing security of land tenure, provision of inputs and so on. The WTO's Agriculture Agreement sets the rules on the extent of subsidies allowed. Since many developing countries previously provided only small subsidies, if any at all, mainly because they lacked the financial resources, they are in principle more constrained in the type of support that they can provide when compared to many developed countries. In practice, given the budgetary and administrative constraints that they face, the constraints are unlikely to be binding for most developing countries. Additionally, the agreement on agriculture allows developing countries to have a certain level of *de minimis* support, equivalent to 10 percent of total agricultural value, as well as to make use of the category of non-trade distorting support known as the Green Box (GATT, 1994).

Export restrictions on food products

Boosting local production is a longer-term process. Thus, several developing countries that have become significantly dependent on food imports are asking for assurance that these traditional sources of supply will continue to make the food products they need available. During the 2008 food crisis, a number of exporting countries restricted their exports of certain food items, on the grounds that their own population required the food.

WTO member countries must comply with a number of disciplines in order to ban or impose quantitative restrictions on exports (including on food) or to impose taxes on exports (including on food). These include Article XI of the General Agreement on Tariffs and Trade (GATT) which allows countries to make use of export prohibitions and restrictions only in the circumstances listed. These circumstances include "export prohibitions or restrictions temporarily applied to prevent or relieve critical shortages of foodstuffs or other products essential to the exporting contracting party". Export taxes



(including on food) are permitted by the WTO rules but they must treat destination countries which are WTO members equally. This means WTO members cannot apply higher export taxes on products destined for one WTO member country than another.

Moreover, Article XII of the Agreement on Agriculture sets out two obligations on a WTO member which makes use of Article XI:2(a) of the GATT 1994 to institute a new export prohibition or restriction on foodstuffs. First, the member instituting the measure is required to give due consideration to the effects of such a prohibition or restriction on importing members' food security. Second, the member must give notice in writing to the Committee on Agriculture and consult, upon request, with any other member having a substantial interest as an importer. The obligations in Article XII apply only to developed country members and to developing country members that are net food exporters of the specific foodstuff concerned. In practice, these rules and obligations allow significant flexibility to exporting countries wishing to impose restrictions. Following the recent increases in food prices and the contribution of export restrictions to these increases, there have been increasing calls for strengthening these disciplines.

In April 2011, in the context of the Doha negotiations, the net food importing developing countries (NFIDC) in the WTO proposed that if a non-NFIDC member institutes a new export prohibition or restriction on foodstuffs in accordance with Article XI of GATT 1994, it should not apply that prohibition or restriction on exports of foodstuffs to NFIDCs and Least Developed Countries (LDCs). They also proposed that WTO members should not apply export prohibitions or restrictions to the procurement and transportation of foodstuffs by the relevant United Nations multilateral agencies so they may undertake their humanitarian operations.

The United Nations' High-Level Task Force (HLTF) on the Global Food Security Crisis, in its framework for action, has also proposed that food exporting countries minimize the use of export restrictions (HLTF, 2010). It added that in cases where countries consider using export restrictions, it is important to use procedures for transparency and prior consultation with concerned stakeholders in order to avoid transferring shocks to importers.



Trading agriculture-related goods and services in a green economy context

As the relatively new “green economy” concept is applied to food and agriculture systems, there are emerging issues related to trade that are likely to occupy future public and policy debate. In particular, production and consumption will, to different extents, become subject to environmental footprint standards and labelling (e.g. organic, carbon neutral, GMO-free, virtual water, etc.) and other sustainability claims that could both enhance and hinder trade of certain commodities or imports from certain countries.

Green economy and the risk of trade protection

Policy-makers and experts, especially those from developing countries, have sensibly expressed concerns that if the green economy concept is implemented in a narrow manner, it could become a disguised form of trade protection, or a justification for new subsidies, standards, and conditional aid. To allay these concerns, due attention must be given to climate change mechanisms, carbon emissions, technology subsidies and environmental standards related to food and agriculture systems.

Tariffs. The green economy concept should not be used for trade protectionist purposes. For example, the proposal or plan that a group of countries may impose a carbon tariff or border adjustment tax on imports, including imported agricultural products – on the grounds that they generated emissions of carbon dioxide during the production process above a certain level, or that the exporting country’s emission controls do not meet the standard deemed adequate by the importing country – would penalize developing countries that do not have financial resources or access to low-emission technologies and are not in line with the principle of “common but differentiated responsibilities” that underlines current climate agreements as well as the Rio Declaration.

Research and development subsidies. Developing countries are currently unable to match the large subsidies routinely provided by developed countries to their firms and researchers for research and development (R&D) of environmentally-sound technologies, including in agriculture. Developing countries have been unable to compete with developed countries in regards to R&D grants, firstly because they lack comparable economic public resources, but also due to being potentially more constrained under the WTO rules from using many



types of subsidies that developed countries used when they were in their development phase. As part of the current Doha negotiations, the developing countries have proposed that the subsidies they provide be considered “non actionable”, and thus permitted for certain purposes, including for environmental protection. WTO members are currently urged to refrain from taking action on complaints against developing countries in this area, while the negotiations on this proposal are taking place.

Environmental standards. If certain countries adopt new environmental standards for food and agriculture products, countries unable to meet the standards face the prospect of losing their export capabilities. Thus, the approach towards developing countries should be to provide resources and technology for upgrading their environmental technology and standards, helping to spread new standards more efficiently while avoiding penalizing them in the process. Indeed, the full and effective participation of developing countries in setting international standards is also needed. Many important environmental standards are actually developed country standards that have “globalized” without concomitant support to assist developing countries in complying with such standards.

Aid, loans and debt relief. There are concerns that the green economy concept may be used as the basis for new conditionality on developing countries for aid, loans, and debt rescheduling or debt relief. To allay these concerns, any proposed conditionalities linked to the green development should be undertaken only after consultations with developing countries, which should be given the opportunity to participate in their design. As a rule in such negotiations, the three pillars of sustainable development – environmental, social and economic – should be considered, with a special attention to the food security imperative within the overall context of poverty eradication.

Beyond carbon markets for food and agriculture commodities

Carbon offsets. An emerging issue in climate finance is the appropriateness of various methods of financing small producers in their move to sustainable practices. Historically, development assistance is provided to farmers as grants or cheap credit, or as government programmes for land and soil improvement, water supply, provision of inputs and improved storage and marketing facilities. New financing methods include those relating to climate change, to include agriculture in offset schemes, including



carbon trading. Under such schemes, farmers or their organizations are provided with funds linked to carbon markets, in which companies with obligations to meet emission targets can make payments in order to offset their emissions above their capped emission levels.

Climate financing. The importance of linking carbon finance to mitigation activities in agriculture rests on the fact that many of the necessary climate change response strategies that will need to be implemented in this sector automatically provide for increased carbon storage in agro-ecosystems, as a by-product of creating more resilient and productive production systems. Yet while this may be a new source of finance for the food and agriculture sector, concerns have been raised that this financing method may be inappropriate for the sector (IATP, 2011).

First and foremost, it has been shown that such markets will not be in high demand by large compliance buyers in developed countries, that is, it will be difficult to sell carbon credits from agriculture in volumes sufficient to generate important financial flows. This is because, on the one hand, permanence problems of certain land-based carbon credits (including soil carbon, REDD, etc.) have led to their exclusion from large compliance carbon markets, chiefly the European trading scheme. On the other hand, measurements and verification of emission reductions in land-based projects is highly uncertain, making their use as a commodity quite problematic. Thus, there are significant transaction costs involved in these projects, creating high entry barriers to smallholders to the advantage of large corporations. Indeed, many farmlands and activities of small landholders may need to be pooled to improve efficiency; this may cause social tensions around issues of land tenure and possible displacement of food production and small farmers.

Such uncertainties, however, do not involve non-CO₂ carbon credits, such as those more typically linked to direct reductions of GHG emissions in agriculture, for example: development of more efficient animal waste management systems; more efficient fertilizer management techniques; more water efficient rice cultivation methods, etc. All of these techniques have clear synergies with greening of agriculture efforts, and importantly do not suffer from permanence problems of pure carbon actions such as soil carbon sequestration or forestry activities. Therefore, they should be promoted beyond current levels.



Payments for bundled ecosystem services. Generally, it is clear that significant future efforts in climate financing of developing countries cannot rest on carbon alone as a monetizable commodity for trade in international markets. Rather, it is becoming clearer that funding should focus on agriculture projects that address first and foremost food security, address environmental and social dimensions of rural development, and in doing so, also provide significant climate change adaptation and mitigation benefits. One way to utilize public and private finance for such funding may be the further development of the concept of payments for bundled ecosystem and social services, based on the fact that most of such positive actions have large benefits beyond carbon. In fact, they improve a host of local and regional conditions, from availability and quality of soil and water resources, to biodiversity, to improved income opportunities and gender equality, to efficient development of local bioenergy systems and increasingly, closed energy and material cycles.

Technology and Intellectual Property Rights

Within the green economy context, food availability will call for a technology shift towards cleaner means of production which in turn, will require improved means to transfer innovation. This central role of technology transfer was recognized in the 1992 Rio Summit and its related conventions. They recognized the need for technology transfer is beyond the commercial arena, and called for a pro-active role of national and international public policy to ensure developing countries have access to needed technology. Chapter 34 of Agenda 21 states the need for favourable access to, and transfer of, environmentally sound technologies to developing countries through technology cooperation that enables transfer of technological know-how and building up of economic, technical and managerial capabilities for the efficient use and further development of transferred technology.

Local technology design capacity. Building local capacity to design and make technologies is a central aspect of technology development and transfer. Developing countries should be supported in their climb of the technological ladder, that is from the initiation stage where technologies as capital goods are imported, to the internalization stage where local firms learn through imitation under a flexible intellectual property rights (IPRs) regime, to the final generation stage where local firms and institutions innovate through their own research and development (UNCTAD, 2007).



Intellectual property rights. The role of IPRs has been debated as to whether they help or hinder technology transfer. According to Agenda 21 (para 34.9), a large body of technological knowledge lies in the public domain which is not covered by patents, and there is a need to enhance access of developing countries to such technologies, as well as to build the know-how and expertise required to use them. Expanding the space for technologies in the public domain, and the transfer to developing countries of publicly funded technologies are thus an important part of the solution. At the international level, there can also be public funding and joint planning of R&D programmes. Products and technologies emerging from such publicly-funded programmes should be placed in the public domain further enhancing the pool of knowledge available to all.

Technology patents. For technologies that are patented, there should be a balanced approach to ensure developing countries' access at affordable prices. Agenda 21 (para 34.10) states the need for further exploring the concept of developing countries' assured access to environmentally-sound technology in relation to proprietary rights, with a view to developing effective responses to the needs of developing countries in this area.

One particular concern over IPRs in the agriculture sector is the filing of patent applications by large agrochemical and seed companies to pursue exclusive monopoly over plant gene sequences. In addition to a few companies trying to lay claims to existing plants via patents, hundreds of patents have been applied for in relation to genes of what are called "climate-friendly" crops, including crops that are genetically engineered to withstand environmental abiotic stress such as drought, heat, cold and floods. For example, at least 261 families of patents (subsuming 1 663 patent documents) published between June 2008 to June 2010 make specific claims to confer "abiotic stress tolerance" to drought, flooding, heat, cold or salinity in plants. This patent application rush could lead to a few large corporations monopolizing genes, seeds and crops that contain them, as well as providing them control of important means for climate change adaptation. Just six gene-related companies and their two biotech partners control 201 (or 77 percent) of the 261 patent families referred to. This would restrict the access to germplasm and to seeds. There should be a review of the social and environmental implications of these new varieties, and of IPR laws regarding approval of "climate-related genes" in plants that are either already naturally existing, or have been modified in the laboratory (ETC Group, 2010).



Virtual water

The water embedded in crop commodities has been perceived as a “hidden” solution for food availability (principally cereal commodities) in water scarce regions and termed “virtual water” (Allan, 2006). Virtual water has been referred to as the water consumed in the process of producing a product or service (Zimmer and Renault, 1999). Trade in virtual water refers to the export of the water which was used in the production of the exported product (i.e. the virtual water), as opposed to the actual content of water in the product. The argument that the import of predominantly rainfed cereals has effectively extended the socio-economic development of water scarce economies is clear enough, but the assumption that this explains or determines trade has been discredited by economists and agriculture researchers (de Fraiture *et al.*, 2004, Ramirez-Vallejo, 2006, Wichelns, 2010). Water is one factor of production in irrigated crops, but is generally small in relation to other inputs for energy, labour, seed and fertilizer. Therefore, in strict domestic resource cost analysis, the comparative advantage in a specific crop is usually determined by other productivity factors, principally labour. Water-scarce countries have been importing cereals from rainfed temperate zones since the advent of extensive, mechanized low-yield cereal agriculture in northern latitudes in the late 19th century. Equally water scarce countries in the Mediterranean basin have been exporting water intensive crops including tubers into early season European markets – in some cases using desalinated water to irrigate new potatoes.

The quantitative estimation of the extent of virtual water trade in food products worldwide as well as in individual countries and for individual products (Zimmer and Renault, 1999; Allan, 2003; Hoeskstra and Hung, 2005; Fader *et al.*, 2011; Hoeskstra, 2011), illustrate that patterns of food consumption have a bearing on water usage and requirements, but they do not explain actual trade or determine trade policy (Seekell *et al.*, 2010, Wichelns, 2010). Indeed, greater reliance on food imports would make the importing countries more dependent on foreign food products; the increased reliance and use of imports would affect the livelihoods of local farmers; and increased exports can cause deforestation and water pollution and contamination in the exporting country (Fader *et al.*, 2011).



Conclusions

If historic trends continue, food production can be expected to meet food demands globally. However, with increasing natural resources scarcity, higher projected risk of damage to terrestrial and marine ecosystems under climate change and uncertainties, not to mention the additional demands of sustainability, environmental conservation and adaptation to climate change, the challenge of achieving food security in future decades is much greater than in the past.

Greening the economy with agriculture and increasing food availability should be driven by investments that aim at achieving sustainable rural development, characterized by increased employment opportunities, more gender equality, and better energy and resource efficiency, while resulting at the same time in production systems that are more resilient under climate change, reduce GHG emissions and minimize the overall environmental footprint of agriculture, forestry and fisheries.

Food and agriculture production must progressively move off the chemical and fossil energy treadmill and transition towards lower external input, labour-centred intensification of production systems, especially in employment-scarce settings (Weis, 2007). This development path should maintain, enhance and, where necessary, rebuild natural capital as a critical economic asset and as a source of public benefits, especially for the poor whose livelihoods and security most directly depend on nature. A major effort is required to ensure continued food availability at regional and local levels, especially after 25 years of low investment in agriculture.

FAO (2011b) states that “to feed a growing world population, we have no option but to intensify crop production; but farmers face unprecedented constraints; in order to grow, agriculture must learn to save”. OECD (2011) reports that the available scientific evidence suggests that business-as-usual will lead to a future in which economic growth will be constrained by natural resource limits. Ensuring food availability in the years to come will involve a massive transition towards ecological intensification of production. This entails financing conversion costs in the short term, as well as public investments for the generation and widespread application of more ecologically-sound knowledge and technologies in agriculture, forestry and fisheries.



Science and technology

In the face of crippling food demand, possible climate shocks, increased water scarcity and higher input costs, additional research and knowledge capacity are needed to realize the full benefits of food production systems that maintain and enhance ecosystem services, while responding to the needs of producers and consumers. Although food system ecology is still in its infancy, its application and further development can create unique synergies between environmental conservation and food production. OECD (2011) lists a number of science and technology policy tools for a green growth strategy in agriculture, including public research to promote eco-efficient agriculture (including organic agriculture), research and development of agricultural biotechnology, alternative farming systems and related training.

The technological innovations of Greening the Economy with Agriculture include both environmental science – such as agro-ecology, marine multi-species dynamics and multi-trophic aquaculture – and green inputs, meaning safe, environmentally-benign substances designed to maximize energy efficiency and minimize waste disposal. Their generation and exchange need to be orchestrated by a global agreement on green technologies for global common goods that builds on the technology transfer principles of the 1992 Rio Earth Summit. Furthermore, international guidelines for sustainability assessments of food and agriculture systems are required to guide choices.

More generally, food and agriculture science ought to embrace a more holistic view of the efficiency of agrifood systems in terms of reducing toxicity and carbon emissions, as well as the volume of natural resources needed for food production. Measuring productivity must shift from crop yield to net output per unit area or, even better, to nutrient density per unit area.

Institutions and finance

Food and agriculture systems are increasingly challenged to produce more goods with fewer natural resources. Investments need to be catalyzed and supported by targeted public expenditure, policy reforms and regulation changes. Measures are needed at global, national and community levels.

- Global agreements could include international guidelines and verification measures for producing and trading foods that consider environmental and social accountability.



- National-level measures could include regulations (standards enforced by liability measures), taxes (on negative externalities) and incentives (for lowering footprints) to promote domestic food production of environmentally-sound and socially-just products. Public procurement of green foods and transitional finance can greatly stimulate change towards ecological intensification of food production.
- Community and, more importantly, landscape-level measures could include public-private partnership programmes to expand on PES and remuneration of positive externalities contracts with producers.

Cumulative gross investment requirements for agriculture in developing countries are estimated at nearly USD 210 billion annually, adding up to USD 9.2 trillion by 2050. This includes primary agriculture and downstream services, most of which come from private sources. Climate talks are challenged with sourcing funding for facilitating the agriculture and food security sectors in meeting the designations of a low-carbon (mitigation) and stabilized economy (adaptation). Apart from sourcing funds, this requires changing the way in which existing and new capital is deployed or spent by introducing solutions that increase efficiency and overall impact – upstream in the food value chain.

Greening the economy embraces climate-related efforts but also goes well beyond carbon as the sole commodity used to monetize climate action, by seeking to value and safeguard other critical resources such as water and biodiversity, while aiming for distributional equity. Increasing food availability while delivering a range of environmental services and narrowing disparities requires shifting the political economy to overcome anti-agriculture policy biases, while strengthening governance throughout the food chain at local, national, regional and global levels.



Working Paper 2

Decent rural livelihoods and rights in a green economy environment





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Executive summary

This paper explores “access” to food in the context of a green economy. The paper describes the inclusion/exclusion and socio-cultural dimensions of access and specifically focuses on two principal pillars:

- access to produce food: through entitlement to resources which enables women and men to produce and consume food directly;
- access to purchase food: through decent employment and livelihoods for women and men which enables them to earn the money to purchase food for themselves and their families. These are supported by a safety net of access to knowledge and information.

The paper first sets the context in which the discussions towards a green economy are being held, looking at the “access” concerns that are arising from population pressures and increasing food demand, from globalization issues such as the effects of subsidies and trade on smallholder farmers’ abilities to compete in the market place, and also from the current state of natural resources, such as land, water and biodiversity, and how it affects farmers’ ability to produce food.

It then looks at emerging issues that have increasing impact on farmers and rural communities, such as volatile food prices that affect both farmers who sell food and those who must buy food, emergence of the biofuel industry which often means competition between food and fuel crops, and the foreign investors’ “land grab” that is upsetting traditional farming patterns in developing countries.

In presenting the steps needed to achieve a green economy, the paper applies a human rights based approach, looking at who is included in, and who is excluded from, food security access, and why. This approach puts the individual at the centre of all development policies and programmes and ensures that individual rights are respected, protected and fulfilled. Recognizing that mere charity is insufficient, this approach emphasizes that development plans, policies and processes are anchored in a system of rights, responsibilities and duties for individuals, for private actors and for states. Access to food and natural resources is about human rights, but perhaps more importantly, it is about ensuring that these rights are equitable and meaningful for all, particularly in the socio-cultural context and human rights of women, indigenous peoples and marginal populations. It is about ensuring both physical and economic access to food for rural and urban populations – the latter of which are net food purchasers. The right to food doesn’t talk about handouts, but empowers



individuals and civil society to participate in decision-making and to claim their rights by holding public officials and governments accountable for their policies and programmes.

As highlighted by Millennium Development Goal 3 (gender equity), aiming for equal access to food under the two pillars of producing and purchasing food entails guaranteeing women's and men's awareness of their rights as a minimum condition for their participation in decision-making structures and processes. It also entails securing women's and men's access to knowledge at different levels – from locally generated knowledge to knowledge generated in formal institutions. Doing so ensures these pillars will be sustainable.

Introduction

- **Food security:** Food security exists when all people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life. (World Food Summit, 1996).
- **Access to food:** Access by individuals to adequate resources (entitlements) for acquiring appropriate foods for a nutritious diet. Entitlements are defined as the set of all commodity bundles over which a person can establish command given the legal, political, economic and social arrangements of the community in which they live (including traditional rights such as access to common resources).
- **Green economy:** In a green economy environment, access to food refers mainly to distributional equity in the context of a reallocation of capital into green and greener forms of development. Pursuing a green economy within the context of efficient and sustainable development and poverty alleviation therefore aims to reinforce the integration among the economic, social and environmental pillars of development resources.
- **Green jobs:** Green jobs link Millennium Development Goal 1 (hunger and poverty reduction) and MDG 7 (protecting the environment), making them mutually supportive rather than conflicting. Green jobs include work in agriculture, industry, services and administration that contributes to preserving or restoring the quality of the environment. They also need to be good jobs that meet the goals of the labour movement offering adequate wages, safe working conditions and workers' rights (UNEP, 2008).



- **Right to food:** In reiterating the international recognition of the universal “right to food”, the United Nations Special Rapporteur on the Right to Food underscored the need for a broad understanding of “access” to food, noting that, “accessibility requires both physical and economic access: physical accessibility means that food should be accessible to all people, including the physically vulnerable such as children, older persons or persons with disabilities; economic accessibility means that food must be affordable without compromising other basic needs such as education fees, medical care or housing.” (UNGA, 2010).

The rapid increase in the number of hungry, in part due to recent food, fuel and economic crises, reveals the fragility of present food systems, and points to the urgent need to tackle the structural, root causes of hunger and poverty (FAO, 2011a). The current call for a new economic model – a green economy – aims to sustain and advance economic, social and environmental well-being over the current reductionist economic model which has left millions in poverty and undernourished, as the gap between the rich and poor grows wider (Bapna and Talberth, 2011).

Transitioning to and sustaining such a green economy must build on the internationally agreed right to adequate food for all, as well as on the entitlements, such as natural resources and social safety nets, necessary to secure such access.^{12,13} To this end, natural resources must be supported to ensure that the goal of a green economy is achievable in ways that are socially, economically and environmentally sustainable. Moreover, such a transition must promote and support decent green jobs and livelihoods to enable people to produce or purchase adequate food.

There are numerous global challenges to overcome in addressing accessibility – challenges that have grown in breadth and complexity over the last 20 or so years. These global challenges are linked to, yet go far beyond, the issues of food security and access to food, including: depletion of resources such as water, land, nutrients, agricultural biodiversity, fish stocks, forests, grasslands, and fossil-based energy; the growing global impact of climate change; and increasing food prices and price volatility. A recent global

12 Right to food as outlined in 1966 International Covenant on Economic, Social and Cultural Rights (ICESCR), is a legally binding commitment that sets out explicit national-level obligations under Article 11.

13 The other pillars of food security – availability, stability, and utilization – are discussed in detail in other Working Papers in this GEA series.



assessment found that approximately 60 percent of the world's ecosystem services (benefits that people derive from nature) are degraded or used unsustainably (Layke, 2009).

These global challenges may generate higher risks for food producers and consumers, particularly for those who are already vulnerable, resulting in dietary changes providing less nutritious food. Additional impacts may result in a concentration of food chains in particular regions and increased competition for resources through globalization. In its *State of Land and Water 2011*, FAO highlights the current availability of suitable land and water resources needed to sustain production systems for current and future needs. Those people most affected by hunger and malnutrition are living in poverty; they are the most vulnerable of the vulnerable, and a majority are women (FAO, 2011b).

The agriculture, forestry and fisheries sectors employ one billion people, and the food sector provides direct and indirect livelihoods to 2.6 billion. In addition to providing food for the world population, investing in decent rural agricultural jobs provides important co-benefits for people, the economy and nature.

The paper explores how the demographic, trade, environmental and institutional challenges of the last two decades since Rio necessitate rethinking how food is accessed in the context of increasing food insecurity. The other Working Papers of this book on availability, utilization and stability complement the discussion of how agriculture can be the motor for bringing about a paradigm shift towards a green economy. The paper concludes with a discussion on the changes we want to see in the future.

Context for a green economy

Global trends since 1992

The global situation in 2012 is one of growing inequalities in terms of entitlements distribution and of extreme poverty for hundreds of millions of under-equipped smallholders, landless farmers and rural people. The income inequality gap between rich and poor rose in more than two-thirds of the world's countries between 1990 and 2005 (WRI, 2011). Globally, rural development and food policies have been based mainly on top-down, supply-driven approaches with no holistic overview. Interventions have been divided by sector, focused solely on, e.g. agriculture, natural resources planning and management, or soil and water conservation. This has only partially addressed the



constraints and potentials of local populations and has therefore been rarely adaptable to local contexts or adapted by local people (FAO, 2005a). The evolving agenda on access to food and natural resources points to a global operating context that is more interconnected now than 20 years ago.

Population

Over the last four decades, global population has increased from about 3.6 billion to 6.5 billion, and is predicted to reach 9.1 billion by 2050 (UNFPA, 2009). Essentially all of the growth will take place in the less developed countries, and will be concentrated among the poorest populations in urban areas. In recent years, the number of hungry has increased, reaching about 925 million today.

According to the Population Resource Centre (2008), a growing global middle class will increase demand for liquid fuels, causing oil prices to rise and a greater conversion of croplands to biomass production. According to the FAO publication *How to Feed the World in 2050*, population growth and changing diets will require an increase of about 70 percent in food production, with a higher water demand linked to more meat and milk production. This, plus the increasing competition between food and non-food production around the world, will create great challenges for those requiring access to natural resources (FAO, 2009a).

Globalization

Subsidies: effect of developed country subsidies on developing country farmer livelihoods

According to OECD, a total of USD 252 billion in subsidies was received by agricultural producers in OECD countries in 2009 which is 22 percent of the total value of gross farm receipts in that year and about the same level as in 2007 and 2008. However, general services support in areas such as infrastructure, marketing and promotion are also considered and totalled USD 95 billion, the total support estimate for 2009 is USD 384 billion, so approximately 27 percent higher than in 2008. In some countries, the average level of support was even higher: in 2006–08, it was 27 percent in the EU, 49 percent in Japan, 60 percent in Switzerland and 62 percent in Norway (OECD, 2009). The level of support is high for certain products such as rice, for which commodity-specific support amounted to 60 percent of total producer rice receipts in 2006 (OECD, 2009).



In contrast, several developing countries, especially in Africa, underwent major agriculture reform under structural adjustment programmes in the 1980s and 1990s. The reforms included a reduction in the public sector's involvement and expenditure in agriculture, including dismantling marketing boards, ending guaranteed prices for farmers' products and phasing out or eliminating support such as for fertilizer, machines, agricultural infrastructure. There were also significant tariff reductions. As a result, there was a decline in local production and a rise in food imports, with severe effects on farmers' livelihoods and farm incomes.

The incidence and damaging effects of import liberalization on local communities and rural producers in developing countries have been widely analysed. Research, such as an FAO report on import surges, indicates the level to which small farmers have had their incomes reduced and their livelihoods affected by the influx of imports. More details on the macro effect of agricultural trade and subsidy policies of large countries on increasing food price volatility and thus (negatively) impinging upon developing country farmers can be found in Working Paper 3 on Stability.

An FAO report on trade reform and food security (2003) pointed out that international trade reform might result in developing country tariffs being reduced more rapidly than the removal of production and export subsidies in developed countries. As long as developed country subsidies remain, prices in the world market will not reflect production costs.

It may be economically undesirable for developing countries to liberalize their domestic markets any further on items from other countries that are sold below the production cost. "Whilst this might favour transfer and also exchange entitlements (for producers of non-competitive goods), it would reduce the production entitlement of farmers" (FAO, 2003). This "clash of entitlements" is an important concept, especially in those developing countries where farmers comprise a significant or even the largest proportion of the population, and where their rights to decent livelihoods and incomes should be accorded a higher priority.

Trade: effect of trade policy and reform on farmers' livelihoods and food security

Over the past decade, global food production has followed a mainly positive growth trend, even on a per capita basis. Yet, the number of hungry people around the world has increased. The increase of hunger during the recent food crisis occurred in spite of a record cereal harvest in 2008. Clearly, while there is an adequate supply of food at the aggregate level, globally or nationally, this does not translate into equitable distribution and accessibility



for all people, particularly those who are most vulnerable. Accessibility is often determined by cultural precedents, gender, religion, ethnicity and race (Grazia, 2006).

The food crisis in 2008 provided a clear indicator that the global food and agricultural system, including current national agricultural trade policies and world trade rules, is highly vulnerable. The possibility of a re-occurrence of extraordinary price spikes and food scarcity on world markets calls for reflection on the factors that drive long-term agricultural trade, including a possible reform of global agricultural trade rules. Low-income food-deficit countries are particularly vulnerable to international market shocks due to economic and socio-political instability, as well as for other reasons outlined in this working paper such as the impacts of climate change. Many countries are heavily dependent on food imports and are exposed to international market instability. In this context, poor households are extremely vulnerable to the risk of short-term price increases of basic food stuffs but can also benefit from purchasing artificially cheaper subsidized imported foods (see above).

The trade policies and practices of many developing countries have been influenced by a trade framework comprised of international financial institution (IFI) loan conditionalities, rules of the WTO, bilateral and regional trade agreements, and unilateral policy measures. A number of developing countries have liberalized their agricultural tariffs significantly and reduced their domestic support for farmers over the past years. However, developed countries have not been under the condition of the IFIs and have, for the most part, maintained their traditional support for domestic agriculture through a combination of high subsidies, high tariff peaks, and export promotion permitted by the WTO. In the free trade agreements among developed and developing countries, agricultural subsidies are omitted from the agenda.

*Bilateral and free trade agreements:
effect on access of smallholders to decent livelihoods*

Bilateral and regional free trade agreements (FTAs) that have proliferated in recent years can have a significant effect on access of small farmers to decent livelihoods. If prices are lower, access should increase for consumers as they will have increased economic ability to buy food but will decrease for farmers who will earn less for what they produce. Smallholders are often both consumers and producers so they may stand to gain and lose.

FTAs, especially those involving major developed and developing countries typically require developing countries to undertake deep import liberalization on a broad range of products. Those agreements that are between developed countries – principally the United States of America (USA) and the European Union (EU) – and developing countries have provisions



that oblige developing countries to eliminate their tariffs on goods for a large portion of their total tariffs, typically as 80 percent within 10 or 15 years. However, the reduction of subsidies is not part of the agenda, meaning that developing countries are not able to gain from what might have been the most significant advantage to them, and still have to eliminate their tariffs in a manner that is much more extreme than their obligations at the WTO.

Developing countries also suffer from the weakness of international rules for defining and disciplining agricultural dumping by developed countries.

Doha negotiations: protecting farmers' livelihoods through trade policy

Reforms are needed in the international trade regime in which distortions in agricultural production and trade are caused by the high domestic support in major developed countries. This puts developing country smallholders at a disadvantage, in that artificially cheaper subsidized imports may enter and take a significant share of the local market of the non-subsidized local farmers. Moreover, the developing countries' non-subsidized farmers are unable to compete with the highly subsidized farms of major developed countries in third markets. Thus the subsidies adversely affect the entitlements of the small farmers to a decent livelihood and income level.

A combination of high subsidies in developed countries and low applied tariffs in developing countries has resulted in a high frequency of import surges of a wide range of food products into developing countries – more than 12 187 cases in 102 developing countries from 1980 to 2003 – which adversely affected farmers' livelihoods and incomes (see also Working Paper 1 on Availability). Due to the increasing concern over this, a majority of developing country members of WTO proposed that the Doha negotiations (see additional details on this process at: www.wto.org/english/tratop_e/dda_e/dda_e.htm) introduce two new instruments into the rules of the WTO – special products (SPs) and special safeguard mechanisms (SSMs). The objective of both instruments is to promote the livelihoods of small farmers, food security and rural development of developing countries.

- **Special products.** Under the SP concept, developing countries are entitled to have no or lesser reduction of tariffs on a certain percentage of their agricultural tariff lines as part of the Doha Round's agriculture modalities.
- **Special safeguard mechanisms.** The SSM envisaged as a tool to protect farmers from import surges. The SSM would allow developing countries to impose an additional tariff increase should the price of an agricultural import fall or the volume rise above certain specified levels.



Under the normal WTO safeguard rules, a country has to show that injury has been caused to its farmers by an imported good before it can apply to the WTO to increase the tariff of that good above the bound rate. However, this is inadequate for protecting small farmers in developing countries because it is difficult to prove that an actual injury has been caused by a particular import, and more importantly it would be too late to save the farmers from losses by the time procedures are completed to allow the country to take the safeguard measure. Under the SSM, a developing country can take safeguard action without having to show beforehand the injury to small farmers and relate its cause to imports. Action in the form of imposing an additional tariff can be triggered when either the price of the import goes below a certain threshold or the volume of import increases above a certain threshold.

Acceptance of the SSM and SP instruments was formalized in the WTO's Hong Kong Ministerial Declaration of 2005, marking a major step forward in WTO's recognition of the right of governments to take trade measures in defence of farmers' livelihoods in developing countries.

Box 1. Women and labour in international trade

During the past 20 years, international trade has tended to increase the availability of formal but mostly low-skilled, labour-intensive and low value-added jobs in developing countries, with most of these jobs filled by women. Women workers have been particularly sought by the export industry, because they are generally less unionized. Consequently, they have lower bargaining power over their wages and working conditions, and thus often work in substandard conditions. Export Processing Zones (EPZs) that have contributed to the export success of many developing countries in East and Southeast Asia and Central America since the late 1960s have largely employed a female workforce.

Source: IANWGE, 2011 (www.un.org/womenwatch)



Weakened institutions: affect on state ability to meet food security needs

State infrastructure, policies and capacities to tackle natural resources management challenges have been essentially weakened for a number of reasons including, in part, structural adjustment policies, but also due to a number of other factors including conflict, lack of investment and corruption. Public services in many countries have diminished, left under-resourced and often unable to translate into action what is written in policy and legislation. Weak national and local level institutions are ineffective in responding to the food security needs of the most vulnerable people – particularly those in marginal areas. Moreover, they fail to address the complexities of natural resource management such as assessment, regulation, monitoring.

New consensus on the importance of all human rights: civil, political, economic, social and cultural

The end of the cold war also brought the schisms between, on the one hand civil and political rights, and the other hand, economic, social and cultural rights, to an end. The Vienna Declaration and Programme of Action, as adopted by the World Conference on Human Rights on 25 June 1991 (paragraph 5), proclaimed that all human rights are universal, indivisible and interdependent and interrelated. The many world summits of the 1990s all emphasized the importance of human rights and fundamental freedoms regardless of political, economic and cultural systems. This approach has been now recognized as a driver for UN Agencies, funds and programmes. In 2003, the UN Statement of Common Understanding on Human Rights-based Approaches to Development and Cooperation and Programming¹⁴ was adopted to recognize human rights as the overall goal of development and therefore aimed at guiding international cooperation towards that direction. The Statement clarifies that a “set of program activities that only incidentally contributes to the realization of human rights does not necessarily constitute a human rights-based approach”.

14 The UN Statement of Common Understanding on Human Rights-Based Approaches to Development Cooperation and Programming (the Common Understanding) was adopted by the United Nations Development Group (UNDG) in 2003 (http://hrbportal.org/?page_id=2127).



The core international human rights treaties that gave further development to the Universal Declaration of Human Rights (Bill of Human Rights) have been ratified by a large number of States. The International Covenant on Economic, Social and Cultural Rights (ICESCR), recognizing the right to food in article 11, is now a legally binding instrument for 160 States. As for the Convention on the Elimination of All Forms of Discrimination Against Women (CEDAW), 187 States have ratified this legally binding instrument that is key to women's rights to entitlements, including rural women's access to land and associated resources that are essential to ensuring women's food security.

The World Food Summit of 1996 did this as well and reiterated the right of everyone to adequate food and the fundamental right to be free from hunger. Within FAO, a process started which led in 2004 to the adoption by the FAO Council of Voluntary Guidelines to Support the Progressive Realization of the Right to Adequate Food in the Context of Food Security (Right to Food Guidelines for short) (FAO, 2005b).

Natural resource pressure

Pressure on natural resources affects the access of farmers to food security by impacting their ability to produce food, either for their families or for the market. The following section looks at the current situation with the world's most important resources and how their degradation or overexploitation can affect smallholders and rural communities.

Land

At least 1.5 billion people today have some farmland as a result of land reform, and are less poor than in the past, or no longer so poor. But huge land inequalities remain or have re-emerged in many low-income countries (Lipton, 2009). The world is experiencing rapid environmental changes and decline in the productivity of the global natural resource base due to, for example, worsening land degradation in some of the world's prime agricultural land. Drylands, which cover more than 40 percent of the world's surface and are extremely vulnerable to over-exploitation and inappropriate land use, are increasingly affected by desertification resulting from climatic variations and human activities. Over 250 million people are directly affected by desertification, while a further 1.1 billion people in over 100 countries are at risk (UNCCD, 2005). These include many of the world's poorest, most marginalized and politically weak people.



Vegetation and soil resources are being degraded by overgrazing, deforestation, repetitive tillage (hoe and plough) and shifts towards monocultures that provide inadequate vegetation cover and fail to restore soil organic matter, nutrients and carbon. This jeopardizes fragile ecosystems and leads to loss of biodiversity, soil erosion, increased pests and diseases, soil compaction, low soil moisture retention and high losses of precious rainwater in drier areas (evaporation, runoff and deep drainage) or water-logging in wetter areas.

The result is low and unreliable crop and livestock yields, affecting the access of smallholders and some of the world's most vulnerable farmers to food security.

Forests

An estimated 1.2 billion poor people – or about 15 percent of the world's population – depend on woodlands, homestead tree gardens, and agroforestry production systems for their food, fuelwood and fodder needs (WCFSD, 1999a). Forests are also a key resource for soil protection, optimizing water supply, maintaining biodiversity and adapting to and mitigating climate change. Deforestation remains a major problem. While it shows signs of decreasing in several countries, it is continuing at a high rate in others, with around 13 million hectares of forest converted to other uses or lost through natural causes each year in the last decade, compared with 16 million hectares per year in the 1990s (FAO, 2010a). However, there also was a 59 million hectare increase of forests with a protective function between 1990 and 2010. Today, total forest area stands at 4 billion hectares (FAO, 2010a).

Ownership and management of forests by communities, individuals and private companies is on the rise, although 80 percent of the world's forests remain publicly owned (FAO, 2010a). Africa uses fuelwood for 58 percent of its energy, Latin America uses it for 15 percent and Asia for 11 percent. In some 40 developing countries (many of them among the least developed), fuelwood accounts for more than 70 percent of all energy use. The World Commission on Forests and Sustainable Development (WCFSD, 1999b) estimates that by 2050, demand for fuelwood will increase from 3.0 to 3.5 billion m³ per year. Smallholders living in forest margins in diverse parts of the world earn between 10 and 25 percent of their household income from non-timber forest products (FAO, 2010a).



Water

Approximately 1.2 billion people, live in areas of water scarcity, with 500 million nearing the same situation. Another 1.6 billion people face economic water shortages, meaning their countries lack the necessary infrastructure to take water from rivers and aquifers (UN, 2011a). By 2025, 1.8 billion people will be living in countries or regions with absolute water scarcity, and two-thirds of the world's population could be living under water stressed conditions (FAO, 2007). The situation will be exacerbated as rapidly growing urban centres place heavy pressure on neighbouring water resources (FAO, 2011b). According to Lundqvist, *et al.* (2008), “tremendous quantities of food are discarded in processing, transport, supermarkets and people's kitchens. This wasted food is also wasted water, resources, energy and also lost investments”.

Increased competition for scarce water not only results in reduced productivity and thus food insecurity, but also is at the heart of many resource conflicts within and between communities and other interests. Conflict and unrest over water can lead to longer term food insecurity when peoples' lives become more insecure and they are forced to move away to more peaceful areas or to camps to avoid violent situations.

Fisheries

In 2008, fish consumption reached an all-time high of 114 million tonnes, nearly 17 kg per person, supplying over 4.5 billion people with at least 15 percent of their average animal protein intake. In 2008, almost 45 million people were directly engaged in fisheries and aquaculture, indicating the sector's employment is growing faster than traditional agriculture. Altogether, including the family dependents of those working in secondary fisheries sectors such as handling and processing (of which women represent half of those involved), fisheries and aquaculture support the livelihoods of about 540 million people (FAO, 2010). Slightly more than half of the stocks (53 percent) were estimated to be fully exploited and, therefore, their current catches have reached or are close to their maximum sustainable productions, with no room for further expansion. The remaining 32 percent were estimated to be either overexploited (28 percent), depleted (3 percent) or recovering from depletion (1 percent) and, thus, yielding less than their maximum production potential, owing to excess fishing pressure in the past, with a need for rebuilding plans. This combined percentage is the highest historically (FAO, 2010).



Biodiversity

Agricultural and aquatic biodiversity includes the crops, livestock, aquatic organisms, forest trees and plants, soil and other micro-organisms and invertebrates essential to food production and ecosystem services. This biodiversity, vital for achieving food security and for providing options to face the multiple impacts of climate change (e.g. increasing water scarcity, change in temperatures, drought, flooding) is being lost at an alarming rate. In many instances, crop genetic material currently in use by farmers will not be able to adapt to the new conditions, resulting in local variety loss and genetic erosion (FAO, 2008). Many wild relatives of crops, the richest source of diversity for adaptive characteristics, are increasingly threatened. Increases in the frequency of droughts, floods and disease epidemics will increase the risk of losing entire farm animal breeds and animal populations that have a limited geographic distribution. Local extinctions will have negative impacts on the livelihoods of those women and men who depend on wild biodiversity for food, health, clothing or shelter. Reduced biodiversity means millions of people face a future where food supplies are more vulnerable to pests and disease and where water is in irregular or short supply.

Emerging challenges

Climate change

Climate change brings with it more frequent and intense extreme weather events, droughts and floods, leading to scarcer and harder access water, and more marginal and harder cultivation lands, thus compounding existing threats to food security and natural resources. Agricultural and food production, including fisheries, is, and will increasingly be, adversely affected by climate change, especially in countries which are already climate vulnerable with low incomes and high incidence of hunger and poverty.

A decline of between 20 and 40 percent in overall potential agricultural productivity has been forecast for many developing countries if temperatures rise by more than 2 °C.¹⁵ In the tropics and subtropics, even small temperatures changes could impact crop yields negatively. Many of these countries are situated in regions that already experience heat waves, drought, desertification, deforestation and flooding among other natural disasters.

15 The role of agricultural biodiversity in addressing hunger and climate change. International seminar, Cordoba 13–15 September, 2010 (www.uco.es/internacional/cooperacion/documentos-de-interes/documentos/CEHAP/Declaracion-de-Cordoba-2010-%20componente-internacional-ingles.pdf).



Small island states are particularly at risk. A projected sea level rise of 5 mm per year for the next 100 years would increase soil erosion, loss of land, poverty, dislocation of people and risk from storm surges, reduce the resilience of coastal ecosystems, allow for saltwater intrusion into freshwater sources, and necessitate high resource costs to respond and adapt to changes (Lambrou and Piana, 2006).

Rising and volatile food prices

Food prices are increasing and show greater volatility than in the past (FAO, 2011*d*), which has an impact on both farmers who rely on selling their production and those who use their income to buy food. In terms of its impact on access to food security, this is especially critical for women because they bear the brunt of rising prices. For example, in many countries, as men migrate for employment, women have greater responsibilities in maintaining farmland and looking after dependents. Moreover, escalating prices mean less money for education and healthcare, particularly for those already struggling to feed themselves and their families (Fook, 2011). Continued high food prices particularly impact poor households that already spend a great deal of their income on food purchases. At national level, such high prices affect low-income food deficit countries that may face problems in financing food imports.

The increase in the cost of critical inputs such as fertilizers and water, which both were related to sharp increases in the prices of oil, was a major factor in the increasing food prices through 2008 (Islam and Buckley, 2009).

The FAO Food Price Index (see figure) rose to 234 points in June 2011, 1 percent higher than in May but 39 percent higher than in June 2010 and only 4 percent below its all-time high in February 2011. As of July 2011, international prices of wheat had declined for the second consecutive month while rice prices increased. In Central America, maize prices surged to new highs and bean prices were well above 2010 levels. In Western Africa, cereal prices remained stable or increased but generally still remained at low levels. In Southern Africa, prices declined further in June in most countries. In Asia, prices of cereals remained steady and at high levels despite some declines. In the Commonwealth of Independent States (CIS), prices of wheat remained firm at near record levels (FAO, 2011*d*). “Having already surpassed the levels witnessed during the 2008 food crisis, by April 2011, the new upsurge in food prices suggested the world was facing yet another food crisis.” (Fook, 2011). On the asymmetric nature of price fluctuations please refer to section on global markets in Working Paper 3 on Stability.



Energy development

Access to food is linked to energy for and from agriculture in different ways. For example, large-scale liquid biofuel development may have both negative or positive effects on food prices and on access to land. Food prices also can be heavily influenced by production costs which are, in turn, influenced by the cost of fossil fuels for industrial agriculture. On the other hand, access to affordable, reliable and sustainable energy is crucial for ensuring food security, including access.

Bioenergy currently accounts for approximately 10 percent of the world's energy, but this share is expected to increase up to 25–30 percent (IEA-Bioenergy, 2010). Among the different types of bioenergy, liquid biofuels (often simply called biofuels) have been the most controversial. One particular concern relates to possible competition for land between energy and food crops, and the impact on food prices caused by the diversion of cropland to biofuel production.

However, as with many agricultural products, recent work by FAO¹⁶ and others show that liquid biofuels are not bad or good *per se*. It all depends on how they are produced, by whom and under what working conditions. This includes feedstock and land choice, the farming practices used which may impact male and female farmers differently, and the logistics of the biofuel supply chain that are subject to socio-political and economic determinants (Rossi and Lambrou, 2008; 2009). The overall discussion of carbon markets is detailed in Working Paper 1 on Availability.

Land and resource acquisition

The re-emergence of the land question is directly linked to the whole strategy of fighting poverty. In countries where big landowners own and farm hundreds or thousands of hectares – in much of rural Latin America, and parts of west Asia and north, east and southern Africa – growth has been slower in creating employment or reducing poverty than elsewhere (Lipton, 2009). “Land grabs”, referring to increasing acquisition of vast tracts of agricultural land by big international corporations and foreign governments in

16 FAO's work includes a project on Bioenergy and Food Security (BEFS), Bioenergy and Food security Criteria and Indicators (BEFSCI), a decision Support Tool on Sustainable Bioenergy (with UNEP), and Integrated Food Energy Systems. More details can be found on the FAO bioenergy website www.fao.org/bioenergy



Africa and elsewhere, often obstruct or deny smallholders and pastoralists access to the land upon which they have traditionally depended for their livelihoods and can therefore prevent local population from producing their own food (FAO, 2009b).

The increasing competition of these large industrial units combined with rural population growth has led to smallholder plots shrinking year after year. Farmers, particularly female farmers, are often relegated to marginal lands, and must deal with degraded soils and lack of water. This threatens rural women and men's right to food (UNGA, 2010). Similarly, fisheries agreements enabling one country to exploit the economic zone of another also impact food accessibility, specifically through declining resources for national small-scale fishers. The implications of fisheries access arrangements – social, economic and environmental – have been explored at length on the national and international levels through such bodies as the Coalition for Fair Fisheries Agreements (Gorez, 2005; Orellana, 2007).

Box 2. Land acquisition in Africa

A recent study in Ethiopia, Ghana, Madagascar, Mali, Mozambique, Sudan and Tanzania indicates an overall total of an estimated 2 492 684 ha of approved land allocations since 2004 in the five countries (excluding allocations below 1 000 ha). The study showed that land leases, rather than purchases, are predominant in land acquisitions, and that host country governments typically play a key role in allocating them. Examples of the size of single acquisitions include approved land allocations for a 452 500 ha biofuel project in Madagascar, a 150 000 ha livestock project in Ethiopia, and a 100 000 ha irrigation project in Mali. Deals on the whole are dominated by the private sector and foreign private investors particularly. Rising agricultural commodity prices make the acquisition of land for agricultural production an increasingly attractive option. In fact, some agribusiness players traditionally involved in food processing and distribution are becoming involved in direct production as well (Cotula *et al.*, 2009).



Steps towards a green economy

This section looks at the importance of taking a human rights-based approach when examining the issues of “access” to food and natural resources that must be factored into any plan for transitioning towards a green economy. Specifically, it focuses on two principal pillars in this context:

- access to produce food: through entitlement to resources which enable women and men to produce and consume food directly;
- access to purchase food: through decent employment and livelihoods for women and men which enables them to earn the money to purchase food for themselves and their families.

Access through a human rights-based approach

Transitioning to, and strengthening, a green economy requires, above all, addressing social and economic inequality and the marginalization and outright exclusion of the most vulnerable people. Individuals who are the most affected by hunger and malnutrition experience constant and continued violation of their human rights as a result, in part, of policies that do not recognize or lack effective solutions to the main underlying causes of food insecurity and poverty.

Applying a human rights-based approach in moving towards a green economy puts the individual at the centre of all development policies and programmes and advocates that individual and collective rights are respected, protected and fulfilled. Enforcement of such policies and programmes is key to ensuring that human rights are fulfilled. It puts the empowerment of the people at the forefront, and changes the way of satisfying people’s needs from acts of benevolence to legal entitlements that can be claimed to public authorities through legitimate recourse mechanisms. What makes a human rights-based approach different from other development approaches is that it offers a new way of analyzing the existing problems, developing solutions thereto, assigning responsibilities and resources and monitoring achievement made. It is far from something theoretical or ideal, but rather a very practical approach. Using a human rights-based approach means to empower individuals to hold their governments accountable, ensuring non-discrimination and participatory and transparent mechanisms of policy development involving all stakeholders, creating an independent legal framework where people have



access to recourse and remedy in case of violations paying particular attention to the needs of the most vulnerable.

In addition to achieving technical or economic results, the realization of human rights should be the overarching goal guiding efforts to ensure human development. Secure access to natural resources is crucial for achieving food security and for realizing people's right to adequate food, but a green economy cannot be entirely successful if other legal entitlements are neither respected nor protected in practice.

Individuals as well as private entities should respect just and favourable conditions of work just as they respect resource rights. While private actors should respect national law, it is the state that is the overall guarantor of social justice, having specific obligations under international human rights law. This requires an enabling environment in which authorities are legitimate and accountable, acting efficiently, effectively, and competently in the best interest of people, particularly those who are most in need. Such an environment should also set out clear procedures that guarantee the participation of civil society in decision-making, in which information is transparent, and in which governmental authorities are accountable (Cruz, 2010).

An adequate standard of living, including the realization of the right to food, cannot be achieved if individuals are not aware of their entitlements and or do not know, or have not had the chance to learn how to address public institutions when their rights are not being respected. In this case, access to adequate information is a minimum condition, particularly for those needing prior preparation in order to do so (i.e. literacy, numeracy). As established in national and international law, information should be transparent and accessible to everyone in order to be meaningful.

Access through entitlements

Examining the entitlements context

Entitlements – the rights to manage an area or cluster of natural resources based on a socially recognized, legitimate claim to participate in its management – arise out of a range of society-specific normative values and are not necessarily set in law. Rather, entitlements are the outcome of negotiations among social actors, and this invariably involves power relationships (Leach *et al.*, 1997). Establishing legal entitlements is very important in the context of power inequalities and links to creating a strong institutional



framework. Having legal ownership documents can serve as security which cannot be guaranteed by informal entitlements.

Failure to establish entitlements can materialize in different ways for different populations in different socio-economic, cultural, economic, geographical and environmental settings. They can occur for various political, legal, economic and cultural reasons but most often they happen because of inequitable structures and power dynamics at and between different levels – ranging from household to national and international decision-making bodies and processes. For example, many fishing cultures worldwide have a taboo that prohibits women from fishing. Case studies from Africa often report that women lack direct access to, or decision-making power over fisheries, which limits their possibilities for overcoming intra-household poverty and food insecurity (Te Lintelo, 2008). Men and women migrants also face constraints accessing entitlements when they move to new areas, and because they lack capacity, knowledge or awareness.

As FAO has recognized, entitlement failures need to be addressed through short-term and long-term solutions. This includes social relief and rehabilitation programmes such as social and food safety nets to meet short-term immediate needs, and intermediate and long-term solutions that include strengthening of rural institutions such as rural financial systems, entitlements to natural resources, and employment and labour markets.¹⁷ Access to knowledge and information is also a critical entitlement failure that needs to be addressed. The following sections discuss some of the key entitlements that need to be considered to strengthen a transition to a green economy in ways that ensure people have access to food and the resources they need to acquire food – either through production, purchase or other means such as trade.

Strengthening social safety nets

The right to food requires countries to respect, protect, facilitate and provide the right to food, implying that they should “proactively engage in activities which assure economic and physical access to adequate food”.¹⁸ This can mean providing food directly or providing the means for its purchase, when individuals are unable to provide for their

17 Categories based on FAO (www.fao.org/bestpractices/content/09/09_01_en.htm).

18 FAO. The Right to Food Guidelines: Information papers and case studies, p. 141 (www.fao.org/docs/eims/upload/214344/RtFG_Eng_draft_03.pdf).



families and themselves due to conflicts, natural disasters, long-term employment, or to their living with disabilities or illness. Social safety nets, including the subset of food safety nets, aim to meet state obligations, typically by helping people through short-term crises, either directly through food aid, income transfers through food or cash, or indirectly through policy direction. Social and food safety nets also can contribute to longer range development by guaranteeing paid working days, or setting up food-for-work, school feeding, microcredit or insurance coverage. From a human rights perspective it is important to create legal entitlements, which provide a sense of security as well as procedural safeguards, rather than ad hoc programmes operated as a charity.

However, social and food safety nets do not “solve” hunger or poverty, which is why they need to be part of a bigger policy framework that aims to provide economic opportunities and employment. Social and food safety nets are best viewed as development, rather than charity or welfare, because they do develop important assets for rural livelihoods which is in keeping with human rights-based approaches. A complementary discussion on the Safety nets is detailed in Working Paper 3 on Stability.

Box 3. Insurance schemes for smallholder farmers

In recent years, agriculture-oriented insurance schemes have more become more widely used across Asia and Latin America and the Caribbean to reduce smallholder farmers’ risks. Chile has expanded and increased crop insurance subsidies and, similar to Brazil, has increased the equity and coverage of their funds as collateral for agricultural credit and export. Mexico has initiated a national insurance system while in Peru, Agro-Peru provides guarantees to farmers and an insurance programme for times of emergency. In Asia, public and privately implemented insurance schemes have taken off for crop purposes in Bangladesh, India and Thailand, and for livestock purposes in China, India and Nepal. In Africa, the private sectors of more countries have become involved in the provision of crop insurance (FAO, 2011f).



Improving access to land and other natural resources

Access to land, water, forest, fish and genetic resources is increasingly affected by climate change, natural disasters, conflict, population growth, consumption trends and growing demands for land for agriculture and for new energy sources such as bioenergy. Even when a country ratifies international commitments ensuring access to food and natural resources, often the prevalent systemic social, cultural, ethnic and religious structures – framed as traditions and customary rights – pose challenges to equitable access to food and resources in these different contexts. This is especially an issue for women, children, migrants and other vulnerable groups. Across regions, for instance, women face greater challenges than men in accessing natural resources, inputs and opportunities (FAO, 2007).

Different households and different individuals depend on different resources for their livelihoods, usually according to their communities, be they fishers, forest dependent communities, livestock herders, indigenous people or urban producers. For households that depend on agriculture for their livelihoods, land is the most important asset (FAO, 2007). In this respect, substantial future land reform remains likely and desirable (Lipton 2009). Securing legal title to land allows farmers and communities to use this resource as collateral to access credit to supply inputs, scale up production and embark upon or strengthen post-production and value-addition activities.

Experience has shown that farmers with collateral such as land can more readily access financial services and increase the supply of credit available to them (Tenaw *et al.*, 2009).

Forest resources also provide a basis for food and fuelwood for household use, mainly for cooking food, and for income generation. Access to food depends on access to, and control over, forest lands for hunting, fishing, gathering and other territorial resources for indigenous peoples (FAO, 2009c).

Along with land and forests, water resources are key to providing food access. This includes fresh water for agricultural production and agroforestry, livestock rearing, the growth of wood and non-wood forest products and aquaculture.

However, millions of people face difficulty in accessing water due in part to increasing scarcity, but also the lack of infrastructure to harness it when it is available. Problems arise because local, national or regional water and sectoral policies often conflict with each other and with the needs of producers. Ensuring improved access and addressing inequitable access to land, water and other natural resources, particularly for the most vulnerable, is crucial to improving their access to food, either through direct production or harvesting, or through generating income so that they can purchase food.



Box 4. Fisheries and land entitlements: Diverse and complex regulations and norms

Nigerian fishers from different ethnic and linguistic backgrounds are technically free to fish wherever they choose. However, fishery grounds are rarely “open access”, and instead are governed by different formal governmental regulations, informal regulations and socio-cultural norms. Typically, government regulations control access and effort but are interlinked with socio-cultural norms that serve to minimize conflict between users and determine access entitlements such as inheritance of rights of access, user group membership, gender relations, allegiances or ethnicity (Te Lintelo, 2008).

The following sections highlight the specific areas that need to be considered at all levels – from policy and legislation to research to design to community implementation – in order to redress entitlement failures and ensure a transition to a green economy that recognizes and embraces not only environmental and economic concerns, but also social and cultural concerns.

Women’s access to natural resources

While lack of tenure security affects millions of people across the world, women face added risks and deprivation. In Africa and south Asia especially, women are systematically denied their human rights to access, own, control or inherit land and property (Benschop, 2004). Yet these rights are key to providing women entry points for accessing credit, irrigation water, and equipment. Informal and customary means of access to water and tree products are important for women. For instance, in cases where traditional means of access to water by formal ownership and labour contribution are blocked, women resort to informal means of access, through male relatives or irrigation officials, or simply by taking it or through temporary access linked to land rent. Likewise, land tenure is characterized by nested and overlapping rights, which is the result of social and ecological diversity among various groups of people and resources (Quisumbing, 1999). Women also face inequitable



access to information and communication tools that could help improve their access to resources – and consequently – food. The 2010–2011 FAO State of Food and Agriculture (SOFA) flagship publication found that women across regions have one thing in common: they have less access than men to productive resources and opportunities. If the gender gap in agriculture were closed, they could increase yields on their farms by 20–30 percent. This could raise total agricultural input in developing countries by 2.5–4 percent which could, in turn, reduce the number of hungry people in the world by 12–17 percent.

Indigenous people

Indigenous peoples make up one-third of the 900 million people living in extreme poverty in rural areas (IFAD, 2008). Too many continue to lack the full legal, social or cultural recognition outlined in their rights and continue to suffer from discrimination. Analysing, understanding and addressing the context in which indigenous women and men live as well as the challenges they face politically, culturally and economically is essential to alleviating the poverty and addressing the food insecurity that all too many indigenous peoples face around the world (Grosso and Cenerini, 2010). Natural resources, such as land (including grasslands), water, fisheries, genetic resources, and forests and trees, provide indigenous people their main sources of subsistence harvesting and production but also provide income-generating activities such as collection and use of non-wood forest products. Access to hunting, fishing and gathering grounds provides greater security to adequate food and nutrition for those living in particularly remote areas not served by food markets. In response to continuously growing pressures and rapid changes taking place in the world, the international community has urged that more concerted efforts are made to respond to the needs and demands of indigenous peoples.

The UN Declaration on the Rights of Indigenous Peoples (UNDRIP). Adopted by the UN General Assembly in September 2007, UNDRIP has given major impetus to promoting the rights of indigenous people by prompting national authorities to pursue greater action on this front (FAO, 2010*d*). The right to food of indigenous peoples requires securing recognition of ancestral rights to lands and other natural resources (including genetic resources for food and agriculture) in their territories for all individuals and groups (Knuth, 2009*a*; Knuth, 2009*b*).¹⁹

¹⁹ There is an important link between the right to food and access to natural resources; this is recognized by the Right to Food Guidelines.



Free, prior and informed consent (FPIC). Refers to indigenous peoples' rights of self-determination and is strictly linked to peoples' land and territorial rights through their customary and historical links (ILO, 1989).²⁰ The principle of free, prior-informed consent is acknowledged in several international human rights law instruments. For example, Article 16 of the 1989 International Labour Organization (ILO) Indigenous and Tribal Peoples Convention (No. 169) refers to the principle of free and informed consent in the context of relocation of indigenous peoples from their land. Article 7 recognizes indigenous peoples' "right to decide their own priorities for the process of development" and "to exercise control, to the extent possible, over their own economic, social and cultural development". In Articles 2, 6 and 15, the Convention requires states to consult fully with indigenous peoples and ensure their informed participation in the context of development, national institutions and programmes, and lands and resources. Article 6 requires that consultation be undertaken in good faith, in a form appropriate to the circumstances and with the objective of achieving consent.²¹

FPIC typically allows indigenous people to reach consent and adopt decisions that are in concurrence with their own traditional systems of resource use and management (Groppo and Cenerini, 2010). The relation between indigenous people and other actors including the government, private sector, non-governmental organizations (NGOs) and conservation agencies is complex and characterized by diverse and different visions and often conflict over the use of specific resources (Groppo and Cenerini, 2010). FPIC is best viewed as an ongoing process, rather than a one-shot precondition, and is sought from affected rural communities before adopting and implementing projects, programmes or legislative and administrative measures which may affect them. This is intended to avoid or mitigate adverse effects. Recent areas where FPIC may have become more important include efforts to regulate climate through reducing emissions of deforestation and degradation.

20 C169 Indigenous and Tribal Peoples Convention, 1989 (www.ilo.org/ilolex/cgi-lex/convde.pl?C169).

21 Standard-setting legal commentary on the concept of free, prior and informed consent, omission on Human Rights, Sub-Commission on the Promotion and Protection of Human Rights, Working Group on Indigenous Population, Twenty-third session, 18-22 July 2005 Item 5 (b) of the provisional agenda, E/CN.4/Sub.2/AC.4/2005/WP.1 14 July 2005.



Landless people and agrarian reform

According to the supporters of land reform, its main goal is to reduce gross inequality of access to rural land rights, thus diminishing poverty. Much genuine land reform has happened in the past and has mostly achieved this goal in developing countries (Lipton, 2009). Of the world's hungry people, 20 percent are landless and most work as tenant farmers without secure possession. They often must pay high rents for the land, or they work as agricultural labourers and have to migrate from one insecure, informal job to another as they normally receive very little pay and struggle to feed their families.²² As such, agrarian reform that benefits landless women and men and small-scale landholders, and promotes security of tenure and access to land needs more attention. This means addressing the insecure situations of migrants, including landless, migrant farm workers who face expropriation, forced evictions and displacements from land due to, for example, commercial exploitation through corporate acquisitions, or commercial exploitation through road building, logging or mineral exploration. Recent large-scale land acquisitions have led to exceptional levels of land expropriation, evictions and displacements (FAO, 2005b; UNGA, 2010).

Although few assessments of the impact of these initiatives have been undertaken or heeded, one study by FoodFirst Information and Action Network (FIAN) International found that out of 100 cases of violations of the right to food from 1995 to 2005, the majority were related to expropriation of land, forced evictions and displacements (UNGA, 2010; FAO, 2005b). In fact, the most urgent appeals to the Special *Rapporteur* on the right to food are based on these types of violations (Human Rights Council Advisory Committee, 2011). To transition to a green economy in ways that abide by and uphold human rights calls for greater attention to resolving the issues of expropriation, displacement and forced evictions as well as the overall issue of agrarian reform. Agrarian land reform needs to address the “strong poverty, gender, social-exclusion, and quality-of-life dimensions,” if it is to have a major impact on the sustainability of agriculture (ADB, 2000).

22 Human Rights Council Advisory Committee Sixth Session, 17 - 21 January 2011. Preliminary study on the advancement of the rights of peasants and other people working in rural areas Prepared by the drafting group of the Advisory Committee on the right to food, p. 5



Strengthening institutions

Ensuring access to natural resources and to adequate food can be sustained over the long term, but only if relevant institutions are strengthened. This includes public and private institutions focused on agriculture, forestry, capture fisheries and aquaculture, and natural resources management at local, regional, national and international levels. While social and food safety nets can provide short-term responses to food security issues, there is an urgent need to address capacity strengthening to ensure the coherent, long-term implementation of rights-based approaches and address entitlement failures.

Good governance

Ensuring people's access to food and natural resources depends, to a great extent, on existing economic, political and social institutions and whether these institutions are willing and able to facilitate that access to enable people to produce or purchase food. Governance has a greater chance of ensuring people's access to food and natural resources if it can build positive and resilient relations and rules to regulate the public realm and the space where state, economic and societal actors interact to make decisions (Court, 2006). In this sense, governance refers to actors at different levels including politicians, bureaucrats, political parties, law enforcement officials, members of the judiciary, civil society, and private sector and market-related actors. Weak institutions and weak governance, on the other hand, severely impact the livelihoods and food security of people, regardless of country, region or level of development. Ensuring good governance means addressing issues of participation, fairness (based on human rights), decency, accountability, transparency and efficiency.

Ensuring secure access to land as a crucial link to food security is of direct relevance to good governance, particularly for those leveraging it for agricultural credit and inputs. Yet, as shown on the 2009 Global Corruption Barometer, corruption in land issues is commonplace throughout the world (Transparency International, 2009).



Participatory and negotiated development

Land, territorial and fisheries rights are of particular concern to indigenous peoples who continue to face insecure situations, in part due to dispossession and displacement (Groppo and Cenerini, 2010).²³ Land, water, forests, aquatic and biodiversity resource use and management issues are characterized by a multiplicity of actors holding different and sometimes conflicting values and interests. This may include smallholder farmers, pastoralists, indigenous peoples, private corporate interests, governmental and non-governmental bodies and conservation organizations with different actions and effective policy instruments. To find long-term solutions, negotiation processes demand an in-depth and clear understanding of the context, as well as of the actors and their different and often conflicting values, visions, and interests related to the use and management of land and other natural resources. This means ensuring the participation of those stakeholders potentially impacted by development which may include those most dependent on the resources within specific geographical, cultural or social “territories” (Groppo and Cenerini, 2010).

Aiming for equality in access to food and resources is also an issue of gender equality. Redressing unequal food access demands efforts to ensure that women are meaningfully involved in decision-making processes around natural resources and entitlements. Doing so must include efforts to review existing cultural practices that impede women’s full involvement and facilitate the necessary changes in decision-making structures and processes needed to improve the level of poor women’s participation and representation. This is true for other marginalized peoples that face exclusion from greater participation in the decision-making processes that affects their lives due to ethnicity, caste, religion, race or age.

Responsible tenure governance

The Final Declaration of the International Conference on Agrarian Reform and Rural Development (ICARRD) recognized that the policies and practices for broadening and securing sustainable and equitable access to and control over land and related resources and the provision of rural services should be examined and revised in a manner that fully respects the rights and aspirations of rural people, women and vulnerable groups, including forest, fishery, indigenous and traditional rural communities.

23 The concept, “territorial” is used here in specific reference to the particular challenges faced by the world’s indigenous (autochthonous) peoples. Territorial refers to a social, rather than geographical limited administrative. Rather, it could include different areas. In Groppo, P. and C. Cenerini. (2010). Territorial Development Vision oriented to indigenous peoples: A possible path. FAO, Rome, May 2010 (http://landportal.info/sites/default/files/land_indigenous_peoplesmay_2011doc.pdf).



Box 5. Local rights and local level participation in resource management: a case from Mozambique

In the last decade, several important policies and laws have been passed in Mozambique to enhance rural livelihoods, particularly those of the rural poor, by strengthening their rights to natural resources. For example, the Land Policy and Law (1997) and the Forestry and Wildlife Policy and Law (1999) contain provisions to protect existing local rights and promote local level participation in resource management. The 1997 Environment Law explicitly calls for local participation in its implementation, and creates new “diffuse rights” that apply to social groupings which can be collectively exercised and defended. Key instruments such as environmental impact regulations insist on full consultative processes involving all stakeholders – including local people. However, these new laws have not lived up to their promise in terms of poverty impact and greater local participation in resource management decisions. These questions take on added significance today, as the government develops new strategies for rural development and food security, in which resource management and local participation issues are central areas of concern. The Territorial Planning Law is now being implemented by the National Directorate for Physical Planning (DINAPOT) of the Ministry for Coordination of Environmental Affairs (MICOA), with the technical support of FAO.

It also outlined a number of reasons for lack or loss of access to land, including: “i) customs that discriminate against women’s access to (and in fact, security of tenure to) land and other resources and services; ii) conflict or disaster that leads to people being displaced; iii) corporate purchases or leases of productive lands; iv) policies and laws that prohibit access to land, fisheries, forest resources (e.g. conservation policies); v) territorial disputes, and vi) agrarian reform” (ICARRD, 2006).

To strengthen institutional capacity to improve the governance of tenure, FAO and its partners have worked together and prepared the Voluntary Guidelines on Responsible Governance of Tenure of Land, Fisheries, and Forests in the Context of National Food Security to improve the governance of tenure of land and other natural resources. They were approved on 11 May 2012. These Voluntary Guidelines are intended to assist states, civil society and the private sector in improving the governance of tenure, and



thus contribute to alleviating hunger and poverty, empowering the poor and vulnerable, enhancing the environment, supporting national and local economic development, and reforming public administration. Voluntary guidelines set out principles and internationally accepted standards for responsible practices. They provide a framework that states can use when developing their own strategies, policies, legislation and programmes. They allow government authorities, the private sector, civil society and citizens to judge whether their proposed actions and the actions of others constitute acceptable practices.

Sustainable agriculture practices

Trade measures by themselves are seldom sufficient to promote farmers' livelihoods and food production. They should be accompanied by government support such as provision of low-cost credit, assistance for supply of inputs, storage facilities, road and transport infrastructure, and marketing facilities and networks, as well as support to processing that adds value to the agricultural products. Under the rules of the trading system that allow provision of these supports, some can be supported up to a *de minimis* level, meaning support does not exceed 10 percent of value of total agriculture production, while those in the Green Box subsidy category can be supported without limit.

Box 6. Voluntary Guidelines on Responsible Governance of Tenure of Land, Fisheries and Forests in the Context of National Food Security

The guidelines are the first comprehensive, global instrument on tenure and its administration to be prepared through intergovernmental negotiations. They are based on an inclusive consultation process started by FAO in 2009 and then finalized through CFS-led intergovernmental negotiations that included participation of government officials, civil society organizations, private sector representatives, international organizations and academics. The guidelines set out principles and internationally accepted standards of responsible practices for the use and control of land, fisheries and forests. They place the governance of tenure within the context of national food security, and are intended to contribute to the progressive realization of the right to adequate food, poverty eradication, environmental protection and sustainable, social and economic development.



In terms of promoting a green economy, farmers should be given support and incentives to implement sustainable agriculture practices. For a complete discussion on these proposals see Working Paper 1 on Availability and Working Paper 3 on Stability. Developing countries should consider devoting a larger share of their agricultural budget to promoting ecologically friendly agriculture, which can boost both the livelihoods and food production of small farmers, while protecting the environment and conserving resources such as soil fertility and water. Support could include extension services to train farmers in the best options for sustainable development techniques, development of ecological infrastructure including water supply, improvement of soil fertility and provision of credit and marketing.

Access through knowledge and communication

An adequate standard of living cannot be achieved if individuals lack awareness of their entitlements or if they are unaware of how to address public institutions when their rights are not respected. At a minimum, information should be transparent and accessible to all. However, this may not transpire due to socio-cultural and historic discriminatory practices of exclusion that may not allow or prepare people to do so. Communication supports people in negotiating, developing and acting on knowledge and information, and helps formulate public opinion and sustain democracy (The International Bank for Reconstruction and Development, 2007).²⁴ “Through the lens of communication for development, rights holders are citizens making demands on governments for accessible and understandable information on policies that shape their lives” (UNDP, 2009a).

With the rapid change in the drivers of innovation in recent years, the context in which agricultural knowledge is generated has also changed rapidly (Mytelka, 2000). For example, the role of the private sector and civil society in knowledge generation, dissemination and use has increased significantly and will continue to have an important role as green technology development advances and is applied in the field. Information and communication technology (ICT) and social media have radically changed the pace and

²⁴ First World Congress on Communication for Development, 2006 was held between 25 and 27 October 2006 at the Food and Agriculture Organization (FAO) in Rome, Italy. It was organized by the World Bank, the FAO and The Communication initiative.



accessibility of knowledge. Moreover, the knowledge structure of agriculture is changing. Knowledge increasingly relies on multiple knowledge providers in contrast to the past when there was greater dependence on public agricultural research and development (R&D) institutions and other regional R&D organizations.

These changes have, to some extent, widened the gap for many small-scale farmers who still have difficulty accessing innovations in green technologies and practices. The gap is even more pronounced for those who typically have less access due to lower levels of education and literacy and mobility constraints. Farmers have limited information on green technologies and practices, and rural advisory services remain weak and inaccessible for a number of reasons, such as existing cultural exclusionary norms, weak state institutions, and hiring and retention issues, particularly from a gender perspective.²⁵

Women and men farmers, artisanal fisherfolk and pastoralists continue to innovate locally and develop knowledge, skills and experience that could benefit others in developing green practices and technologies in areas and regions using recent innovations such as the Internet and mobile technologies (Rajalahti, 2009). Investment is needed to enable increased participation of men and women farmers in the knowledge exchange, generation and use of green practices and technologies. Additionally, it is important to support participation of farmers and food purchasers in decision-making processes, in order to increase innovation capacities in different contexts.²⁶

25 World Summit on the Information Society, Geneva 2003 – Tunis 2005 (www.itu.int/wsis/index.html).

26 First World Congress on Communication for Development, 2006 (www.fao.org/sd/dim_kn1/kn1_060601a1_en.htm).



Access through decent green work and livelihoods

Driving rural employment agriculture

Agriculture including fisheries, forestry and hunting provides the main source of employment and income for approximately two-thirds of the labour force in least developed countries (LDCs). In sub-Saharan Africa and in Asia, an even larger share of the working poor is found in this sector (ILO, 2011). Economic growth that originates in the agricultural sector, particularly by smallholders, is at least twice as effective in benefiting the poorest as growth originating from non-agricultural sectors. This illustrates the potential impact of enhancing productivity and returns to labour in the agriculture sector – as part of efforts to increase productive employment and decent jobs in many least developed countries (LDCs) and to provide women and men with adequate income to purchase food for their families and themselves. Creating jobs outside of, or complementary to, agriculture in rural areas is essential in creating green economic opportunities that will allow rural communities to flourish and reduce urbanization. This challenge has been underappreciated and requires comprehensive attention to improve rural labour markets. Addressing the challenges must include developing and implementing agriculture, labour and trade policies that reduce discrimination between men and women as well as supporting measures to improve equal access to education, skills and entrepreneurship for both. More detailed discussion on measures to promote organic farming, including exports from developing countries, is in Working Paper 4 on Utilization.

Yet, according to FAO, three-quarters of the millions of people living with chronic malnutrition are based in the rural areas (Mazoyer, 2001). They are extremely poor, mainly women and men smallholder farmers who are under-equipped, more or less landless with less than 0.5 ha, and living in environmentally and climatically challenging regions. They are generally underemployed and, if employed, they are typically poorly paid agricultural labourers, artisans and traders. The remaining 25 percent of those living with chronic malnutrition – the non-rural undernourished population – mostly originally come from small farming households and have had to migrate to urban slums where they struggle to find the means to survive (Mazoyer, 2001). Thus the majority of the undernourished population are small farmers, and the extreme poverty and malnutrition of most of the others essentially results from the poverty and malnutrition of the small farming sector.



Rural poverty and malnutrition remains more or less constant (Mazoyer, 2001) even without migration to urban areas. There must thus be a compensating influx of new poor and undernourished from other areas or across borders. It is therefore to conclude that the world's poor and undernourished are not simply a legacy of the past, but also the result of ongoing processes that maintain a status quo of ever renewing extremely impoverished, malnourished, underequipped, poorly located, land-deprived and relatively unproductive rural inhabitants, small farmers and fishers.

Anticipating employment and income growth through agriculture

Entitlement failures are, in part, a result of poverty caused by unemployment, underemployment, and real wages that are at or below the poverty level, processes which reinforce each other creating cyclical causality. The UN Special *Rapporteur* on the Right to Food emphasized the link between the right to have regular, permanent and unrestricted access to food and the means of financial purchases. The current global financial and economic crisis threatens to wipe out much of the modest progress made in poverty reduction since the 2000 Millennium Summit, while climate change increasingly threatens the lives of the poor. Moreover, as discussed earlier, the soaring food prices have had a drastic impact. The World Bank estimates that an additional 44 million people have been forced into poverty due to the drastic rise in food prices since June 2010 (World Bank, 2011).

The global agriculture sector, including forestry and fisheries, currently provides over one billion jobs (ILO, 2011) and 3 percent of the global GDP. In many developing countries, agriculture provides from 20 percent to more than 50 percent of national GDP. There is a wide disparity between developed and developing countries with regards to the proportion of their workforces involved in agriculture, ranging from 6 percent in the EU to 56 percent in Africa.²⁷

Transitioning to a green economy is projected to create more employment – over 200 million fulltime jobs by 2050 – particularly more decent green jobs across the entire food production system over the long term. This anticipated growth in income will include more labour-intensive green farming practices and operations, management and preservation of ecosystems, research and development, and training of rural populations in the use of green agriculture technologies (FAO, 2007; Pretty *et al.*, 2006; UNDP, 2009*b*; UNEP, 2008).

27 FAOSTAT 2010 (<http://faostat.fao.org/default.aspx>).



Box 7. Burkina Faso farmers establish green jobs

In Burkina Faso, young farmers have initiated activities that not only increase income, they help retain the rural populations. Rather than migrating, the young men have gone from village to village to help farmers improve their lands, specializing in land rehabilitation techniques such as traditional *tassas*, also known as *zai*, planting pits. They have now begun to buy degraded land for improvement, and pay other labourers to work their land using conservation agriculture techniques. They have improved yields, but also, their labourers now have income and thus do not have to migrate to urban areas (Pretty *et al.*, 2011).

Farming and green jobs. As job losses occur in some sectors, others will be created elsewhere through the localization of input production, farm manufacturing, construction and maintenance of infrastructures. As the farming sector demand for these products grows, direct employment in green input supply chains is also expected to grow. Over time, improvement in rural social and economic conditions, and growth in green farm mechanization will result in lower labour intensity per unit of agricultural output, leading to higher per capita incomes due to increases in yields beyond those projected for continued business-as-usual investment decisions (Pretty *et al.*, 2011). However the lower labour intensity will result in job losses and creates the need to create new opportunities outside of the agriculture sector. Additionally, green practices such as organic production and local value addition through processing and non-farm enterprises can also lead to positive net employment gains as they depend more on labour than industrialized farms. Both on- and off-farm activities under these sorts of green approaches provide opportunities such as higher skilled job opportunities, local multiplier benefits and extended circulation of local income in rural communities (Pretty *et al.*, 2011). Improving access to water for agriculture by smallholders – through water harvesting, small-scale storage, pumps and irrigation kits – has great potential to reduce poverty and hunger (Molden, 2007).



Forestry and green jobs. World wage employment in forestry is approximately 3 million people, about 1 million in industrialized countries. Unpaid subsistence work, primarily fuelwood harvesting, probably occupies about 14 million people full time, 90 percent of them in developing countries. While wage employment is largely a male domain, with women rarely exceeding 10 percent of the workforce, subsistence employment is dominated by women in many developing countries (ILO, 2004).

Afforestation and reforestation – including the restoration of degraded or desertified lands – offer opportunities for job creation in areas where there is high unemployment or underemployment (Nair and Rutt, 2009). During 2005 to 2010, the area of planted forests increased by about 5 million hectares per year, most of which was established through afforestation. Land preparation, production of planting material and planting and maintenance adapted to specific local conditions, knowledge and skills are important sources of employment. Many countries have substantial experience in afforestation and reforestation and could scale up these activities.

Taking into account the availability of suitable land and the institutional capacity, the rate of establishment of productive and protective plantations could be increased. Additionally, bioenergy and the green building sector have the potential to boost the amount of green jobs in the forestry sector and could be optimized through tools such as life cycle analyses. In Chile, half a million rural people depend on forestry activities largely stemming from plantations, and job creation in forest plantations is higher on a per hectare basis than in traditional farming activities (CIFOR, 2001). In China, World Bank-funded plantation projects provided incomes and temporary employment for 2 million poor people, while a total of 12 million people were provided temporary employment through National Afforestation Projects (Rozelle *et al.*, 2002).

Fisheries and green jobs. Small-scale fisheries provide opportunity for employment in a green economy. A recent report argues that marine small-scale fisheries “need to be promoted” and that they are not, as yet, “sufficiently recognized as a provider of livelihoods, food, employment and income” (FAO, 2010e).

Moreover, those fisherfolk involved in small-scale fisheries often have limited opportunities for other employment, suffer from a lack of equitable access to land and social services, are poorly served by infrastructure such as roads and markets, and often have weak political representation (Allison *et al.*, 2011).



Investing in green jobs and decent work

Transitioning to a green economy in a way that embraces green jobs and decent work and livelihoods – whether in agriculture, forestry, fisheries or other sectors – requires an enabling environment of policy interventions that strengthen fiscal measures such as subsidies, taxes and public R&D, regulatory actions that establish standards, mandates and certification procedures, and public information and awareness campaigns (Herren *et al.*, 2011). Supporting the broad-based transitions needed in the agriculture sectors of developing countries under a green economy will require leveraging funds from the international community (Herren *et al.*, 2011). Limited access to financial capital and foreign exchange plus high poverty levels pose serious challenges for developing countries undertaking such transitions.

Creating decent jobs in the rural areas that are outside, but connected to, agriculture is critical for creating economic opportunities that will allow rural communities to flourish and reduce urbanization pressure. This is an insufficiently recognized challenge that requires comprehensive attention to rural labour markets, including policies that reduce discrimination between men and women, aim to eliminate child labour, and to improve education, skills and entrepreneurship.

Box 8. Green jobs, green agriculture

Green employment covers the full spectrum of decent jobs that are created by green agriculture farming practices – those practices that maintain and increase farm productivity and profitability, ensure provision of food on a sustainable basis, support a transition to positive externalities, and strengthen and build natural resources. This encompasses not only on-farm job creation, it also includes input supply chains and post harvest field-to-market value added food sector operations. Green jobs might include unskilled manual field labour, sustainable input production jobs, skilled agriculture extension agents, community-level food storage and processing operations, university researchers and educators, and entrepreneurs in sustainable agriculture related enterprises.



Conclusions

Final considerations

The access-to-food debate has become more complex over the past two decades. It has grown to recognize there are many and diverse options for improving access to food and natural resources, but that these need to be assessed in the context of a globalized and highly interconnected environment – an environment that includes new developments such as the Internet and mobile technology.

The world's resource base – its land, water, fisheries resources and agrobiodiversity – is shrinking at a rapid pace. Diminishing fresh water resources and the impact of climate change are leading to recurring droughts and floods that impact food production, especially for the poorest and most vulnerable populations of the world.

Access to productive land and other resources is becoming more difficult as growing numbers of competing interests, including large foreign corporations, buy or lease land once used by local farmers for large-scale production of food and, increasingly, for biofuels. This growing competition for resources raises new challenges, including potential or real conflicts over water, land and agricultural biodiversity rights. Increasingly water is privatized; land is lost to large corporations; agricultural biodiversity, which is to be protected for present and future generations, is patented under private intellectual property regime depriving indigenous peoples of access to, and benefits of, their heritage, and the energy crisis is fuelling higher input prices and the diversion of food crops to energy production with ensuing hunger and malnutrition for the most vulnerable.

The agricultural sector – including capture fisheries and aquaculture, livestock production and forestry – must be seen from a broader perspective that links agricultural, forestry, and fisheries improvements and natural resources management to the creation of decent, fair employment that values women's and men's labour equally and respects labour rights according to international standards and legal instruments.²⁸ This must include respect for legal entitlements and human rights, as a matter of respect for the rule of law, not of political will.

28 For more on specific standards, go to International Labour Organization (ILO) (www.ilo.org/global/about-the-ilo/decent-work-agenda/rights-at-work/lang--en/index.htm). For more on legal instruments, see ILO (www.ilo.org/global/standards/introduction-to-international-labour-standards/conventions-and-recommendations/lang--en/index.htm).



Transitioning to a green economy calls for identifying and building on a number of creative options that build on human rights-based approaches, making them inclusive of, and of benefit to, women and men of different ages, abilities and socio-economic groups. This includes strengthening structural and institutional mechanisms to enable greater participation of, and benefit sharing with, less powerful women and men through approaches that honour and build on community experience and knowledge, and identifying human development as the main goal of policies and legal frameworks developed at national and international levels. A green economy will be successful if human rights are respected, protected and fulfilled, and thus should be designed and implemented in ways that respect the needs, interests, and challenges of poor and vulnerable men and women without jeopardizing the livelihoods and well-being of future generations. To implement and enforce the above ideal actions, legal enforcement that builds on existing informal and customary practices must be championed by governments with checks and balances from civil society to ensure their application. A human rights-based approach offers an alternative way of identifying, analyzing and solving the underlying problems of hunger and poverty, and thus offers an alternative method of achieving development. It is a novel technique for fulfilling the MDGs in general and informing the design of a specific policy in particular – such as greening the economy. What the right to food as a concept adds to the issue of food security and development is foremost that it takes programming one step further by legally obliging governments to enable, without discrimination, all individuals within their borders to produce or procure adequate quantities or quality of food for an active and healthy life.

A responsible and sustainable green economy scenario is one that moves from a reductionist commoditization of labour and food to one that is more holistic, builds on human rights, embraces and reflects human dignity and guarantees decent employment and livelihoods as well as equality of access for women and men in producing food for themselves and for others without impediment due to race, age, caste or ethnicity.

Rationale for a shift towards a green economy

Recent food and energy crises have increased the vulnerability of hundreds of millions of people. Even the modest gains in poverty reduction since the Millennium Summit have been threatened by a number of challenges outlined in this working paper, including the current global financial and economic crises and climate change. The fragility of these gains calls for a fundamental re-examination of current development models along the lines proposed for the transition to a green economy (UN, 2009). Specifically, transitioning



to a green economy requires a major paradigm shift – one that calls for action at the international and local (country) levels (Herren *et al.*, 2011).

- **At the global level**, such a paradigm shift needs to recognize, and invest in, smallholder farmers’ potential contributions to a global green economy.
- **At the local level**, mechanisms that accommodate the diverse visions and interests of the different actors as well as their entitlements need to be developed.

This also implies the need for an approach that addresses, to the extent possible, the existing asymmetries of power, including those along gender and socio-economic lines, through a process of dialogue and negotiation (FAO, 2005*a*).

Access to food in a green economy. Transitioning to a green economy provides farmers (producers and consumers) with new opportunities for improving and ensuring access to food and guaranteeing access to resources to produce or purchase food – particularly for especially vulnerable groups including indigenous peoples and people living in marginal environments. Leveraging this opportunity requires a consciously applied shift towards a better understanding of the social institutional contexts including gender, caste and ethnicity, as well as the political, economic and environmental contexts in which people live and work. Economic and institutional change can transform social processes including legislation and policy and has to emerge from a participatory process between civil society and the state. To address the problems in this complex context requires redefining the parameters of development in a country and region specific way. As a recent study in India shows, both men and women farmers have the capacity to address emerging challenges such as climate change but face different institutional impediments (Lambrou and Nelson, 2010).

Human rights in a green economy. Transitioning to a green economy provides the world with an opportunity to strengthen the application of human rights-based approaches and address entitlement failures. More specifically, there is great opportunity to improve women and men’s “access to entitlements” and strengthen efforts to grow green jobs, decent work and livelihoods. This all demands broader, more inclusive access to knowledge and information. In promoting these approaches and advocating for the realization of human rights, there is also a new role for so-called experts to take roles as “facilitators” of processes rather than as “developers”. All of this calls for a radical shift in the types of policies and investments promoted to ensure that the necessary change in prevailing development trends occurs (IASSTD, 2009).



Decentralization and the green economy. At local levels, there are opportunities to strengthen decentralization efforts. For many years, there has been a growing push for decentralization – yet in practice, this has proven to be less than ideal. While responsibilities have been decentralized, this has happened without the necessary devolution of power to equip lower administrative levels with the necessary financial and human resources. Elsewhere, as responsibilities have been decentralized, there has been a disengagement of the state that has resulted in severe gaps in the fulfilment of state functions. This has resulted in decreased civil society confidence in public administration and ultimately considerable obstacles to the realization of women and men’s visions for themselves, their families and their communities. In turn, this lack of confidence heavily affects public administration efforts to enforce law and order, redistribute welfare, collect taxes, and provide basic services. A key element of this aspect is fostering public participation, which is seen as public accountability as well as recognition of public knowledge and its worth (ADB, 2000).

Natural resources and the green economy. Given the growing competition for limited resources among actors and in recognition of the need to strengthen the credibility of public administrations to support local action, there is also need for programmatic support to organizations of smallholder farmers, fishers, pastoralists, forest-dependent people and others.

Table 9. Key elements for a paradigm shift as identified by the International Conference on Agrarian Reform and Rural Development (ICARRD, 2006)

SHIFT FROM AN EMPHASIS ON:	TO AN EMPHASIS ON:
Rural development as mainly a <i>production issue</i>	Rural development as mainly a <i>socio political issue</i> , i.e. capacity of different stakeholders to adapt to socio-economic and technical change and make informed and meaningful choices on a range of development policy options, methods and technologies
<i>Sectoral perspective</i>	<i>Livelihood and/or territorial perspective</i>
Participation as a consensual approach to <i>gathering information and identifying people’s needs</i> (i.e. tends to apply an “instrumentalist” approach to participation)	Participation as an <i>engagement</i> by all relevant stakeholders, including the negotiation of stakeholders’ roles and the “rules of the game”, notably in key decision-making processes
<i>Needs-based intervention strategy</i>	<i>Rights-based intervention strategy</i> (as this requires consideration of both people’s rights and responsibilities to fulfil these rights, as well as governance issues)
<i>Needs-based capacity development</i> , based on skills	<i>Rights, responsibilities and incentive-based</i> emerging from negotiations on stakeholders’ roles and the “rules of the game”, to support effective partnerships



It should also acknowledge the diverse needs of the wide range of smallholders – from small subsistence to commercial-oriented farmers (Faurès and Santini, 2008) – and target each subgroup specifically in terms of the role it can have in the green economy. Such efforts should stimulate and support cooperative development in ways that redress existing power asymmetries, and establish and maintain inclusive social dialogue. Intermediate level institutions have an important role in facilitating the participation of different actors in governance frameworks.

Moving forwards: the changes we want to see

Moving forwards and transitioning to a green economy in ways that ensure access to food for all will require greater efforts to support women and men in securing their access to entitlements and developing and growing green, decent work and livelihood opportunities. This can be done through applying human rights-based approaches and through investing in and supporting green agricultural (including forestry, fisheries) practices. At the very least, this will require policy and institutional support and investments (more on Policy and Institutions is available in Working Paper 1 on Stability).

Policy requirements

Small-scale food producers' livelihoods are supported; social welfare is strengthened; women's rights to access and control resources are recognized, promoted, and secured; tenure systems are secure and fair for women and men; and women and men realize the benefits of these entitlements so that they can to continue their roles as on-farm developers and productive curators of agricultural landscapes which are public goods for all of humanity.

Social protection systems are strengthened, enable poor women and men and children to secure access to food, and enhance their resilience to risks and shocks, particularly in times of crisis. Although there are examples of successful efforts throughout the world,²⁹ only 20 percent of people in the world have access to social protection systems of any kind.

29 The *Di Bao* Minimum Living Subsidy Scheme in China, the *Maharashtra* National Rural Employment Guarantee Scheme in India, the *Oportunidades* programme in Mexico, the *Bolsa Familia* in Brazil, and the Productive Safety Net Programme in Ethiopia are successful examples of social protection systems.



The innovative potential of small producers is recognized and supported by policy.³⁰ Small food producers are at the centre of strategies to create jobs and strengthen rural communities. This is vital in a time of economic crisis and enables rural societies to determine their own development paths. Their strategies, combined with adequate incentives and supportive public policies, are at the base of increasingly resilient agro-ecological systems.

Institutional requirements

Apart from the need to improve the functioning of global food markets (explored in Working Paper 3 on Stability), changes can be promoted on a smaller scale. In this context localized biodiversity-rich food systems are strengthened and associated local knowledge and skills are enhanced. Towards this, extension systems optimize the use of locally available resources, rather than inputs that create dependencies. Publicly-supported R&D is reinvigorated, rather than using private R&D which often is more concerned with maximizing profits than long-term sustainability and distributional equity.

Participation in decision-making is improved, women and men's access to locally-needed resources is secured, and rights, including farmers' and women's rights, are respected.

Transparency and accountability are embraced as are holistic, integrated and adaptive management and development approaches that promote social responsibility, protection and solidarity.

Efforts to adjust state procedures are supported to enable equitable access to natural resources and food. For example, adjusting land registration forms to permit space for two names encourages joint-titling and protecting rights of women within marriage. Brazil changed its forms in 2001, even though women had been guaranteed equal rights since 1988 (FAO, 2007).

Participatory natural resource use planning at community and municipal levels are supported so that users gain the capacity to develop and implement action plans for the improved management of their natural resources and wider landscapes. At the same time, issues of equity and tenure security are addressed to allow for the wider adoption of

³⁰ Farmers, fishers, pastoralists, forest keepers, indigenous people and urban producers; women play a major role in all of these categories.



sustainable natural resource management practices adapted to the changes that impact the diverse crop, livestock, fisheries and forest systems, such as population, market forces, climate change and competition for resources. A landscape approach to planning may require structural changes in institutional governance, not only to consider the people and livelihoods affected by land use planning decisions, but also to ensure such decisions maximize the supply and demand for soil protection, clean water and biodiversity.

Investment requirements

Increased government investments enhance the productive capacity of agricultural food systems in sustainable ways, create green jobs and decent employment for women and men, and contribute to the creation and distribution of knowledge.

Remuneration of positive externalities for livelihoods is supported during the transition to green economy practices (including payment for environmental services and carbon credits).

Alternative modes of production, based on diversity in all its forms, may seek to showcase small-scale producers and encourage them broadly. Diversity is essential to cope with climate change and future challenges. Small producers would be the first to safeguard the seeds, crop, livestock and other agrobiodiversity threatened by climate change. They also can reduce agriculture's environmental footprint and engage with consumers in innovative food systems to guarantee locally accessible, diverse and balanced diets.

Investments in science and technology respond to a fast changing agricultural context while respecting the needs and rights of small farmers as well as encouraging participatory local and national innovation.

Information and access to knowledge remains the key building block for the creation of a participatory and equitable green economy model with agriculture at its centre.

Putting people back at the core of the debate

People build together the strategies needed above to cope with an increasingly complex world. Through dialogue and negotiation in a context of human-rights based approach, they engage in creating together a future where development is based on people-generated solutions. The search for solutions must be built on dialogue, consensus and a shared vision.

People (from producers, consumers, farmers to entrepreneurs, and policy-makers) commit themselves to address the existing asymmetries of power distribution including those along gender and socio-economic cleavages.



G E A - A C C E S S

Governments commit themselves to engage their citizens in a process of debate about the difficult choices that lie ahead in the future in order to build a shared commitment for the sustainable development of societies.

The non-realization of human rights is both a result and a cause of poverty and working to protect and promote these rights is therefore vital for combating poverty and enabling people to feed themselves in dignity. This is why a human rights-based approach is an appropriate framework for designing the path towards a green economy.



Working Paper 3

Stability of food security in a green economy environment





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Executive summary

Stability is a key dimension of food security, alongside availability, access and utilization. To be food secure, a population, household or individual must have access to adequate food at all times. Although recent price rises and price volatility on global markets have grabbed much attention, there are many other types of instability that can affect food systems, such as loss of access to natural resources, production shortfalls or income shocks. These risks affect households in different ways, depending on whether they are net producers or consumers of food and on whether they have adequate coping mechanisms. Instability has a major impact on poor households, as they are unable to smooth incomes and expenditure, and it can contribute to poverty traps³¹.

The green economy agenda is highly relevant to the stability of food security. Many of the threats to stability are linked to the environment and natural resources management. These threats already contribute to volatility in food markets and are likely to intensify under “business as usual”. Climate change is expected to result in more extreme weather events, such as droughts and floods, which pose a major risk to food production. The availability of food is also threatened by the loss of ecosystem services due to land degradation, water scarcity, a decline in genetic diversity and the exhaustion of wild resources. Energy markets and food markets have become coupled because of bioenergy demand and the reliance on fossil fuel-derived agricultural inputs – as a result, energy shocks may become food shocks too. The functioning of food systems is dependent on broader economic and social stability, but in some cases this is also jeopardized by environmental degradation and competition over natural resources. Finally, price volatility may be exacerbated by trade restrictions, financial speculation and global imbalances.

The intensifying risks facing the global food system reinforce the need to pay more attention to risk, stability and resilience when developing policy. Rather than focusing only on increasing production or economic efficiency, it will be necessary to assess the risk-adjusted returns for different strategies. Adaptive capacity will be key. The good news is that there are many solutions that address these threats and increase stability, and at the same time are consistent with the goals of the green economy.

31 Poverty trap is defined by Azariadis and Stachurski (2005) as “any self-reinforcing mechanism which causes poverty to persist”.



This working paper suggests five main action areas for strengthening the stability of food systems: i) investing in agricultural production and downstream food systems in developing countries, with a focus on smallholders; ii) implementing and scaling up farming and other production systems that are resilient to climate volatility and that make sustainable use of natural resources; iii) managing the links between food and energy markets by amending biofuels policies and making more efficient use of energy-intensive inputs; iv) improving the functioning of national and global food markets by limiting export restrictions, widening and deepening markets, and improving information and transparency, and v) establishing safety nets for the most vulnerable households in developing countries, supported by international funding mechanisms and food aid programmes.

Although most of these measures are “win-win-win” in terms of food security, economic development and environmental sustainability, there may be some trade-offs. There will also be costs and risks associated with a transition to “green” food systems. Supportive policies and institutions will be needed at national and global levels. The amount of investment in developing countries will need to be stepped up, new mechanisms, such as payments for ecosystem services, explored, and new sources of funding, such as climate finance, secured. This should be accompanied by more research into food systems that are more resilient to climate extremes, improve input use efficiency and build ecosystem functionality.

Introduction

Stability is a key dimension of food security, alongside availability, access and utilization. To be food secure, a population, household or individual must have access to adequate food at all times. In the past, there was a tendency to underplay the importance of stability but recent volatility in food markets has brought this issue to the fore. During 2007 and the first half of 2008, the price of staple crops such as maize, wheat and rice more than doubled. The FAO Food Price index, which tracks the prices of a basket of foods in local markets around the world, rose by almost 90 percent. Prices fell by one-third over the following 12 months but during 2010, they rose sharply again. By early 2011, the FAO Food Price Index had reached its highest level since it began in 1990. Of course, increased price levels are not the same as volatile prices but history shows that the two usually occur together.



The impact of higher and volatile food prices on the poor has been immense. During 2008, it is estimated that 75 million more people became malnourished (FAO, 2008c). The total number of people going hungry rose to one billion by 2009, more than one-seventh of the world's population and the highest number in 30 years. The number fell to 925 million in 2010 because of declining food prices and an improving economic environment, but with recent food price rises the number is increasing again (FAO, 2010a). Recent research indicates that an additional one billion people suffer from “hidden hunger”, meaning they lack essential micronutrients such as vitamins and minerals in their diets. Diets of the poor often lack diversity so the scope for switching to less expensive foods is often limited (Foresight, 2011). This has dire consequences for the survival and growth of children, and for health and productivity across age groups (FAO, 2010a).

Rising and volatile food prices also forced many more people into poverty. During 2008, it is estimated that at least 110 million people were driven into extreme poverty, which is defined as living on less than USD 1.25 per day. The World Bank estimates that between June and December 2010, another 44 million people were pushed into extreme poverty on account of high food prices (World Bank, 2011). Urban poor, female-headed households and other vulnerable groups that are net buyers of food suffered the most (FAO, 2008a).

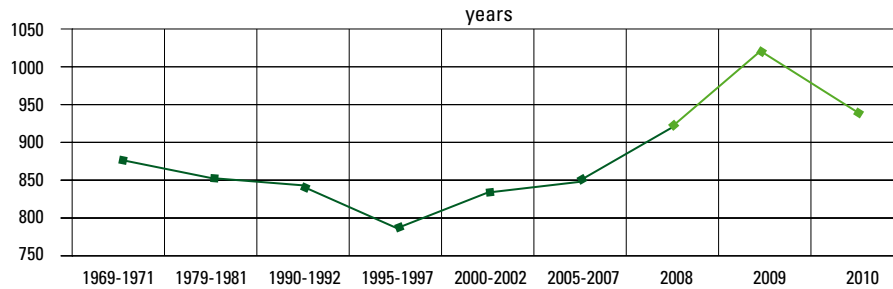
Rising and volatile prices, as well as instability in the underlying production and marketing conditions that drive this volatility, can increase the vulnerability of the poorest members of society and have a devastating effect on food security. Instability also increases uncertainty, which has important implications for investment decisions, from farm to national and international levels. It can reduce the capacity and willingness to commit resources to activities that generate long-term benefits. Without these long-term investments and decisions, it can be difficult to achieve the multiple objectives of increased food security, improved environmental management and increased social equity.

This paper will attempt to take a comprehensive view of food system instability and its relationship with the green economy. It draws on three separate bodies of research that focus on micro-economic household impacts, the environmental context and world markets.

The first body of research, with the longest tradition, focuses on risk and resilience at the household level. Using a micro-economic approach, this research has sought to understand how poor households in developing countries deal with fluctuations in food production, food prices and incomes.

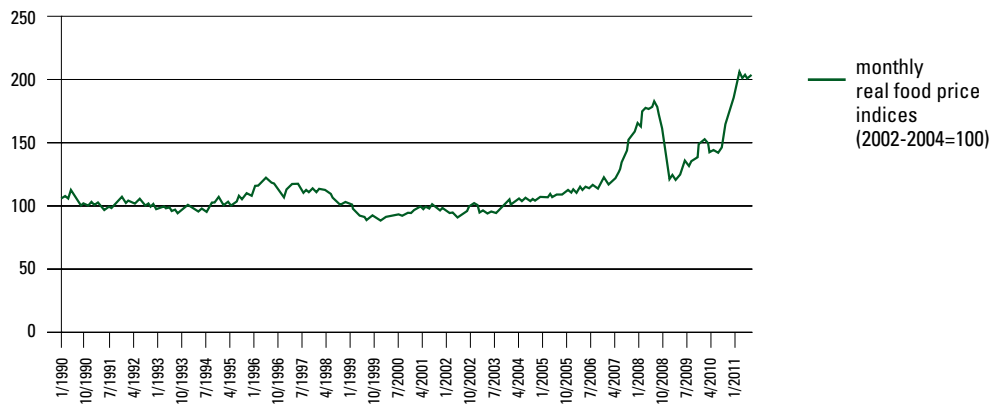


Figure 3. Number of undernourished in the world (1969-1971)



Source: FAO

Figure 4. Monthly real food price (2002-2004=100)



Source: FAO

Note: Figures for 2009 and 2010 are estimated by FAO with input from the United States Department of Agriculture, Economic Research Service.

A second field of studies looks at the role of environmental threats such as land degradation, water scarcity and biodiversity loss, often at a macrolevel, with much recent work on the future impacts of climate change. The third, and newest, body of literature focuses on the exceptional price volatility in world food markets since 2007, seeking to understand its causes and to measure its impacts on hunger and poverty in developing countries. This has led to a number of specific proposals to improve the functioning of global commodity markets.



All these approaches provide valuable insights into the relationship between food stability and the green economy. This paper draws on material from each, attempting to integrate findings on household resilience, environmental threats and food price volatility into a common perspective. It is based on literature from within the FAO and other organizations.

The paper begins by setting out a conceptual framework for understanding the role of stability in food security and its relevance to the green economy, focusing on the impacts of instability on the poor in developing countries. It then assesses the threats to stability that may arise in the next 40 years, arguing that these risks are likely to intensify under a business-as-usual approach. The following working paper looks at ways that the global food system can be made more resilient and shows how this is consistent with the principles of the green economy. The final working paper discusses some of the policies, institutions and financing mechanisms that will be needed to encourage the transition to more stable, resilient and sustainable food systems.

Stability and the green economy

Defining stability

To be food secure, a population, household or individual must have stable access to adequate food at all times. There are two distinct types of instability. The first is predictable or cyclical, for example the variability associated with seasons or harvesting cycles. The second type of instability consists of sudden disruptions or shocks. Although both types of instability can threaten access to food, unpredictable shocks often pose a greater risk as they cannot be planned for (Stamoulis and Zezza, 2003).

Many of the models used to estimate the supply and demand of food to 2050 assume gradual changes, exclude extreme events and generate results based on an average equilibrium at global or regional levels. They do not capture the effect of shocks, volatility, non-linear changes or “bubble dynamics” in markets, nor do their results reveal regional or intraregional disequilibria and temporal discontinuities in food availability, even though these are the source of much food insecurity (Working Paper 2 on Availability). A focus on stability shifts attention to risk and vulnerability and to ways that food systems can be made more resilient in a context of uncertainty. There are many different sources of instability, which can be grouped according to the other three dimensions of food security.



Availability. Food availability is threatened by production risks associated with the environment – extreme climate events, natural disasters or loss of ecosystem services. Production can also be affected by social disruption (war, internal conflict, state collapse) and economic disruption (unavailability of credit, inflation, and market breakdown). At a national level, availability that depends on imports can be vulnerable to trade restrictions by exporting nations, disruption to transport and logistics, and adverse swings in terms of trade and balance of payments.

Access. Food access has more complex potential causes of variability, as people acquire food through production, exchange or transfer. Food producers are vulnerable to the loss of access to natural resources, whether land, water or wild species. However, most people rely on markets for their food and, in their case, access can be affected by loss of income and/or food price rises. The loss of social entitlements (including public transfers) also can remove an important mechanism for food security for the most vulnerable.

Utilization. Stability of food utilization is critical to food security. A shift from diverse foods to staples because of higher prices or lower incomes can produce a diet lacking in essential proteins, fats and micronutrients. At a household level, the loss to illness of family members responsible for food preparation, especially women, can affect the entire household. The absence of storage and marketing infrastructure can exacerbate fluctuations in food availability and agricultural incomes. At a global or national level, the diversion of food to new markets, such as biofuels, can have ripple effects throughout food markets.

Who is vulnerable

The ability of countries, communities, households and individuals to deal with variability in food systems depends on three things.

- **Effective storage, infrastructure and markets.** Storage and processing facilities allow food to be kept for times when supplies are low; infrastructure such as roads and railways ensures that food can be moved to where it is most needed; well-functioning markets provide an efficient means of exchange between producers and consumers.
- **Sufficient incomes, savings or assets.** Wealthy households are able to cope with higher prices or loss of income by diverting more of their discretionary spending towards food, utilizing savings or liquidating assets. A household with several assets can maintain its consumption level more effectively by disposing of some of these assets.



- **Access to credit or insurance.** Consumers can borrow during times of low income and high food prices, thus smoothing consumption. In theory, a perfect credit market would minimize the effect of an income shock by allowing the household to achieve whatever degree of consumption-smoothing it desired. Producers can insure themselves against the risk of production shortfalls, thus achieving smoother flows of income (Prakash, 2011; IFAD, 2011).

To a large extent, these conditions exist in developed, high income countries. For example, in OECD countries, average per capita spending on food is less than 20 percent of income (Gilbert and Tabova, 2011), which means that most consumers can adapt during periods of high food prices. Effective means of transport and exchange also mean that supply and demand can be efficiently balanced. Efficient credit and insurance markets facilitate income and consumption smoothing across periods of disruption. However, this is not the case in low income countries. Here, many households spend up to 80 percent of their income on food. These households find it difficult to smooth income and expenditure during times of disruption because they lack savings, assets or access to credit or insurance. Poor storage, infrastructure and market functioning can exacerbate swings in food availability and food prices. As a result, people in these countries are much more vulnerable to shocks (Prakash, 2011).

Within developing countries, different groups are vulnerable to different types of variability. Some may benefit, some may lose out (Stamoulis and Zezza, 2003). Taking four risks – loss of access to natural resources, production shortfalls, decreases in incomes, and increases in food prices – the following section analyses how they affect the food security of different types of households in developing countries.

- **Self-sufficient households without access to markets:** Subsistence farmers, herders, fishers and forest-dependent peoples who produce food for their own households are subject to risks such as the loss of access to natural resources (land, water or forests) and to production shortfalls associated with variability in farming or wild provisioning. However, they represent a small number of people: in Malawi, only 5 percent of rural households do not buy or sell anything to the markets; in Nepal the proportion is 8 percent (Karfakis *et al.*, 2011). The vast majority of households rely on food markets to some extent.
- **Food producing households that are net sellers of food.** Within rural economies, there are farming and fishing households that produce and sell more food than they purchase.



These households are vulnerable to loss of access to natural resources, and to the variable productivity of the resource base, which can reduce their incomes, but they will tend to benefit from increases in food prices. Again, they are a minority in developing countries, even in rural areas. An analysis of 12 low income countries from the three main developing regions found that, on average, only 31 percent of rural households were net sellers of food (FAO, 2008a).

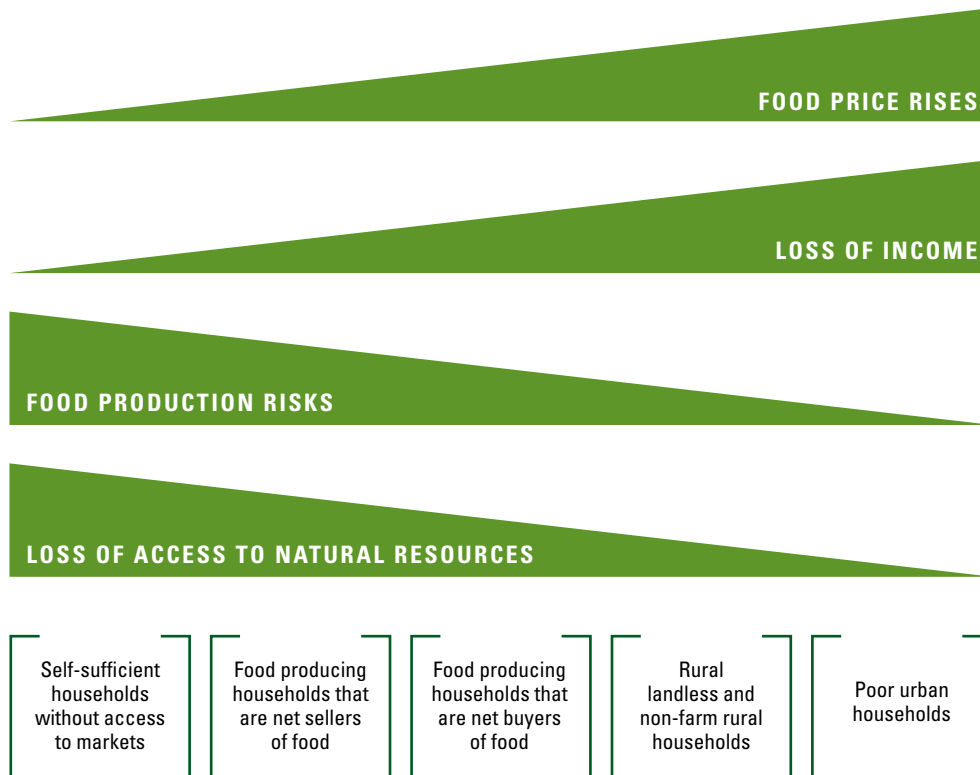
- **Food producing households that are net buyers of food.** Most farming households in developing countries are both buyers and sellers of food, using markets to supplement a lack of quantity or variety in domestic production or to bridge seasonal periods of food shortage. They are vulnerable to production risks, which can affect incomes, and to higher food prices. The interaction among these risks depends on the relative movement in prices of different agricultural commodities and on the extent to which these households rely on off-farm income.
- **Rural landless and non-farm rural households.** Their food security depends on relative changes in incomes and in food prices. As non-producers, they are not directly affected by production risks, although their employment prospects and incomes may be affected by the poor performance of local farms and the rural economy more broadly.
- **Poor urban households.** Their food security depends on relative changes in incomes and food prices. Urban consumers are especially vulnerable to changes in global food prices, as they are more likely to consume staple foods derived from tradable commodities, whereas rural populations consume more traditional staples such as roots or tubers. This vulnerability may be partially offset if households grow some of their own food through urban or peri-urban agriculture (FAO, 2008a).

Within each group, there is a gender dimension. Women and female-headed households are particularly at risk, in both urban and rural areas. As food consumers, female-headed households tend to have lower incomes and less access to assets, savings and credit, which increases their vulnerability to food price rises (FAO, 2008a). As food producers, where women farm their own land, there are gender gaps in the access to a wide range of agricultural resources, including land, livestock, farm labour, education, extension services, credit, fertilizers and mechanical equipment. For example, in developing countries for which data is available, although women make up from 20 to 50 percent of the agricultural labour force, they only represent between 3 and 20 percent of landholders. As a result, women farmers typically achieve lower yields than



men, which makes them more vulnerable to production and income shocks. Where rural women are employed, they tend to be segregated into lower paid occupations and are more likely to be in less secure forms of employment, such as seasonal, part-time or low-wage jobs (FAO, 2011a).

Figure 5. Vulnerability of different groups to types of instability





Consumption smoothing and poverty traps

The single characteristic uniting all these vulnerable groups is poverty. Research shows that chronic poverty does not usually lead to starvation in itself. Rather it negatively impacts welfare by raising vulnerability to adverse shocks. The effects of these shocks manifest themselves not only in terms of short-term reduction in consumption but also in terms of reduced ability to deal with subsequent shocks. In this sense, risk is fundamental to the persistence of poverty over time (Fafchamps, 1999).

Risk, instability, poverty and underdevelopment are often interlinked in a vicious cycle. In a volatile, high-risk environment, where there are few tools to manage these risks, poor households tend to pursue low-risk options with lower returns. Extreme volatility – in food prices or income – tends to lower investment in physical and human capital. Diminished income in already low-income countries can result in malnutrition, mortality, withdrawal of children from education, and long-term unemployment. This can be irreversible and lead to a vicious downward spiral of increasing vulnerability as fragile coping mechanisms are eroded (Prakash, 2011). The result can be a poverty trap.

The effect of volatility on poor farmers in rural developing areas has been much studied. Pest attacks, floods or droughts, price shocks or other impacts, and the uncertainty about their incidence are not easily handled by small farmers, and their impacts are felt for a long time afterwards (Dercon, 2004). Mechanisms to reduce risks, such as formal insurance, are usually absent, while informal assistance is insufficient to absorb the full size of shocks and instabilities (Morduch, 1995). Assets – such as livestock – are then sold at lower prices, further deteriorating welfare and deepening poverty. As a result, it becomes increasingly difficult to maintain a smooth consumption pattern in the household.

Farmers often respond to an unstable environment by choosing activities that are less risky but which generate lower economic returns (Rosenzweig and Binswanger, 1993). In Ethiopia evidence shows that farmers reduce the use of fertilizer by about 16 percent when their income is expected to fall as a result of a drought. In anticipation of shorter rains, they use fewer and fewer purchased inputs, risking a spiral into poverty from which they cannot escape (Dercon and Christiaensen, 2011). The strategies that the rural poor have developed to cope with risk are subject to technological, environmental and economic constraints that limit their effectiveness and inhibit development (Fafchamps, 1999).

In developing countries, food price volatility may also impose negative externalities on supply chain intermediaries, such as traders and processors, as they usually have limited



access to credit and are unable to hedge risks on futures markets. The consequence is that intermediaries will often operate at a small scale and inefficiently, which will increase costs for local consumers and put these companies at a competitive disadvantage relative to multinational competitors (Gilbert and Tabova 2011).

National-level impacts

So far, the analysis has focused on the impact of instability at the household-level. But unstable food systems can also have a major effect on the national economy. The physical and cognitive impairment caused by malnourishment reduces productivity and has a negative impact on GDP. Food insecurity and malnourishment place strains on public health systems. Where countries rely on agricultural exports for foreign exchange, production shortfalls or declines in commodity prices can cause a worsening of the current account. Net food importers suffer when global food prices rise. This has been the case for Low Income Food Deficit Countries (LIFDCs) during the period since 2007, as some countries (although not all) have suffered adverse shifts in their terms of trade. When coupled with the need for governments to fund social protection schemes, this can place a severe strain on government budgets and divert investment from education, health, infrastructure and other development priorities.

The impact of macro-economic and terms-of-trade volatility on welfare has been much studied by economists. These studies show that while long-run growth, irrespective of the amount of volatility from year to year, may be the most important determinant of welfare for industrialized economies, the opposite is the case for developing countries. Lower volatility in national income, even if it may result in slightly lower overall growth, produces greater welfare in these countries (Prakash, 2011).

Finally, rising and more volatile food prices have led to political disruption. Food riots or civil unrest have broken out in many developing countries – Egypt, Ethiopia, Haiti, Mexico, Morocco, Mozambique and Yemen, to name a few – and contributed to the overthrow of governments. Instability in food systems can be a threat to political stability as well.



Relevance to the green economy agenda

The United Nations Environment Programme (UNEP) defines a “green economy” as “one that results in improved human well-being and social equity, while significantly reducing environmental risks and ecological scarcities”.

The GEA agenda is highly relevant to efforts to increase the stability of food systems in three ways. First, many of the sources of instability can be traced back to the “environmental risks and ecological scarcities” that the green economy initiative is designed to tackle – these include climate change, land and water degradation, ecosystem collapse and energy scarcity. Other sources of instability are connected with the poor functioning of markets and the general levels of poverty and under-development in low income countries, which come from a lack of sustainable development and social equity. If not addressed, these threats are likely to intensify, posing even greater risks for food security in the future. These threats will be explored in the next section.

Second, instability in food systems can lead to unsustainable use of natural resources and negative environmental externalities. Uncertainty and poverty reduce the willingness and capacity of producers to make investments required for sustainable production systems, and can create incentives to deplete natural resources, rather than to use them sustainably, in agricultural production systems.

Depletion of soil nutrients, the cultivation of unsuitable marginal land and clearing of biodiversity-rich forests are examples. Fishers may over-exploit fish stocks for the same reasons. This can lead to a vicious cycle, as unsustainable activity jeopardizes future food security and forces people to erode natural resources even more (UNEP, 2011). Thus, a stable food system is a necessary platform for the transition to a green economy. The two are interdependent.

Third, many of the solutions to food instability can be found within the green economy agenda (this will be explored in a following section). Improving natural resources and environmental management will help reduce the risks associated with climate change, land degradation, water depletion and energy scarcity. Achieving broad-based, socially equitable development will strengthen the resilience and the adaptive capacity of the poorest and most vulnerable. There are additional measures needed to control food instability that fall outside the normal focus of the green economy – the green economy can be seen as a necessary but not sufficient condition – but they are complementary and can be integrated with this agenda.

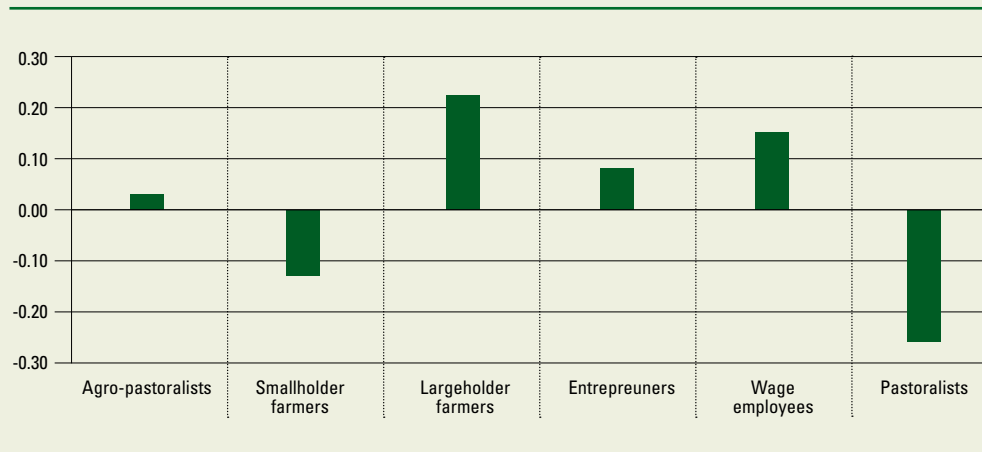


Box 9. Factors affecting livelihood resilience for different household groups in Kenya

In economic terms, household resilience refers to the ability of the household to maintain a certain level of well-being (e.g. food security) while withstanding shocks and stresses. This ability depends on the options available to the household to make a living, and its ability to handle risks. Ongoing FAO research (Alinovi *et al.*, 2010; 2011) studies household resilience in Kenya and Palestine.

This analysis of resilience by livelihood group in Kenya (Figure 6), shows that large-holder farmers are the most resilient (their resilience index is 0.22), followed by wage-employees (0.15), entrepreneurs (0.08) and agro-pastoralists (0.03). The worst-off are pastoralists and smallholder farmers (scoring -0.26 and -0.13, respectively).

Figure 6. Resilience Index by Livelihood Strategy Group in Kenya



Unpredictable shocks and crises are among the major causes of food insecurity in sub-Saharan Africa. Kenya has a long record of shocks and crises that can be traced back to four main causes – droughts, floods, diseases and political crises – which are often intertwined, compounding the impact of each shock. Among these determinants, droughts are the most relevant shocks in Kenya.





The country is a drought-prone country, with arid and semi-arid lands (i.e. areas where the annual rainfall range is between 200 and 500 mm per year) covering 80 percent of the territory. From 1985 to 2005, there were at least seven shortfalls in food supply directly linked to droughts, and 2011 has seen another occurrence, affecting the entire Horn of Africa.

The northwestern districts are the main areas of concern. In Ukambani, Mbeere and Tharaka, farmers have adopted innovations and new production techniques to cope with long dry spells that threaten subsistence farming. The Arid Land Resources Management Project II (ALRMP) and the Ministry of Northern Kenya and Other Arid Lands are spearheading this effort and renewing farming systems through the provision of food and financial resources to support farmers in beating the drought.

The Greening the Economy with Agriculture Initiative refers to a process of transformation. The goal is to move an economy from an initial state of poverty, food insecurity, inequality and poor natural resource management to one of sustainable development, food security and poverty alleviation. Increasing the stability and resilience of food systems must be a key part of this transformation.³²

32 “Stability” and “resilience” have two different, if linked meanings. Stability has been defined as “the capability of the system to remain close to stable states of equilibrium when facing “normal” variations, and is reflected in the frequency and amplitude of fluctuations in the state variables. “Resilience” refers to the aptitude of the system to maintain its performance defined by capacity and stability after a disturbance or long-term or permanent changes in its environment or internal conditions” (Holling, 1973).



Threats to food stability

This working paper will analyse five key threats to the stability of food systems. They include:

- extreme weather events
- loss of ecosystem services
- energy scarcity
- economic and social disruption
- malfunctioning global markets.

This working paper will show how these risks are already affecting food systems, contributing to the recent volatility in food markets. It will also demonstrate how these risks are likely to intensify in coming decades under business-as-usual approaches. Some of these threats are core concerns of the green economy agenda. Others would be addressed by the sustainable development, poverty alleviation and improvement in social equity that would come from a transition to a green economy.

Extreme weather events

There has been extensive research on the potential long-run impacts of climate change on food production, in terms of mean changes in temperature and precipitation. The focus here is on how climate change is likely to contribute to weather variability and, in particular, to extreme weather events.

Although food scenario models do not take into account the impact of extreme weather such as droughts, storms or floods, nearly all researchers conclude that increased climate variability and extreme weather events are projected to increase in the near term, affecting all regions (Cline, 2007). In many areas of the world where agricultural productivity is already low and the means of coping with adverse events are limited, climate change is expected to reduce productivity to even lower levels and make production more erratic. Changes in the frequency and severity of individual extreme weather events will probably have a much bigger impact on food production and food security than mean changes in climate, especially in the period to 2050 (Foresight, 2011).



Indeed, there is evidence that this is already happening. Data from FAO's Global Information and Early Warning System on food and agriculture indicates that sudden-onset disasters – especially floods – have increased from 14 percent of all natural disasters in 1980s to 20 percent in 1990 to 27 percent since 2000 (Selvaraju *et al.*, 2011). An average of 500 weather-related disasters were taking place each year by the mid-2000s, compared to 120 in the 1980s, and the number of floods increased six-fold over the same period (FAO, 2007). Analysis performed on Munich Re's natural catastrophe database, the most comprehensive in the world, substantiates that the number of extreme weather events such as windstorms and floods has tripled since 1980, and the trend is expected to persist. Researchers are increasingly willing to make a direct link between these events and anthropogenic climate change. "Our figures indicate a trend towards an increase in extreme weather events that can only be fully explained by climate change," said Professor Peter Höppe of Munich Re. "It's as if the weather machine had changed up a gear" (*Scientific American*, 2011; Munich Re, 2010).

Over the past five years, extreme weather events have caused significant disruption to world food supplies. In 2005, drought in Australia halved wheat production, while drought in Russia and Ukraine, and a dry spring followed by harvest-time floods in northern Europe, damaged crops, contributing to a 2.1 percent drop in world cereal production. Wheat harvests were again poor in 2006 and 2007. World cereal production rose in 2008 and 2009, but weather events again played a major role in 2010. Floods in Pakistan devastated the country's cotton and rice crops; Australian wheat producers were affected by rain; and heat waves and fires in Russia destroyed one-third of the country's wheat crop and led to the imposition of export bans. In January 2011, Cyclone Yasi damaged sugar-cane production in Australia, the world's third largest producer, contributing to sugar prices surging to a 30-year high (ISU, 2011). Volatile weather has been a major contributor to volatile food prices during this period.

There is a need to make food systems more resilient to floods, droughts and other extreme events. Agriculture will need to adapt to this riskier environment. Yet, agriculture is also a significant contributor to climate change, directly responsible for 13 percent of greenhouse gas emissions and perhaps indirectly responsible for another 17 percent if deforestation and land use change are taken into account (IPCC, 2007).



Loss of ecosystem services

Apart from climate, food production systems depend on a number of ecosystem services for their functioning. These include the provision of moisture, nutrients and soils, the control of pests and diseases, the regulation of surface and groundwater circulation and, in the case of wild species, direct provisioning of food. This paper focuses on how this degradation contributes to food instability. In particular, it is important to consider the “tipping points” or thresholds at which there is a non-linear acceleration of negative impacts, possibly leading to an ecological collapse. The concept of Planetary Boundaries refers to potential tipping points at a global, aggregate level (Rockström *et al.*, 2009). However, such effects are most likely to occur at the level of particular ecosystems.

Land and water

A forthcoming piece of research by FAO, *The State of the World's Land and Water Resources for Food and Agriculture*, warns of “the creeping degradation of the land and water systems that provide for global food security and rural livelihoods” (FAO, 2011b). Approximately 25 percent of the world's agricultural land area is highly degraded. Degraded soils, lacking in soil organic matter and nutrients, are more vulnerable to temperature extremes, droughts and floods. Agriculture accounts for 70 percent of all water withdrawals. The rapid uptake of groundwater over the last 60 years, as pumping technology has become available, has been instrumental in expanding, stabilizing and intensifying food production from irrigated areas (Siebert *et al.*, 2010; Shah, 2009). Yet, in fast-growing low income countries, demand for water already outstrips the useable supply. By 2050, more than half the world's population will live in countries with severe water constraints, including China, Egypt, Ethiopia, India, Iran, Jordan and Pakistan (Bruinsma, 2009). This has major implications for stability of production. The non-availability of water, whether due to adverse weather or the depletion of annually recharged aquifers, can cause agricultural production to plummet from one season to the next (FAO, 2011b).

In the case of water scarcity, the tipping point for agricultural production is not always the physical exhaustion of renewable and non-renewable water resources but the intervention of government once it becomes clear that existing practices are unsustainable. Saudi Arabia provides an example. During the 1980s, the pumping of water from underground aquifers allowed farmers to greatly increase domestic wheat production.



The country achieved self-sufficiency and, by the early 1990s, became the world's sixth largest wheat exporter. But the water began to run out, and, as a result, the government decided to phase out the expensive subsidies that underpinned the irrigation programme. Wheat production halved between 2000 and 2008, and it will end entirely by 2016. As a result, Saudi Arabia is now a major wheat importer, buying in 3 million tonnes per year, or about 2–3 percent of globally-traded wheat (Rice, 2009; Lidstone and George-Cosh, 2009). The Australian federal government has also attempted to control the over-exploitation of the Murray-Darling river system for irrigation, first introducing a water trading scheme and then spending USD 3 billion to buy back water entitlements from farmers, thereby reducing the amount of irrigated farmland (Connor *et al.*, 2008). Political pressure has led to a review of these initiatives, and a new basin plan with revised allocations for agriculture is to be presented in 2012.

Pests, diseases and genetic resources

The application of modern science to agriculture has brought huge advances in our ability to manage pests and diseases. Yet, a large amount of the world's potential agricultural production is still lost to this threat (Pretty, 2006). Moreover, there are certain features of modern production systems that may increase vulnerability. The homogenization of crops and livestock means that an ever greater proportion of the world's food supplies are produced from an increasingly narrow gene pool. This can increase the risk of widespread loss should outbreaks occur. The reduction of wheat varieties is a particular cause of concern: a new variant of wheat rust (Ug99) has spread from Africa to the Middle East and now threatens crops in India and Pakistan. In addition, the over use of pesticides over long periods can increase selection pressures towards resistance and unbalance natural biological control mechanisms. For example, the weed *Amaranthus palmeri* has developed widespread resistance to the herbicide Glyphosate in southern USA, especially affecting cotton (Gaines *et al.*, 2010). Climate change may lead pests and diseases to spread to new areas and new combinations of pests and diseases to emerge, with negative impact on agro-ecosystems (FAO, 2008b).

The intensive raising of livestock and fish creates its own problems. Confined animal feed operations create the ideal environment for diseases to spread. This is not just a risk for food production but a threat to human health: about 75 percent of all diseases emerging in the last two decades have been zoonoses (those that pass from animals to



humans). The widespread use of antibiotics in animal feed operations can also increase the selection pressure for antibiotic resistant pathogenic bacteria. Aquaculture, which in 2010 accounted for more than half of all fish consumed, is vulnerable in the same way. The outbreak of disease in a fish farm often leads to huge losses in production and can also spread to wild fish stocks. For example, the Chilean salmon farming industry, which had grown to become the world's second largest supplier, collapsed in 2007–08 due to the outbreak of the infectious salmon anaemia (ISA) virus (UPI, 2010). As population growth leads to more pressure to intensify production, the risk of pest and disease outbreaks may increase.

Homogenization, simplification and specialization in modern food production systems have shrunk genetic diversity. The loss of genetic diversity in agriculture reduces the genetic material available for future use by farmers and plant breeders. Seed banks – such as the Global Seed Vault in Svalbard, Norway – are an attempt to maintain this store of genetic material, but such a store cannot replace the continued natural evolution of species that occurs due to their cultivation under changing local conditions. The ability to adapt crops and animals to future cropping systems and climate change will depend upon access to genetic variation (FAO, 2011c; ISU, 2011).

Wild resources

Although most of the world's food comes from managed agro-ecosystems, it should be remembered that wild species play a crucial role in food provisioning, especially for the poor. Threats to the stability of these systems come from over-exploitation and encroachment by human activities.

Over-exploitation is most evident in the case of capture fisheries. Fish (from both capture fisheries and aquaculture) provide more than 1.5 billion people with almost 20 percent of their average per capita intake of animal protein, and three billion people with at least 15 percent of such protein. Fish make an especially big contribution to balanced diets in low income countries. Yet, FAO data indicates that 32 percent of marine wild capture fisheries are over-exploited, depleted or recovering from depletion. An additional 53 percent of fisheries are being exploited at their maximum level, and there is a considerable risk that they will become over-exploited in the absence of management reforms. Some fisheries have already collapsed, for example the North Atlantic capelin fishery declined from 2.6 million tonnes in 1980 to 300 000 tonnes in 2008. Globally, the size of the total



catch peaked in 1996 at an estimated 86 million tonnes and has since levelled out at an annual production of approximately 80 million tonnes (FAO, 2010b). Over-exploitation, poor management and climate change impacts will increase the risk of fishery collapses.

Natural forests also play a vital role in provisioning food for some of the poorest and most vulnerable people in the world. Non-wood forest products, such as fruits, seeds, roots of trees, mushrooms, wild animals and insects found in forests provide important nutrient and vitamin-rich supplements for rural households. They do this by adding variety to diets, improving taste and palatability of staples, and by providing essential vitamins, protein and calories. Bushmeat and other edible wild mammals, reptiles, birds and insects that live in trees and forests can account for up to 85 percent of the protein intake of people living in or near forests. In some areas of Africa, wild resources cover up to 80 percent of household food needs during staple crop shortages (FAO, 2008d). This food supply can be threatened by deforestation, which has occurred at a rate of 13 million hectares per year over the last decade, mostly due to the conversion of tropical forests to agricultural land (FAO, 2010d). This conversion may increase the total amount of food produced, but it may not be accessible to marginalized hunters and gatherers who have lost access to the natural resources on which they depend. This is an example of how stability of access to entitlements can be critical to food security.

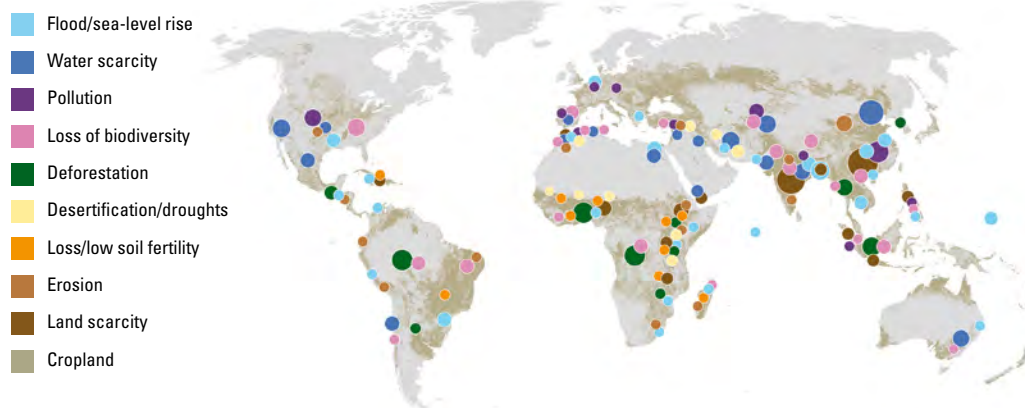
Mapping the risks

FAO has identified a number of “at risk” agricultural production systems around the world. It has mapped the prevalence of risks such as sea level rises, water scarcity, floods, pollution, loss of biodiversity, deforestation, desertification, loss of or low soil fertility, erosion and land scarcity (see Figure 7). Many are clustered in developing countries and in areas of dense population where agricultural production is concentrated, including deltas and coastal plains (FAO, 2011b).

The threats discussed in this section – the degradation of land and water resources, the erosion of genetic diversity, the creation of conditions that favour outbreaks of pests and diseases, and the weakening of ecosystem functionality – are examples of the depletion of natural capital. Many agriculture and fishery systems are spending this capital in an unsustainable way. As natural capital is depleted, food systems come closer to critical thresholds and become more vulnerable to disruption.



Figure 7. Global distribution of risks associated with main agricultural production systems



Source: FAO, 2011b

Energy scarcity

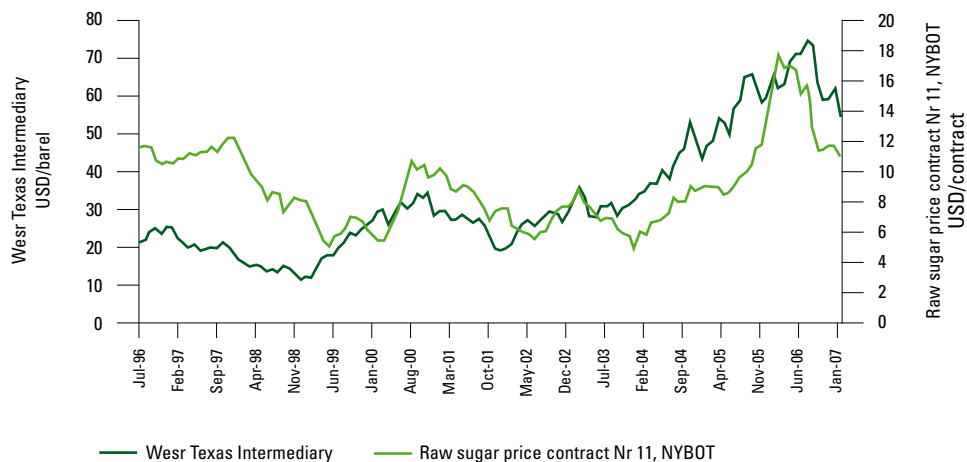
Another threat to the stability of food systems is that food prices are becoming more and more coupled with energy prices. This occurs because biofuels policies create a new source of demand for food, land and water. In addition, modern food systems are heavily reliant on fossil fuel energy, either directly as fuel (for pumping water, field mechanization or processing) or indirectly as a key input into the manufacture of nitrogen fertilizers (Freibauer *et al.*, 2011; Schmidhuber, 2007). This creates new risks. Volatility in energy markets is likely to cause volatility in food markets; energy shocks may become food price shocks too.

Biofuels demand

Between 2000 and 2009 global output of bioethanol quadrupled and biodiesel increased tenfold (FAO *et al.*, 2011). The diversion of food crops towards biofuels was a major factor in the increased demand that contributed to volatility in food markets. Between 2005 and 2007, the use of cereals for biofuels increased by 47 million tonnes, which was about 60 percent of the total increase in cereals use (Tangerman, 2011). In the USA, four



Figure 8. Crude oil prices drive sugar prices



out of every ten tonnes of corn grown now go to fuel vehicles (*Wall Street Journal*, 2011). If current policies continue, FAO estimates that by 2020, industrialized countries may be consuming 150 kg of maize per head per year in the form of bioethanol – which is as much as all the food cereals consumed by each person in developing countries (FAO, 2011c).

Biofuels demand had a particularly strong impact on food markets in recent years because it was highly inelastic to price. Because of strong mandates, maize continued to be purchased for conversion to bioethanol even as prices rose (Tangerman, 2011). Even without these mandates, food will be converted to fuel once oil prices reach a point at which the costs of the feedstock and of the conversion process make bioenergy competitive. These break-even points have been estimated at USD 35 per barrel of oil (bbl) for the average sugar-cane producer in Brazil, at USD 38/bbl for large-scale cassava-based ethanol production in Thailand, at USD 45/bbl for palm oil-based biodiesel in Malaysia, and at USD 58/bbl for maize-based ethanol in the USA (Schmidhuber, 2007). IFPRI and World Bank simulations tend to show a potential significant impact on food prices through competition for land and inputs, especially for ethanol (Mensbrughe *et al.*, 2009).



Because the energy markets are “big” relative to the agricultural market, energy prices will determine agricultural prices where agriculture provides competitive feedstocks. This will create a floor price for agricultural produce, but it will also translate energy price spikes into food price spikes. This will have varying effects in developing countries. Some farmers may benefit from higher incomes, due to higher food prices and the greater volume of products they can sell on markets. But urban consumers will suffer, as will those many rural households (including farmers) that are net buyers of food. Moreover, food prices and energy prices will tend to rise in tandem and in a non-linear way, which will have a negative impact on net buyers of food and energy. At the household level, a poor urban household with a high expenditure share on both food and energy would be particularly hard-hit. At the country-level, net importers of food and energy may experience balance of payment problems due to simultaneous price rises in both sectors (Schmidhuber, 2007).

Attempts are being made to develop second generation biofuels derived from non-food feedstocks, such as miscanthus grasses, algae, jatropha, wood and agricultural waste. These alternatives would reduce the direct pressure on food markets, while creating new income opportunities for farmers and contributing to a low-carbon energy mix (WWF, 2011). Yet, indirectly, second generation biofuels will still compete with agriculture for land, water and inputs, which will tend to preserve the link between food production and energy demand (Eisentraut, 2010).

Modern biofuels, however, only account for a very small part of bioenergy. Approximately three billion people in developing countries rely on biomass-based energy sources – primarily wood, charcoal and animal dung – for their basic cooking and heating needs. Although essential to food utilization and food security, these sources are often harvested in an unsustainable way, leading to deforestation and environmental degradation. This activity is driven by poverty and a lack of access to modern energy sources: 1.6 billion people still lack access to electricity (FAO, 2010c). It also poses a risk to food production, as deforestation can lead to soil erosion, flooding and changes in microclimates. Haiti is a good example of a country where food security has been weakened by the clearing of forests for energy (ISU, 2011).

Agricultural inputs

Modern food systems are heavily reliant on fossil fuel energy. Intensive, high-input farming systems are heavy consumers of fossil fuels, both directly in the form of fuel for farm machinery and indirectly in the form of the energy used to manufacture fertilizers,



agrochemicals and other inputs. Natural gas is especially important because about 80 percent of all ammonia fertilizers are synthesised through the Haber Bosch process, which uses the gas as a source of hydrogen as well as a primary fuel (Dawson and Hilton, 2011). Further energy is used for the transport and processing of food. Indeed, in the European Union two-thirds of the energy consumed by the food supply chain is used beyond the farmgate.

Rising and volatile energy prices in recent years were a major cause of volatile food prices. As the price of crude oil reached USD 150 per barrel, the cost of fuel for farm machinery and transport rose correspondingly. Between 2000 and 2008, the cost of nitrogen fertilizers increased fourfold, largely because of the soaring price of natural gas (Piesse and Thirtle, 2009). Although it is impossible to forecast energy prices, it seems clear that the world is approaching an energy crunch, as the production of oil peaks and then starts to decline. This is likely to lead to greater price volatility. The situation for natural gas is more complex, as new technologies have allowed large quantities of shale or “tight” gas to be exploited in some countries, bringing prices down (*The Economist*, 2010). However, carbon pricing, as part of climate change mitigation efforts, will place further upward pressure on fossil fuel prices.

Energy price rises will be passed through to agriculture in the form of higher operating costs and then passed on to consumers in the form of higher food prices. In a simulation of future oil prices, the OECD found that a 10 percent increase in the price of oil results in a 2.3 percent rise in the price of wheat and a 3.3 percent rise in the price of maize and vegetable oil – even excluding the potential effects of biofuels and climate change (Tangerman, 2011). This is an important potential source of instability for food security.

Another finite resource crucial to modern agriculture is phosphate fertilizer, which is derived from mining phosphate rock. Between 2000 and 2008, the price of phosphate increased fivefold, which contributed to food price rises during this period. There are varying estimates of the extent of phosphate rock reserves, with some experts warning that supplies could run out in 50 to 100 years (Cordell *et al.*, 2009). It is likely that further reserves will become available, so long as prices justify their exploitation. The key risk to food systems is not the absolute scarcity of phosphate, but that its price is likely to rise and become more volatile as easily-mined reserves are depleted and production shifts to more difficult areas. This could be another source of price instability for high-input farming systems (Dawson and Hilton, 2011).



Economic and social disruption

Economic and social instability can jeopardise the availability of food, people's access to food and the effective utilization of food. A stable macro-economic framework is crucial for reducing uncertainty and risk, and enhancing consumer and investor confidence. Fiscal, monetary, exchange rate and labour market policies all contribute to shaping the incentive structure faced by producers, investors, and consumers as they take the actions that will result in food security outcomes at the national, household and individual levels. Conversely, macro-economic instability can deter investment in food production, erode incomes and savings, trigger unemployment and lead to volatility in food prices (Stamoulis and Zezza, 2003).

Social capital is just as important to food security. Weak governance arrangements and public administration, or the breakdown of local institutions, can limit or disrupt household access to entitlements such as land, water, employment and public services. An inability to control human diseases such as HIV/AIDS can have devastating impacts on household structure, incomes and agricultural productivity. At the extreme, internal conflict, war and state collapse can cause sudden food insecurity for large numbers.

FAO has identified 22 countries as being in protracted crisis.³³ They face enormous challenges such as repeated food crises and an extremely high prevalence of hunger due to a combination of natural disasters, conflict and weak institutions. They are characterized by long-lasting or recurring crises and limited capacity to respond, exacerbating food insecurity problems. On average, the proportion of people who are undernourished in these countries is almost three times as high as in other developing countries. More than 166 million undernourished people live in countries in protracted crises, roughly 20 percent of the world's undernourished people, or more than a third of the global population, if large countries such as China and India are excluded from the calculation (FAO, 2010a).

Although there are many reasons these countries are in protracted crisis, environmental degradation plays a role. Unsustainable livelihood systems are often a feature of these countries. Deterioration in the sustainability of livelihood systems is a contributing factor

33 They are Afghanistan, Angola, Burundi, Central African Republic, Chad, Congo, Côte d'Ivoire, Democratic People's Republic of Korea, Democratic Republic of the Congo, Eritrea, Ethiopia, Guinea, Haiti, Iraq, Kenya, Liberia, Sierra Leone, Somalia, Sudan, Tajikistan, Uganda, Zimbabwe.



to conflict, which may in turn trigger a protracted crisis (FAO, 2010a). Subsistence crises can lead people to resort to violence to secure food supplies and other resources (de Soysa *et al.*, 1999). There is an extensive literature on the relationship between environment and conflict, which points to the risks posed by climate change, energy scarcity, land degradation and water depletion (Paskal, 2010). Africa, identified as the most vulnerable continent, may see widespread displacement and migration due to environmental change, which could cause tensions (ACCES, 2010).

The causal linkages between environmental change, poverty, conflict, and economic and social disruption are a threat to the stability of food systems. A transition to a green economy can help address this. Better natural resources management can remove some of the causes of conflict. Sustainable development and poverty alleviation will also lead to greater economic and social stability in poor countries.

Malfunctioning global markets

Most researchers on food systems agree that there is unlikely to be a structural food deficit by 2050 when the global population is predicted to reach 9.1 billion. With the resources available, the world will be able to produce enough food for everyone (FAO, 2009c). There may be large discrepancies in the supply and demand of food between regions and between different parts of society, but the assumption is that markets will serve to balance out these discrepancies. However, this may be too sanguine. There is a risk that markets may not function so smoothly and that certain groups could find themselves on “the wrong side of the trade”. This issue will need to be tackled if the green economy is to deliver stable food security for all countries.

Normal volatility in world food markets

It is important to recognize that some variability in global food prices is inevitable. Tangerman (2011) argues that agricultural markets are by their nature more volatile than other types of markets because of the vulnerability of food production to adverse weather and pests, the low elasticity of supply and demand, and the long time it takes to increase production. World food markets are also thinly traded: exports account for only 12 percent of production of coarse grains and 18 percent of wheat. As a result, food prices on international markets have to vary widely in order to equilibrate supply and demand (Tangerman, 2011).



This same research also shows that these price fluctuations are asymmetric – the rate at which prices rise tends to be faster than the rate at which prices fall. This is because agricultural products are storable commodities. When prices fall, users and traders build up stocks, adding to demand and dampening the price falls. In theory, this process of stock building can go on indefinitely. When prices rise stocks are depleted as traders release stocks, but there comes a point when there are no more stocks left to release. At this point, prices have to rise enough to ration demand, which can lead to dramatic price spikes because of the low elasticity of demand for these goods. Markets can also enter a “bubble dynamics” phase, when panic and hoarding break out. In a situation of depleted stocks, soaring prices can become a self-reinforcing process. Market participants may take continued price rises as an indication of growing scarcity and begin to expect further price rises. As a result, sellers sell later in order to capture the higher prices, while buyers try to buy earlier to lock in lower prices. This has a concertina effect along the supply chain, reducing overall food availability. For example, during the 2006–2008 period, importers, especially state or parastatal actors, bought earlier and in bigger quantities than normal as they feared further price rises. This market dynamic can result in a “rational panic” which can quickly get out of control and drive prices to unprecedented levels, although it is normally followed by a collapse as the fundamentals re-assert themselves (Tangerman, 2011).

The changing nature of world supply may also increase volatility. Global food markets now rely on more marginal areas of agricultural production that have inherently more volatile climate or that lack the infrastructure of more developed regions. For example, world wheat markets are now more dependent on supplies from the Black Sea region. In 2008 and 2009, Russia, Ukraine and Kazakhstan accounted for 20 percent of world exports of both wheat and barley, compared to just 3 percent in 1995. During these two years, these countries’ wheat exports were 44 percent larger than the USA’s. This region is historically more susceptible to volatile climate and volatile yields, as illustrated by events in 2010. This is likely to increase volatility of supply in global markets (FAO *et al.*, 2011).

Variability in food prices and occasional price spikes are, therefore, normal features of food markets. However, this variability can be exacerbated by trade distortions and financial speculation.



Trade distortions

The agricultural trade and subsidy policies of large countries are usually pro-cyclical. When global food prices are low, protection is increased in order to support domestic producers, lowering demand on world markets and depressing prices further. When food prices are high, import barriers are lowered and export restrictions sometimes enforced, increasing demand on world markets and driving prices even higher. Thus, large country trade policies tend to increase food price volatility. This was the case during the 1980s, 1990s and early 2000s when OECD subsidy policies contributed to low and declining real food prices (which unsubsidized farmers in developing countries struggled to compete with) (Anderson, 2010). It has been even more evident in the five years since 2006 when rising global prices prompted many countries to relax import tariffs and to impose export restrictions in an effort to keep domestic prices down (Tangerman, 2011). Of 81 developing countries studied by FAO, 43 reduced import taxes and 25 banned exports or increased taxes (FAO *et al.*, 2011).

Export restrictions sparked panic in global food markets. In particular, they set off a scramble for rice in 2007 and 2008 which left some countries fearing that they would be unable to obtain supplies at any price. Research indicates that export restrictions can amplify a 10 percent rise in world prices to 20–50 percent (FAO *et al.*, 2011). They are “beggar-thy-neighbour” policies that can have serious impacts on the welfare of poor, food-importing countries, and have been strongly criticized for this reason. Nevertheless, these restrictions tended to work in those countries that used them, keeping domestic food prices below international prices (Tangerman, 2011). Consequently, there is a risk that food exporters will resort to them again during times of food crisis, magnifying volatility and instability in the global market.

Financial speculation

Commodity markets, including food markets, have seen a large inflow of speculative funds since the early 2000s – what has been called the “financialization of commodity markets”. Much of this has been channelled through index funds, which invest in future contracts in the hope that prices will rise: according to Barclays Capital, about USD 320 billion is invested in various commodity index funds (Berg, 2011). There also has been an increase in managed funds or hedge funds that go “long” and “short”, depending on their analysis of the market. On many future markets, speculators now greatly outnumber commercial operators seeking to hedge “real” exposure to changing food prices. Investors have been



Box 10. Price transmission – from global to local

Changes in local food prices in developing countries can sometimes be very different from the prices quoted on commodity markets in Chicago or London. Volatility of food prices is frequently measured with the use of a statistical measure called Coefficient of Variation (CV). The CV represents the ratio of the standard deviation of a price in time to its average – thus, the higher the CV, the higher the volatility of the price series. Between June 2007 and June 2008, price volatility in sub-Saharan Africa (SSA) was higher than on world markets for the same key food crops. The CV for maize, measured 38 percent in African markets, compared to 33 percent in world markets. Variation in wheat prices was 38 percent in Africa and 36 percent internationally. But for rice, the CV was measured at 22 percent in African markets, but was nearly twice as high (42 percent) in world markets (Minot 2011).

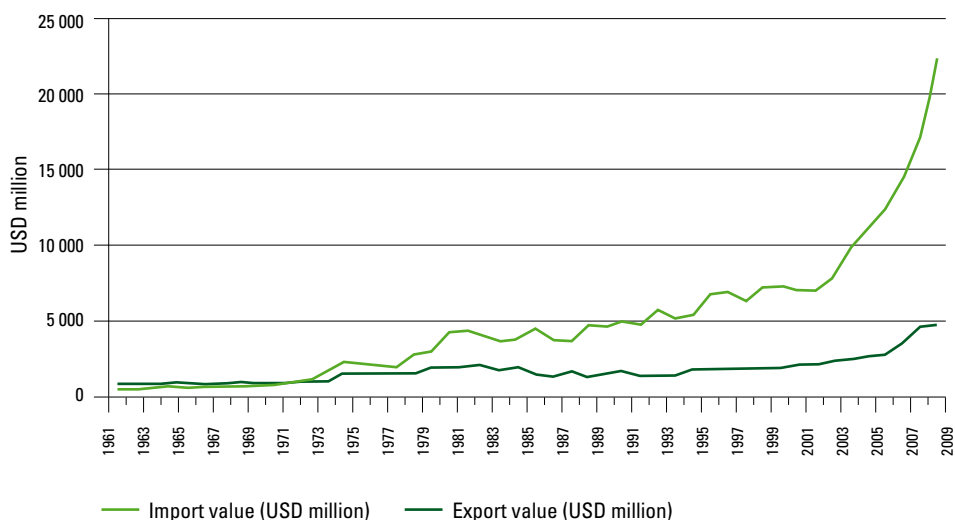
In the first half of 2011, maize prices in many southern African countries, such as Malawi, South Africa and Zambia, have remained relatively flat even while prices on the Chicago exchange have doubled. Why? There have been large surpluses due in part to favourable weather conditions and to the use of input subsidy programmes in some countries, but these surpluses are not always finding their way into regional or global markets due to limited infrastructure and government export restrictions motivated by food security concerns – i.e. domestic prices are significantly insulated from global developments (Morrison, 2011).

The opposite effect can be seen in Central Asia, where local wheat prices increased at a faster pace than the global price during 2010, in part because this region is heavily reliant on imports from Russia and Ukraine, which suffered significant production shortfalls, prompting them to impose export restrictions (Morrison, 2011).

Local prices for foods that are not widely traded on global markets, for example roots and tubers, can diverge even more from region to region. Nevertheless, price transmission has generally strengthened over the past three decades because of better infrastructure and communications technology, the lowering of trade barriers in developing countries and the increased reliance of developing countries on food imports (Morrison, 2011).



Figure 9. LDC imports and exports of food (1961-2008)



Source: FAO

motivated by the desire for diversification, the desire for a hedge against inflation and the belief that market fundamentals would support higher food prices. They have been facilitated by the deregulation of commodity markets and the loose monetary policy that has led to large amounts of liquidity in the financial system (Berg, 2011).

There is a vigorous debate about the extent to which this trend has contributed to recent volatility in food markets. Some analysts question, first, whether the increased speculative flows led to any rise in futures prices, and, second, even if they did, whether futures prices can affect the actual prices of physical commodities (Irwin and Sanders, 2010). However, several authors argue that speculation was a significant factor in the 2006–08 food price spike (e.g., Masters, 2008; Cooke and Robles, 2009; von Braun et al., 2008; Baffes and Haniotis, 2010). Recent reports from UNCTAD and the High Level Panel of Experts of the Committee on World Food Security have tended to agree, concluding that the financialization of commodity markets probably has exacerbated recent volatility (UNCTAD, 2011; HLPE, 2011). If there is no reform of these markets there may be heightened volatility in the future.



Global imbalances

There are already large imbalances between areas of food surplus and areas of food deficit, mostly, if imperfectly, evened out by trade (and aid). Cultivated land per person in developing countries is less than half that of high income countries and its suitability for agriculture is lower (FAO, 2011b). Net imports of food and agricultural products by least developed countries soared over the past 20 years to a level of nearly USD 14 billion by 2007 as shown in the graph (Schmidhuber and Bruinsma, 2011).

Because of natural endowments, patterns of population growth and expected climate change impacts, these imbalances may grow. Most of the population growth of the next 40 years is expected to take place in developing countries. For example, the population of Africa, now one billion, is estimated to double by 2050. India is expected to become the most populous country in the world, growing from 1.2 billion to 1.75 billion people (PRB, 2010). Yet, many regions with the fastest growing populations are in tropical and subtropical zones where climate change is likely to have the most negative impacts. Some of these regions are also already suffering from land scarcity and water stress.

In contrast, the more developed temperate regions in the northern latitudes may actually benefit from climate change in the medium-term, facilitating further increases in food production. As a result, some experts argue that an increase in the level of food trade is inevitable and that it represents a good adaptation strategy for climate change (Foresight, 2011; IFPRI, 2010).

However, a greater reliance on trade comes with risks. Countries will be exposed to the vagaries of global food markets which, for the reasons explained above, can be volatile and subject to occasional price spikes. In recent times, global markets have come close to breaking down completely, as was the case with rice, (Gilbert and Tabova, 2011). Large increases in trade will also place pressure on the global transport and logistics infrastructure, which may also be vulnerable to climate change and policies that mitigate climate change.

The ability of food deficit countries to participate in markets will depend on their ability to access foreign currency. In turn, this will be affected by the terms of trade between the goods and services they export and those they import. An analysis of four countries – Benin, Kenya, Malawi and Nepal – shows that they experienced deterioration in their terms of trade of between 10 and 14 percent between 2005 and 2008, largely driven by higher food prices. However, when this analysis is extended from 2005 to the first half of 2010, it shows that terms of trade of these countries improved by between 1 and 8 percent, largely because



the price of export commodities remained high while food prices fell (Gilbert and Tabova, 2011). Therefore, the impact of higher prices will depend on the mix of sectors in a particular economy and relative changes in prices between those sectors.

In a world where food and energy prices are closely linked, the most vulnerable countries will be those that are net importers of both food and energy, but that are unable to pass higher import expenditures to value-added export products or to other commodity exports. These countries could face a double blow to their current account – from higher global food and energy prices – which could threaten food security (Schmidhuber, 2007).

Ultimately, global markets will only be accessible to the poorest countries and the poorest sections of these societies if they have sufficient purchasing power. In a world where population growth, changing diets in middle income countries and biofuels are creating new demand for food, higher food prices are likely in coming decades. Research shows that the elasticity of food demand is much lower in high income countries than in poor countries, and that this difference in elasticity is widening over time (HLPE, 2011). In other words, when food prices rise, high and middle income consumers continue to purchase regardless, whereas poor consumers are forced to reduce their consumption – the burden of balancing global supply and demand falls mostly on them. In order to compete on world markets, therefore, poor countries and poor consumers will need sufficient income. This makes overall economic growth an essential (if not sufficient) part of building stable food security. In most developing countries, agriculture is the largest sector of the economy and therefore should be a major driver of this growth.

Conclusions

There are a number of risks that threaten food security, especially for the poorest citizens of developing countries. Many of these risks have played a role in the volatility that has been such a feature of global food markets since 2006. There is evidence that they are likely to intensify in coming decades if current practices persist. These risks are also likely to be interconnected and reinforcing, with positive feedback loops leading to non-linear results. Extreme weather events, environmental degradation, energy price shocks, market disruptions and macro-economic instability may all occur at the same time and in the same place.

Climate change, loss of ecosystem services and energy scarcity are core concerns of the green economy agenda. If left unaddressed, they will pose a significant threat to the stability of food security in the twenty-first century. They can be best addressed



by a transition to a green economy. Economic and social disruptions, together with malfunctioning global food markets, have many causes. However, the most vulnerable countries can address these risks through sustainable development, poverty alleviation and social equity – core goals of the green economy. The GEA Initiative should go a long way towards reducing some (if not all) of the risks to the stability of food systems in developing countries.

Measures to strengthen resilience

Recent instability in food systems, and evidence that threats are likely to intensify under business as usual, reinforce the need to pay greater attention to stability when developing food security strategies. Rather than focusing simply on productivity increases or economic efficiency, policy-makers must take into account the risks associated with different strategies – they must try to assess the risk-adjusted returns. This is because food security can only tolerate a low level of risk: there is no point in designing a system that delivers food security in nine years out of ten but then collapses in one year due to internal stresses or external shocks.

This leads to two complementary approaches. The first is to reduce the risks that a food system faces, either by re-designing the system itself or changing the external conditions in which it operates. However, some level of variability is inevitable, given the complex ecological systems that are the basis for our food. Therefore, a second way to increase stability is to improve the ability of households and countries to cope with disruptive events. Adaptive capacity is crucial.

This working paper suggests five main action areas to strengthen the resilience of food systems:

- investing in food and agriculture systems and rural development in developing countries;
- implementing food and agriculture production systems that are resilient to climate volatility and that build natural capital;
- managing the links between food and energy markets by amending biofuels policies and making more efficient use of energy-intensive inputs;
- improving the functioning of national and global food markets;
- building safety nets for the most vulnerable households and countries.



Table 10. Action areas for addressing risk in food systems

RISK	ADDRESSED BY...	CROSS-CUTTING MEASURE
Extreme weather events	<ul style="list-style-type: none"> • Implementing sustainable and resilient production systems 	Building safety nets for the most vulnerable
Loss of ecosystem services	<ul style="list-style-type: none"> • Implementing sustainable and resilient production systems • Investing in rural development 	
Energy scarcity	<ul style="list-style-type: none"> • Managing food and energy links 	
Economic and social disruption	<ul style="list-style-type: none"> • Investing in rural development 	
Malfunctioning global markets	<ul style="list-style-type: none"> • Improving the functioning of markets • Investing in rural development 	

The good news is that these measures are complementary and will tend to reinforce one another. They are also in accordance with the principles of the green economy and will help deliver the wider goals of the green economy. However, there may be some trade-offs: for example, decoupling food and energy markets may slow the development of bioenergy, and efforts to boost agricultural productivity could lead to some increases in greenhouse gas emissions (FAO, 2009a). Understanding and optimizing these trade-offs will be crucial. In addition, the way in which these measures are implemented will vary considerably across countries according to local conditions – obviously, there is no “one size fits all”.

Investing in agriculture and rural development

Domestic production

Improving the performance of farms in poor rural and peri-urban communities in developing countries will be essential to achieving food security. In order to meet growing demand, it has been estimated that global agricultural production will need to grow by 70 percent between now and 2050 (Bruinsma, 2009). Many low income countries that currently depend on food imports possess the natural endowments to allow for greatly increased production – there is a major “yield gap” in these countries, especially in Africa. Low income countries can reduce their vulnerability, and make a contribution to global food security, by increasing the quantity and quality of local food production (FAO *et al.*, 2011).



Smallholder farms must be at the centre of this strategy. Increasing the productivity of smallholder agriculture will not only increase local food availability, it will also make a major contribution to poverty alleviation and economic development. Vulnerability to hunger is, above all, a manifestation of poverty.

Seventy-five percent of the world's poor are found in rural areas. Many directly depend on agriculture or draw a large share of their incomes from agriculture-related activities. Others work as small entrepreneurs in the agriculture-related processing, machinery, storage, seed, feedstuffs or fertilizer sectors. While so many poor and hungry depend on agriculture for their livelihoods, a profound and prolonged lack of investment in agriculture has held back the overall productivity of the sector. Lack of investment also has reduced the ability of farmers to cope with price volatility and exogenous shocks, both weather-related and economic ones. There is ample evidence that this lack of investment can be addressed successfully and that investments can have a massive effect in reducing poverty. For example, econometric analysis presented in the World Development Report 2008 suggests that GDP growth arising from agriculture is almost twice as effective in reducing poverty as GDP originating outside the sector (World Bank, 2008).

As a labour-intensive sector, agriculture can absorb underused labour, such as landless rural workers and farmers who own too little to make a living. Moreover, agricultural growth reduces food prices and acts as a multiplier in local economies, eventually leading to higher rural wages and vibrant rural markets where farmers and workers spend their earnings (Schmidhuber and Bruinsma, 2011). Therefore, investing in smallholder agriculture is not just a necessity for food security – it also is an opportunity to promote equitable economic growth while making use of natural resources where available.

Self-sufficiency and trade

Since the 1980s, the availability of cheap food imports from low price and relatively stable global markets has led to complacency about national food production and facilitated the dismantling of agriculture support policies in developing countries under structural adjustment programmes. This policy not only contributed to rural economic stagnation in many of these countries, it left many of them exposed when food markets entered a period of volatility from 2006 onwards. Now, it is clear that a long-term solution must include increased local food production in developing countries. Because of the risks outlined in



the previous section, global food markets are likely to experience higher and more volatile prices in the future, which could expose food deficit countries to greater shocks.

Not all countries can achieve self-sufficiency – some lack the agroecological capacity and gain sufficient foreign currency from other activities to purchase food. But other developing countries have the capacity to increase domestic production, possess large underemployed rural labour forces and are at risk from a deterioration in their terms of trade. In other words, they could be said to be below their optimal level of food self-sufficiency. In those cases, it will make sense to invest in greater domestic production, as a measure for food security and as an engine of economic growth.

This may require some changes to national-level trade frameworks. Many developing countries have significantly liberalized their agricultural tariffs and reduced their domestic support for farmers, while rich countries have kept protectionism and dumped subsidized food on world markets. Developing countries must have adequate policy space, in terms of tariffs and domestic subsidies, to enable them to support farmers' livelihoods and food security during times of high and low global prices (HLPE, 2011).

Downstream activities

Any efforts to boost production must be accompanied by the development of post-harvest activities such as storage, trade, transport, processing and retailing. These will be essential to ensure that the food produced is available to consumers. But they can also play an important role in increasing stability.

FAO estimates suggest that post-harvest losses account for 25–40 percent of total agricultural production in developing countries (Schmidhuber and Bruinsma, 2011). Losses can be even higher for individual countries and individual crops, particularly when bumper harvests yield output that is well in excess of limited storage capacities. Building or improving storage facilities to reduce these losses is therefore an important element of this programme. Improving the availability and effectiveness of cold storage will be especially important. Better storage contributes to stability by providing a buffer for production shortfalls and thus helping reduce swings in market prices for farmers and consumers (Schmidhuber and Bruinsma, 2011).

In addition, food processing preserves food for later use and allows it to be consumed in more convenient and nutritious forms, thus reducing post-harvest losses and smoothing food availability. Packaging has an important role to play in reducing food loss, and a



clearer understanding of its protective and marketing functions can help to promote its use. A support infrastructure in the form of roads, warehouses, water, electricity, information and communication technologies, and waste disposal facilities must also be available to underpin processing operations and facilitate links between processors and input and output markets.

Scale of investment

It has been estimated that public investment of USD 50 billion per year would be needed to eliminate hunger by 2025. The largest part would go to improve rural infrastructure and market access through investment in physical assets, such as irrigation, rural roads and railways, rural electrification and storage. But investment in people and technology would also be critical, for example through investment in research, development and extension to encourage innovation, or in strengthened rural institutions, such as finance providers or farmer cooperatives. The two regions of sub-Saharan Africa and south Asia would account for 62 percent of the overall programme (Schmidhuber and Bruinsma, 2011). This public investment would need to be accompanied by, and indeed leverage, a large amount of private investment in agriculture. FAO estimates that USD 209 billion of mostly private investment will be needed in developing country agriculture each year between now and 2050 to achieve necessary production increases (FAO, 2011c).

Box 11. Mitigating the food security risks of rising temperatures in rural Nicaragua

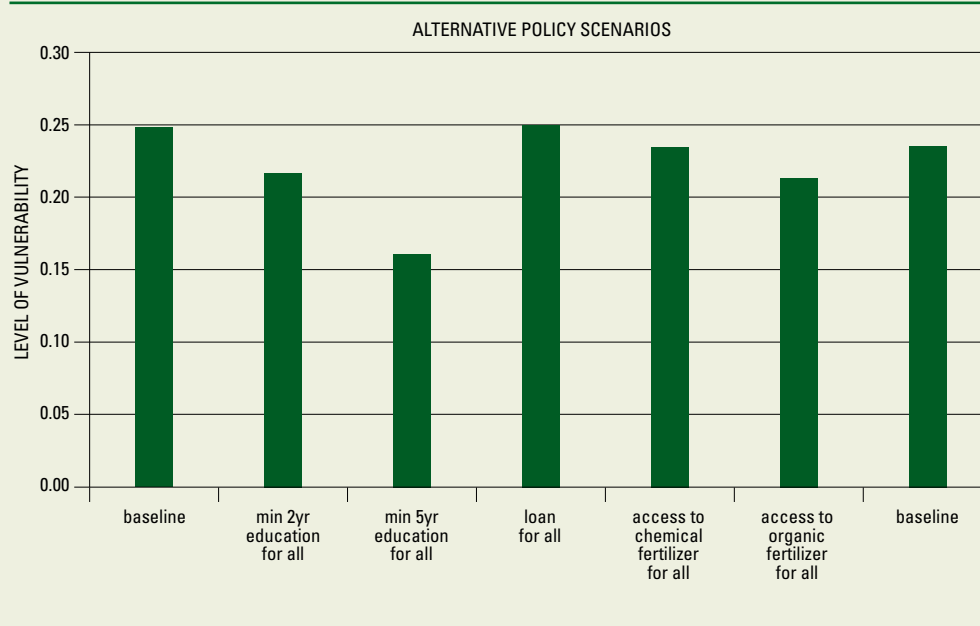
Rising temperatures constitute a food security risk for rural households. Analysis of household data from Nicaragua provides evidence of the impacts of rising temperatures on agricultural yields and food security (Karfakis *et al.*, 2011).

Over the period 1971 to 2010, the average temperature in Nicaragua increased by 1.1 °C and became increasingly unpredictable, with large swings from year to year. Nearly 90 percent of the farmers experienced increases in temperatures of varying degrees during 2001.





Figure 10. Education has the greatest impact on reducing vulnerability



Note: The level of vulnerability indicates a household's probability of becoming food insecure in the near future.

In addition, 25 percent of farming households are extremely poor, experiencing chronic or temporary food insecurity; more than 50 percent of their income is generated through farming; and their agriculture is mostly rainfed, with less than 2 percent of households reporting use of irrigation. Data analysis indicates that temperature increases over historical averages significantly reduces the value of farm output per hectare. In turn, reduced farm productivity increases the probability of a household becoming food insecure.

Analysis of the effectiveness of alternative interventions in mitigating risk and vulnerability to food insecurity provides valuable insights for policy (see Figure 10). Investments in human capital, such as raising education levels to complete primary education, have the strongest effect on reducing vulnerability. Increased access to agricultural inputs, such as fertilizers and pesticides, also has significant impact. In contrast, increasing access to credit has only a limited effect on reducing vulnerability.



Although crop and livestock production sectors require the largest amount of investment, increasing the resilience of fisheries and forests will also be important. It is estimated that ensuring the sustainable use of the world's fisheries would require public investments of an additional USD 2.4 billion per year, which would be used for fisheries monitoring and protection, and for the creation of alternative livelihood sources. Additional fish demand would be met mainly from aquaculture, in which relatively modest public investment would trigger large private investment commitments. A similar amount of public investment would be required to protect forests from unauthorized or unplanned conversion, to manage wild food sources in forests, to develop alternative livelihood opportunities for food-insecure forest-dependent populations, and to minimize and offset the negative consequences of converting forest to agricultural land (Schmidhuber and Bruinsma, 2011).

Transitioning to sustainable and resilient production methods

Investing in food and agriculture systems is not enough. It will also be important to transition towards types of food production systems that will be less vulnerable to the risks outlined in the previous working paper, as well as more capable of effectively responding to the risks without loss of food security. This means adopting farming, fishery and forestry systems that are more resilient to climate change and, in particular, extreme weather variability. It means managing land, water, biodiversity and ecosystems in ways that enhance their long-term productivity rather than depleting them – i.e. building natural capital instead of spending it. But it also means reducing the external polluting effects of agriculture, especially in the form of greenhouse gas emissions.

FAO has identified sustainable crop production intensification (SCPI) as one of its strategic objectives. Ecological intensification has been defined as producing more from the same area of land while reducing negative environmental impacts and increasing contributions to natural capital and the flow of environmental services. To achieve this, FAO has endorsed an “ecosystem approach”, which means using inputs such as land, water, seed and fertilizer to complement the natural processes that support plant and animal growth. A range of farming practices and technologies, often location specific, have been developed, drawing on five broad types of practices (FAO, 2011c).



Box 12. Transitioning to climate-smart agriculture to improve resilience

Climate-smart agriculture seeks to increase productivity and food security sustainably, strengthen farmers' resilience to climate variability and change, and reduce and remove greenhouse gas emissions. One of the main features of climate-smart agriculture is increasing resilience in agricultural production systems to climate shocks such as drought and flooding. FAO (2010c) highlights many different examples of how this can be accomplished in differing situations. For example, improving soil quality is one of the fundamental activities of climate-smart agriculture, as higher quality soils are better able to retain moisture and reduce runoff – two important features for responding to drought and flooding (FAO, 2009c).

- **Soil fertility.** Building soils with a high content of non-living soil organic matter, a rich diversity of its biota, good physical structure and adequate crop nutrients through a combination of organic nutrient inputs and judicious use of mineral fertilizers.
- **Farming systems.** Implementing agro-ecological approaches that minimize soil disturbance by mechanical tillage, enhance and maintain organic matter cover, and diversify plant species in associations, sequences and rotations, and integrate them with livestock.
- **Seeds and breeds.** Improving the conservation and use of genetic resources, and developing crops and varieties that are more resilient to climate extremes, pests and diseases, less dependent on external inputs and better adapted to ecologically based production practices. Utilizing publicly funded research, local seed and breed delivery systems and the private sector to disseminate new or improved varieties to farmers.
- **Water management.** Increasing soil moisture conservation in rainfed systems by building soil health, expanding use of water harvesting and retention structures on farms, rehabilitating and constructing irrigation systems, and improving water-use efficiency in irrigated systems (where the natural resource base is not already constrained).
- **Plant protection.** Tackling pests through an ecosystem approach that relies as much as possible on natural predation, other natural control mechanisms, diversity and resistance, with judicious use of pesticides, i.e. integrated pest management.



Agro-ecological approaches can also be used to increase the resilience of livestock systems. Pastures occupy approximately 3.5 billion hectares or 69 percent of total agricultural land, and the sector accounts for 40 percent of agricultural GDP. Degraded grasslands can be restored through better management practices – such as use of rotational grazing, the reintegration of crop and livestock activities or agroforestry systems – while animal productivity can be increased through better genetics and the application of better animal health systems and procedures (FAO, 2009b; FAO, 2011c). Other opportunities include the integration of aquaculture with irrigated agriculture. For example, the integrated fish and rice fields in Laos are responsible for about 50 percent of all fish consumed by rural households and, at the same time, provide benefits such as pest management, weed control, maintenance of biodiversity and reduction or elimination of chemical pollutants (FAO/LARReC, 2007).

Diversification will be a key feature of resilient and sustainable production systems. Biodiversity serves as insurance against environmental changes by increasing the system's adaptive capacity. Agro-ecosystems that produce a diverse range of food types in an integrated way will be more resilient to pests, diseases and climatic fluctuations (Lin 2011; Perrings, 2006). Dietary diversity is also essential for food and nutrition security. Initiatives aimed solely at increasing production and increasing energy intake will not reduce malnutrition as effectively as those that also recognize the importance of dietary quality and diversity. Foods sourced from animals, including fish, and legumes, fruits and vegetables are all important components of a nutritious diet. Thus, the agricultural sector can contribute to nutrition security by investing in small livestock and poultry ventures, sustainable aquaculture and horticulture, alongside staple crops. This will also help to diversify sources of income for farming households, another proven risk-reduction measure.

There are many synergies between the goals of environmental sustainability, food security and economic development – potentially “win-win-win” scenarios. For example, many options for agricultural mitigation of climate change, particularly those that involve soil carbon sequestration, also benefit adaptation, food security and development. Efforts to increase levels of soil organic matter translate into better plant nutrient content, increased water retention capacity and better structure, eventually leading to higher yields and greater resilience (FAO, 2009a).



Managing links between energy and food markets

The ever closer integration of food markets with energy markets increases the risk that shocks may be transmitted from one to the other. Therefore, insulating food systems from volatility on energy markets will help increase stability. This means addressing the cost side – energy-intensive inputs – and the demand side – biofuels.

Reducing agriculture's dependence on energy-intensive inputs can be achieved through the same conservation and agro-ecological approaches described in the previous section. Farming systems that make better use of manures, legumes, crop residues or agroforestry to maintain soil nutrient levels will have less need for nitrogen-based fertilizer. No-till systems will require less fuel for tractors. More efficient use of water in irrigation systems will reduce fuel use for groundwater pumping. A key goal of these agro-ecological approaches is to increase the energy efficiency of agriculture, making maximum use of solar energy rather than fossil fuel inputs while enhancing soil fertility (Pretty, 2006). For small-scale farmers in developing countries faced with lack of capital and low product prices, recycling nutrients as efficiently as possible is a necessity (Zundel *et al.*, 2008).

Higher and more volatile energy prices will tend to encourage farmers to increase their energy efficiency as a matter of course. But public subsidy programmes for agricultural inputs can shield farmers from these price signals, and instead place the burden of higher energy costs on government budgets. For example, in 2008 the rapid ascent in international fertilizer prices caused the agricultural subsidy bill in India to balloon to over USD 30 billion, which was almost 2 percent of GDP (ICIS, 2011). Subsidy programmes should be designed to discourage wasteful use of energy, to promote recycling of agricultural biomass and, ultimately, to encourage a shift away from reliance on fossil fuel-based inputs.

On the demand side, a number of measures have been proposed to reduce the pressure on food markets from biofuels. In a joint paper for the G20, a number of multilateral agencies³⁴ recommended that governments remove provisions of current national policies that subsidize (or mandate) biofuels production or consumption. They also recommended opening international markets so that renewable fuels and feed stocks can

34 FAO, IFAD, IMF, OECD, UNCTAD, WFP, the World Bank, the WTO, IFPRI and the UN HLTF.



be produced where it is economically, environmentally and socially feasible to do so while accelerating scientific research on second-generation biofuels that would compete less with food (FAO *et al.*, 2011).

Although the link between food and energy markets poses a risk to food security, it is also possible to envisage a scenario under which bioenergy provides an opportunity to smallholder farmers and contributes to poverty alleviation. There are a number of examples of integrated food-energy systems that simultaneously produce food and energy, either by growing food and energy crops on the same land as in agroforestry systems, or by using food residues to produce energy as with biogas digesters. This reduces farmers' reliance on fossil fuel energy. Bioenergy can also lead to new farm revenues, where there is an energy surplus that can be sold into markets. In addition, by providing a sustainable source of energy, it can take pressure off surrounding forests and reduce the degradation of ecosystems (FAO, 2010c)

If the link between energy and food markets is managed carefully, the bioenergy sector could absorb agricultural surpluses during times of over-production, thus assuring farmers more stable revenues, and release stocks during times of under-supply, thus reducing pressure on food prices. In this way, the bioenergy sector could act as a buffer between food supply and food demand, potentially *reducing* food price volatility. However, this will only work if policy-makers treat food security as a higher priority than energy consumption at all times, and if private bioenergy companies are able to maintain profitable operations in the face of potential fluctuations in supply. Along these lines, some experts have proposed measures that would divert foodstuffs from the biofuels sector when food prices rose beyond a certain level. This could be done by governments temporarily withdrawing biofuels mandates and subsidies once a pre-defined limit – for example a price or inventory level – had been surpassed (FAO *et al.*, 2011). Another proposal (Wright, 2010) is for governments to purchase call options on grain from biofuels producers which would be triggered once an indicator of food shortage had been reached, thus freeing up more stocks. Further work is needed to devise workable policy mechanisms that ensure that bioenergy plays a positive role in global food security.



Box 13. National Biogas Programme, Viet Nam

Viet Nam embarked on an integrated land management scheme after giving land rights to individual farmers. This is supported by the Vietnamese Gardeners' Association (VACVINA), which works at all levels to promote the VAC integrated system – combining gardening, fish rearing and animal husbandry – to make optimal use of the land.

Traditional fuels such as wood and coal for cooking are becoming increasingly scarce and expensive, and can contribute to deforestation. Increasing livestock production in rural communities with high population density leads to health and environmental issues due to the quantity of animal dung produced. Biogas digesters, part of the solution offered by this initiative, use the waste to generate energy and the resultant slurry as a fertilizer to improve soil quality.

A market-based approach has been adopted to disseminate the biogas digesters, and the service provided to those buying the biodigesters is comprehensive. The customer must have at least four to six pigs or two to three cattle that provide the animal dung. They pay the total installation cost for the digesters to local service providers who provide them with operating instructions. A biodigester produces enough daily fuel for cooking and lighting. It improves the surrounding environment, while livestock produces meat, milk and fish products for local consumption and subsistence farming (FAO, 2010d).

Improving the functioning of food markets

Due to their nature, agricultural commodity markets are bound to experience a certain amount of variability, with occasional upward price spikes more likely than severe price troughs. However, the imperfect functioning of global markets has undoubtedly magnified price volatility in the period since 2006. This has had devastating effects on the world's poor, while also creating fiscal and monetary problems for governments. As a result, there has been much recent study on possible ways to improve the functioning of global food markets with the aim of reducing volatility.

Although debate continues, there are reasons to suspect that many of the proposals put forward to control food prices on global markets are unlikely to be effective. International



buffer stocks are expensive, they are vulnerable to speculative attack, and they require collective international action. When attempted in the past, they have tended not to work. “Virtual” reserves – created by governments participating in the futures markets – may be counterproductive and hand more profits to speculators. There are also a suite of national policies that can be used to control volatility – tariffs, export and import restrictions, price controls, intervention buying, rationing, user subsidies, deficiency payments – but all come at an economic cost and many create unintended consequences (FAO *et al.*, 2011; Tangerman, 2011). Instead, attention has focused on three possible measures that could help reduce market volatility, namely reforming trade rules, widening and deepening markets, and improving transparency.

Reforming trade rules

As already explored, the trade and subsidy policies of large countries are pro-cyclical, depressing world prices further when prices are low and pushing world prices up even further when they are high. The imposition of export restrictions – by developing as well as developed countries – can be particularly damaging, leading to panic on world markets and extracting a significant cost from food importers.

The World Trade Organization (WTO) Agriculture Agreement, and subsequent talks on agricultural trade as part of the Doha Round, took place against a backdrop of structural over-production, persistently low food prices and concerns over the dumping of subsidized products on world markets. Now, in a time of rising and volatile prices exacerbated by export restrictions, priorities are very different (HLPE, 2011). There is a need to draw up an entirely new agenda for trade talks, which includes a greater emphasis on safeguarding the needs of food insecure and food importing countries. In a joint paper for the G20, a number of multilateral agencies urged countries not to impose food export restrictions without carefully considering the consequences for global food security and called for the strengthening of existing WTO rules on the use of export restrictions in times of emergency. At a minimum, it was proposed that emergency food aid, as needed by the World Food Programme (WFP) for example, be made exempt from export restrictions (FAO *et al.*, 2011).

At the same time, it is also important to recognize the rights of less developed countries to special and differential treatment in relation to import policies. As this paper has already argued, in the future it will make sense for many developing countries to be more active in



developing their domestic agricultural sectors, for reasons of food security and economic development. This may require tariffs and other trade policy measures, in particular to prevent dumping of food products by other countries during times of low prices (HLPE, 2011).

Widening and deepening markets

Food markets in many developing countries do not function smoothly, because of poor infrastructure, weak institutions and a lack of appropriate regulation. Improving the functioning of domestic markets will smooth variability, facilitating the transfer of food surpluses across geographies and the management of price fluctuations over time. In particular, it will be important to develop agricultural markets and value chains that allow smallholders to participate. This may mean lowering transaction costs through aggregation (FAO, 2011c). Developing countries should also be helped to set local commodity exchanges, including derivatives or futures markets (Tangerman, 2011).

New instruments for mitigating commodity price risk exposure might be explored. A market approach to price volatility involves setting up structures and institutions which allow governments and supply chain intermediaries to cope with price volatility instead of attempting to reduce or eliminate this volatility (Gilbert and Tabova, 2011). For example, a global wheat contract that would specify export delivery points in the major producing regions has been proposed. This would identify “cheapest to deliver” sources by designating delivery points all over the world and act as a global signalling system of both price and regional supply availabilities. Developing countries could enter into futures contracts, or purchase options on the basis of this instrument, which would allow them to lock in a price for future food imports and therefore manage fiscal risks. As part of this, an international grain clearing arrangement could be set up to eliminate counterparty risk for developing countries. It would hold a certain amount of food in reserve and ensure that physical delivery of food could be made in a crisis (FAO *et al.*, 2011; Tangerman, 2011). Such proposals, which require further study, could help ensure that global commodity derivatives markets work to the advantage of low income, food importing nations.



Information and transparency

A lack of reliable and up-to-date information on supply, demand and stocks contributed to recent price volatility on food markets. An FAO proposal to establish an agricultural market information system was approved at a G20 meeting of agriculture ministers in June 2011. Under this system, governments will commit to provide timely and accurate data on food production, consumption and stocks. International organizations will undertake monitoring, reporting and analysis of current conditions and policy developments in major markets. A rapid response forum will be set up, with broad involvement of countries, to promote policy coherence and coordination in times of crisis. Finally, international organizations will support the improvement of national or regional monitoring systems, in order to enhance early warning systems in vulnerable developing countries and regions (FAO *et al.*, 2011).

The transparency of commodity future markets should also be enhanced. One of the reasons for the lack of consensus over the role of speculation in recent price volatility is that our understanding of the behaviour of futures and options exchanges, and the way they affect “real world” prices, is very limited (Tangerman 2011). There are grounds to suspect that the financialization of commodity markets has exacerbated price volatility, without making much useful contribution to the commerce of food (HLPE, 2011). In order to improve understanding of the interactions between speculation and food prices, greater transparency is needed, especially with regards to over-the-counter markets, where transactions take place off the regulated commodity exchanges (HLPE, 2011; UNCTAD, 2011). Once these interactions are better understood, there may be a case for strengthening regulation of commodity future markets.

On a broader level, climate science can play an important role in improving the stability of food systems. Better data and tools are needed for making seasonal and intraseasonal weather predictions and providing usable advice to farmers and policy-makers. Localized, farm-level risk management systems, incorporating climate, crop and economic data, could give local communities “advisories” on decisions such as the appropriate crops to plant, the timing and quantity of inputs, management practices, the timing of harvests, and storage strategies. At a global level, climate science, supported by satellite data, can help provide early warning of food security crises and humanitarian crises (Selvaraju *et al.*, 2011).



Box 14. The G20 and the AMIS system

Recognizing the importance of timely, accurate and transparent information in helping to address food price volatility, the G-20 (which includes 19 countries and the EU) launched the Agricultural Market Information System (AMIS) in June 2011. The main purpose of AMIS is to improve the quality, reliability, accuracy, timeliness and comparability of data on agricultural markets.

The experience of the 2007–08 food price crisis and the current excess price volatility in many international food markets have exposed weaknesses in the provision of market information at the global level but also in the coordination of policy responses to food price volatility. AMIS will be building on and complementing existing systems, working to improve global market information; policy guidance could be achieved through a collaborative food information and policy initiative.

Through its comprehensive coverage of major global food markets and its close monitoring of prices in combination with food security assessments across vulnerable countries, AMIS will also provide a mechanism for global early warning.

AMIS will involve a number of international and intergovernmental organizations that have capacity to collect, analyse and disseminate information on a regular basis regarding the food situation and outlook, the major producing and consuming countries, as well as commercial enterprises. It can make a significant improvement in the ability to monitor world food markets through improving collaboration and the synergies within a key set of major producing and consuming countries. For food crops as rice, wheat, coarse grains and soybeans, access to better information on production in a few countries can go a long way toward helping to understand market trends at the global level. For instance, in the case of wheat and rice, less than ten countries account for over 90 percent of world production.

Participation in AMIS is open to all countries. However, early efforts would focus on the main market players which account for the greater part of world food production, consumption and trade (FAO *et al*, 2011).



Building safety nets for the most vulnerable

The measures outlined so far will go a long way towards increasing the stability of food systems. But they will not remove variability altogether. Prices in agricultural markets will continue to move erratically, and food production will inevitably rise and fall due to climatic fluctuations. Therefore, in addition to markets, it is just as important that people are able to cope with variability which, as this paper maintains, can best be achieved by having sufficient income or wealth, i.e. a personal “safety net”. This reinforces the importance of investing in smallholder agriculture to set in train a positive cycle of rural and national economic development. However, public safety nets also must be present to provide security for the poor and vulnerable. As recent research suggests, public safety nets can play an important role in enabling the poor to make productive investments that generate long-term benefits in terms of poverty reduction and environmental management (see Box 15).

Box 15. Social safety net cash transfer programmes

Most safety net programmes seek to reduce poverty and vulnerability by improving food consumption, nutritional and health status and school attendance through the regular provision of cash.

Cash transfers influence the livelihood strategies of the poor, who in rural areas usually depend on smallholder agriculture. Cash transfers programmes often operate in places where markets for financial services (credit, savings or insurance), labour, goods and inputs are missing or do not function well. Beyond injecting resources into the local economy, cash transfers can thus relax credit and liquidity constraints, allow households to take more risk and influence social networks of reciprocity.

These impacts are manifested through changes in household behaviour, which can include: i) reallocation of household labour; ii) investments that improve income-generation capacity; iii) investments that improve natural resource conservation, and iv) changes in risk management, including adopting more profitable production strategies, avoiding detrimental risk-coping strategies (distress sales, school dropouts) and decreasing risky





income-generation activities (commercial sex, begging and theft). Safety net programmes also benefit the local economy, as there are multiplier effects via local goods and labour markets, and there are transfers between beneficiary and ineligible households, which can relieve pressure on existing social reciprocity networks.

Some programmes, such as the Productive Safety Net Programme (PSNP) in Ethiopia and the Vision 2020 Umurenge Programme (VUP) in Rwanda, explicitly recognize some of these linkages. The goal of the PSNP is to reduce the number of Ethiopians suffering from extreme hunger, malnutrition and poverty and to lead to the rehabilitation of the environment by strengthening soil and water conservation and making agriculture more productive and sustainable. The PSNP provides cash to beneficiaries under two modalities: the large majority participates in labour-intensive public works projects, while direct support is given to labour-constrained households who cannot undertake public works. The public works component of the PSNP, when regular and predictable, has been shown to lead to modest improvements in the food security status of beneficiaries, including livestock accumulation and the ability to deal with emergencies. Combining the public works component with a package of agricultural support, such as irrigation or seeds, increased these impacts and, moreover, led to large increases in agricultural productivity (Gilligan *et al.*, 2009).

Most social safety nets do not explicitly make these linkages, but still have been shown to have significant impacts on beneficiary productive activities. For example, the objective of the Malawi Social Cash Transfer Scheme is to reduce poverty, hunger and starvation, and improve school enrolment and attendance and the health and nutrition of children among the poorest 10 percent of households in Malawi. However, cash for household consumption also plays an important role building up the productive capacity of poor households, most of whom are dependent on subsistence agriculture. The programme was found to increase investment in agricultural assets, including crop implements and livestock. Beneficiary adults reduced involvement in low-skilled labour outside the home, children worked less outside the home, and both adults and children spent more time on household farm activities, leading to increasing their own farm agricultural production and consumption. The programme also reduced household vulnerability to shocks, with reduction detrimental risk coping strategies, such as taking children out of school (Boone, *et al.*, 2011; Covarrubias, *et al.*, 2011).



National programmes

Safety nets play a number of different roles in terms of stability of food security. Most safety net programmes seek to reduce poverty and vulnerability by improving food consumption, nutritional and health status and school attendance through the regular provision of cash. Not only do safety nets reduce poverty and vulnerability; if regular and predictable, they can change attitudes towards risk.

Safety net schemes can include cash transfers, in-kind transfers (e.g. of food), public works programmes, food stamps and mother-and-child health and nutrition programmes. They often work best when they target women. A large body of evidence suggests that the greater the degree of control exercised by women over the family income, the greater the proportion of income spent on food (IFAD, 2011). Because they targeted the poor, they are more affordable than economy-wide subsidies. It is estimated that developing countries spend 1–2 percent of GDP on safety net programmes (Tangerman, 2011). But only about 750 million people worldwide have access to adequate social assistance schemes (Evans, 2011).

Effective schemes take time to set up and therefore should be started during “normal” times rather than during food crises. A case of “maximum synergy” is one in which safety nets and food assistance programmes, such as school lunches, are supplied with local production. Supplying safety nets with locally produced food whenever possible will lead to an expansion in market opportunities, farm output and employment, while providing food to those who need it (Stamoulis and Zezza, 2003). Although the design and establishment of safety nets is a complex and technical challenge, there is a vast literature on the subject based on hundreds of programmes that have operated worldwide over the past 50 years (Tiba, 2011).

Global safety nets

Although safety nets are national programmes, international cooperation can facilitate their operation. In times of crisis, contingent and compensatory financing facilities are important to assist countries in avoiding major fiscal deficits and lowering the cost of imported food, while maintaining key social assistance programmes. The World Bank’s Global Food Crisis Response Program, FAO’s Food Import Financing Facility, IMF lending facilities and bi-lateral aid programmes all played a role in helping to finance social safety nets during the recent food crisis (FAO *et al.*, 2011).



Market-based protection of a country against the impact of severe weather shocks, such as droughts, can also be achieved through the use of weather-index insurance. An index links rainfall and crop production, so that changes in weather will reflect the likely loss in production. Using such an instrument, if production is negatively impacted by a specified weather parameter, the country will receive a payout. The payout can be used to finance either food imports or social safety net programmes to ensure food security in the affected area. Weather-index insurance was first used in Malawi in 2008 and is still in operation (FAO *et al.*, 2011).

The World Food Programme (WFP) represents the safety net of last resort for millions of the most vulnerable and food insecure. During the market volatility of 2006–2008, the WFP sometimes struggled to purchase food for its programmes because of higher prices and because of restrictions put in place by exporters. It was forced to appeal for additional funds, which slowed its response. WFP is seeking to develop a cost-effective system of small, strategically positioned emergency food reserves by the end of 2011. FAO and other multilateral agencies have called for the development of a code of conduct to ensure the free flow of humanitarian food supplies, to enhance responsibility and transparency, strengthen the global food security architecture and avoid negative effects on the market (FAO *et al.*, 2011; Gilbert and Tabova, 2011). WFP funding must also be able to accommodate higher food prices, as it is during times of high prices that WFP assistance is often most needed.

International food aid can provide relief to the most vulnerable in times of crisis. Under the 1999 Food Aid Convention, there is a commitment to provide assistance to meet the annual food needs of approximately 23 million people. In the past, food aid has been used to dispose of the structural surpluses of developed countries. If poorly designed, food aid programmes can inhibit the development of agriculture in recipient countries and create dependency (Konandreas, 2011). Instead, programmes should be used to encourage the resumption and expansion of local production as soon as possible, using sustainable and resilient approaches. The 1990 Comité permanent Inter-Etats de Lutte contre la Sécheresse dans le Sahel (CILSS) Food Aid Charter, which is currently being revised, provided an example of a code of conduct for food crisis prevention and management (OECD Web site; Oxfam/Save the Children, 2008).



Policies, institutions and finance

Barriers to implementing suggested measures

The measures described in the previous section would go a long way towards reducing and containing future threats to the stability of the global food system within the context of a green economy. Yet, the difficulty of implementing such measures should not be underestimated. Although the theory may be compelling, the practice often looks different. Where such measures have been adopted it has often been on a small scale, with special support, and the challenge of scaling them up remains. Doing this will mean overcoming three barriers.

Shifting to more sustainable and resilient food production systems can involve losses and risks in the short-term, before the full benefits are realized. An FAO analysis of food security and climate adaptation options found that most of them strengthened resilience and increased food production in the long term, but this sometimes came at the price of reduced productivity (for example, through lower cropping intensity) in the early years, which could threaten household food security. Moreover, almost all the options required some sort of upfront investment. For example, the establishment of new irrigation schemes or soil and water conservation structures require relatively high upfront costs in terms of labour or machinery (FAO, 2009a). In addition, agro-ecological farming systems are knowledge-intensive and may require considerable education and demonstration. These high transition costs, together with the risks that accompany major changes, can act as a strong disincentive for farmers. Therefore, new extension, financing and risk reduction mechanisms will be needed to encourage large-scale adoption of new practices.

Improving the functioning of global markets requires collective action by many countries. The recent histories of WTO and UN Framework Convention on Climate Change (UNFCCC) talks indicate the limits to collective action that exist within the current system of global governance. Countries should continue to strive to improve global food governance through the UN system and other institutions such as the WTO and G20 process, as this will produce the greatest welfare benefits for all participants. But governments will also need to develop plans on the basis of current realities. This may mean a greater emphasis on national or regional policies to reduce risks emanating from global food markets, including a greater focus on self-sufficiency.

Many of the problems and solutions sit within the context of broader developmental challenges. Improving the productivity of smallholder agriculture, building functioning



domestic markets and putting social safety nets in place will require new forms of policies, institutions, finance and governance in the least developed countries, as part of an accelerated development process. There are many examples of countries that have successfully followed this path, but there are other examples of countries that have remained in “protracted crisis” for some time, despite the best efforts of domestic leaders and international partners (FAO, 2010a).

Policies and institutions

Building the resilience of food systems will require changes to policies and institutions at a national and global level.

National policies

The most important changes will occur at the national level. Although global markets can be the source of much instability in food systems, governments can do much to increase their countries’ resilience. The first step will be to assess the risks to a country’s food stability based on its unique circumstances. Every country will need to design its own comprehensive food security strategy (HLPE, 2011). The second step will be to institute an integrated development approach that establishes linkages among policies for food, energy, trade, economic growth and the environment. This level of integration may be lacking at the moment. For example, in the case of African countries, it has been noted that agricultural development and investment strategies developed under the Comprehensive African Agricultural Development Programme (CAADP) umbrella are not always consistent with plans put forward for climate change adaptation and mitigation (FAO, 2010c).

In many countries, a keener focus on risk and resilience may lead to reform of subsidy policy. As already discussed, biofuels policies have had unintended consequences for the world’s poor and require adjustment. In addition, policies that subsidize inputs or energy should be carefully examined. They deliver short-term productivity improvements but, when poorly designed, can pose long-term sustainability challenges by encouraging environmentally-harmful practices (FAO, 2011c). And, although they remove the risk of energy price shocks from farmers, they may simply transfer this risk to the government, which can have major fiscal implications during times of volatility in energy and food markets.



International policies

Coordinated international action should be taken to improve the functioning of global food markets. This means removing trade-distorting tariffs, subsidies and restrictions in some countries, but allowing poor countries the freedom to manage trade if necessary; regulating commodity derivatives markets; creating risk mitigation instruments for developing countries; and improving transparency and the flow of information on food trade and availability (as previously detailed). Biofuels mandates and subsidies should be examined, to ensure they do not jeopardize the food security of the world's poor. Through development assistance and specialist food security programmes, support should be given to developing countries to implement measures that will improve the resilience of their food systems. Agriculture should be fully integrated into multilateral environmental policies, in particular climate change mitigation and adaptation mechanisms with the UNFCCC. The newly-reformed Committee on World Food Security can play an important role in ensuring that food security is taken into account in a range of international policies and institutions.

Box 16. Strengthening governance of food security and nutrition through CFS

The Committee on World Food Security (CFS) was established in 1974 as an intergovernmental body to serve as a forum in the United Nations System for policies concerning world food security, including production, and physical and economic access to food. During 2009, the CFS underwent reform to make it more effective by including a wider group of stakeholders and increasing its ability to promote policies that reduce food insecurity. The vision of the reformed CFS is to be the most inclusive international and intergovernmental platform for all stakeholders to work together to ensure food security. The key roles for CFS are:

- to enhance global coordination of food security and nutrition actions by stakeholders;
- to strengthen policy convergence, and
- to facilitate support and advice to nationally-owned and regional food security and nutrition plans.



Finance and investment

Investment in agriculture in developing countries has long been neglected. The share of public spending on agriculture has fallen to an average of around 7 percent in developing countries (even less in Africa) and the share of official development assistance going to agriculture has fallen to as little as 3.8 percent. Commercial bank lending to agriculture in developing countries is also small – less than 10 percent in sub-Saharan Africa (FAO *et al.*, 2011). This trend will need to be reversed if hunger is to be eliminated and rising demand met through sustainable agriculture and sustainable food systems. The most important measure for increasing food security stability will be to invest in the development of smallholder agriculture in the least developed countries. This will require investment in, *inter alia* infrastructure, storage, research, extension and mechanization. Further details on the scale of investment needed can be found above.

Encouraging farmers to use more sustainable, resilient and resource-efficient agricultural practices will require more targeted support. As mentioned, transitioning to these systems can entail significant transactions costs and risks, before benefits are realized. Mechanisms will be needed to create the incentives for farmers to embark on these changes. Payment for ecosystem services (PES) schemes can play a role: for example, in Colombia, Costa Rica and Nicaragua, farmers are being paid to implement silvopastoral approaches that restore degraded pastures and reduce deforestation (FAO, 2007). Emerging sources of finance related to environmental benefits can support the transition to more resilient forms of agriculture.

It should also be remembered that the bulk of financing for food systems will come from private sources, which includes everyone from smallholders to large agribusinesses and financial institutions. Public money should be used in such a way that it leverages much larger flows of private investment. Through subsidies and other policies, the government's task is to price environmental externalities and correct market failures so that the economic incentives of private actors are consistent with the transition to sustainable and resilient food systems. In this case, downstream companies in the food supply chain (such as processors or retailers) may play important roles in supporting stability throughout the chain, as stable supplies are a prerequisite for their business operations.



Box 17. Linking and leveraging alternative sources of finance to support the GEA transition

New sources of public and private finance will be needed to support the transition to more resilient and sustainable agricultural systems. Climate finance is one of the most important with potential financing for both mitigation and adaptation-related activities. Under the Cancun Agreement of the UNFCCC reached in December 2010, developed countries committed to mobilize new and additional resources approaching USD 30 billion for the period 2010–2012 and USD 100 billion annually by 2013 (UNFCCC Decision 2/CP.15, para 8). This same agreement established the Green Climate Fund (GCF) as a financial mechanism under the Convention. There is still considerable uncertainty as to how this fund will operate, and potential channels for financing to agriculture in developing countries are yet to be established. One promising avenue is through Nationally Appropriate Mitigation Actions (NAMAs), which are voluntary mitigation actions proposed by developing countries (Meridian Institute, 2011).

Aside from climate finance, there is a range of public and private sources of financing emerging for environmental services such as biodiversity conservation, watershed protection and the restoration of degraded land. The Global Environmental Facility (GEF) is the financial mechanism that assists developing countries in meeting the objectives of international environmental conventions, including the UNFCCC, the Convention on Biological Diversity, the Stockholm Convention on Persistent Organic Pollutants and the Convention to Combat Desertification. The GEF Trust Fund has recently been replenished to a total of USD 4.25 billion to fund GEF projects for the period July 2010–June 2014.

These additional sources of potential financing represent a relatively small share of the estimated investment requirements (FAO, 2009a); thus their most important role will be in leveraging additional funds. There are various mechanisms for channelling these types of finance to the agricultural sector in developing countries. Direct payments for environmental services supplied by farmers are one option, although this entails significant transactions costs (FAO, 2007). Another option is to finance institutions and policies needed to achieve resilient and sustainable development, such as safety nets, insurance programmes or extension systems. Finally, support for the adoption of sustainable development policy and measures (SD-PAMS) is another option that has received much attention in the context of the UNFCCC negotiations.

Source: Vernooy, 2003



Box 18. Linking farmer's knowledge to plant breeding programmes

Together with Syria and other Middle East and North African countries, the International Center for Agricultural Research in the Dry Areas (ICARDA) has undertaken a programme of participatory plant breeding which maintains high levels of diversity in the breeding programme and produces improved material capable of good yields in conditions of very limited rainfall (less than 300 mm per year). Following crosses made on-station, based on collaborative selection of parental materials, a bulk pedigree system is used and F3 materials are tested by farmers. In Syria, the procedure has produced significant yield improvements and increased the resistance of the varieties to drought stress.

Research and technology

Investment into agricultural research and technology development is a fundamental requirement for achieving more resilient and sustainable production systems. Yet in most cases, public support has significantly declined in recent decades. Reversing this neglect is thus an important priority. Shifting the focus of agricultural development from maximizing productivity to reducing risk and improving resilience has some important implications for priority setting in agricultural research and technology development. It will require paying greater attention to identifying the resilience of varying systems over a range of agro-ecological and socio-economic conditions. Equally important will be assessing the potential trade-offs between risks and returns to agricultural production strategies, and better incorporating them into agricultural development planning and investments.

There should be a greater focus on the development of technologies for low-input food production systems in low potential or marginal areas, which are home to hundreds of millions of the poorest and most food insecure people. Developing and disseminating improved and adapted plant varieties and animal breeds is key, particularly in response to climate change. There is a huge, but underutilized potential to link farmers' traditional knowledge with science-based innovations, and to increase the participation of farmers in conservation, crop and breed improvement, and the maintenance of seed supply systems (FAO, 2011c).



Agricultural biotechnologies can play an important role as well. These technologies cover a wide range of functions such as the use of: molecular marker-assisted selection (MAS) to speed the development of improved varieties; molecular markers to identify priority genetic resources for conservation; tissue culture to overcome reproductive barriers; and biotechnologies for disease diagnosis and vaccine development to assist in reducing economic losses due to debilitating diseases (Lidder and Sonnino, 2011). An international technical conference on agricultural biotechnologies in developing countries held by FAO in March 2010 recognized this potential, with member states calling on developing countries and international organizations such as FAO to increase capacity for the development of agricultural biotechnologies to support smallholder agriculture.

While more work on developing technologies to support resilient and sustainable production systems is needed, an equally important issue for research is to improve understanding of why existing and known practices that meet these objectives are not more widely adopted, and to develop appropriate responses. More effective extension systems will play an important role. In recent years, FAO has promoted Farmer Field Schools (FFS) as a participatory approach to farmer education and empowerment. The aim of the FFS is to build farmers' capacities to analyse their production systems, identify problems, test possible solutions and adopt appropriate practices and technologies. Field schools have been very successful in Asia and sub-Saharan Africa, notably in Kenya and Sierra Leone, where they cover a broad range of farming activities, including marketing, and have proven to be sustainable even without donor funding (FAO 2011c).



Working Paper 4

Improving food systems for sustainable diets in a green economy





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Executive summary

The world is producing enough food to feed all its population. Yet almost one billion people go hungry. Two billion are malnourished, lacking the essential micronutrients they need to lead healthy lives. One billion adults are overweight and almost half a billion are obese. These figures show profound imbalances in consumption and diets.

The green economy aims to improve human well-being and social equity, while significantly reducing environmental risks and ecological scarcities. As such, it also aims to reduce these imbalances. Malnutrition, in all of its forms, places an intolerable burden not only on individuals and national health systems, but on the entire cultural, social and economic fabric of nations. It represents one of the greatest – and most preventable – impediments to the fulfilment of human potential. Improving nutrition and food utilization is a key tool to ensure sustainable development.

Improving nutrition and food utilization is also in itself an important mark of the achievement of sustainable development objectives. Indeed food consumption trends and patterns and related agricultural production trends and patterns are identified as one of the most important drivers of environmental pressures, especially habitat change, climate change, water use and toxic emissions of pollutants. Population and income increase, as well as urbanization, are driving increased food and feed demand. Because of that, and also to respond to other trends such as urbanization and globalization, food systems are already suffering profound changes worldwide.

It is necessary to address the needs of a growing world population, richer and more urbanized, while at the same time preserving resources. Food utilization, if pushed towards more sustainable diets, should be seen as a main lever to orient the evolution of food systems towards more efficiency in the use of natural and productive resources. Directions of the needful evolutions include:

- preserving traditional food systems, often more balanced, from the threat of environmental degradation and economic and social changes;
- promoting food-based approaches for improving nutrition and health as compared to more expensive and non-sustainable supplementation programmes;
- grounding nutrition in agricultural systems, using diversified crops and local varieties rich in micronutrients to improve diets;
- improving the efficiency of food chains to feed the increasing urban population;
- reducing the extent of food losses before consumption, particularly in developing countries.



Sustainable consumption is a powerful driver of Green Economy, to reduce ecological scarcities and improve social equity, between consumers and also between nations. It involves harnessing global demand by promoting more sustainable diets in rich countries, where reducing waste at consumer level should be a priority. Voluntary sustainability standards can help sustainable consumption drive sustainable production and create value for producers. Well managed, they can become tools participating to the empowerment of smallholders to access global markets. The transformation of food systems towards sustainable diets is an essential part of the green economy. It offers vast economic and social opportunities, while preserving natural resources. It requires enabling policies and investments and a strong involvement of the private sector. Giving its true value to food – nutritionally, economically and symbolically – could be a core principle of the green economy, driving development especially in rural areas and developing countries.

Introduction

The world is producing enough food to feed the entire world's population. Yet almost one billion people go hungry. Another billion are malnourished, lacking the essential micronutrients they need to lead healthy lives. One billion adults are overweight of which almost half a billion are obese. The imbalances in consumption and diets are profound.

Food utilization, an essential dimension of food security, refers to how humans use food's various nutrients. General hygiene and sanitation, water quality, health care practices and food safety and quality are all determinants of food utilization. Adequate intakes of energy and nutrients by individuals is the result of access to, and consumption of, foods that are adequate in quantity (calories) and quality (variety, diversity, nutrient content and safety) for a healthy diet conditioned by household food and nutrition security as well as by good care and feeding practices, food preparation, and appropriate intrahousehold distribution of food. While food security has traditionally been measured as sufficient food energy and protein, the term "food and nutrition security" makes explicit the importance of the quality of the food supply not just calories and in addition to calories also looks specifically at proteins, fats, micronutrients and trace elements needed for a healthy diet. Solving the problems of hunger and malnutrition requires more than just producing more food, and more than ensuring physical and economic access to enough food. It requires that foods be also properly used by the body for good nutrition.



Malnutrition, in all of its forms, places an intolerable burden not only on individuals and national health systems, but also on the entire cultural, social and economic fabric of nations. It represents one of the greatest – and most preventable – impediments to the fulfilment of human potential. Improving nutrition and food utilization is essential to ensure sustainable development. It is both a tool and an achievement for the green economy.

Good utilization, good nutrition and food security itself, are traditionally seen through a human lens that focuses on making the most of available and accessible food for a human living. But today, merely ensuring adequate nutrition is not enough to characterize proper utilization of food.

Food consumption trends and patterns and related agricultural production are also identified drivers of environmental pressures, especially habitat change, climate change, water use and emissions of pollutants. Increase in food and feed demand is directly linked to population and income increase. Increased urbanization will also profoundly change the very organization of food systems, in an increasingly globalized world.

This is why food systems have to be considered in their entirety, acknowledging the interdependency of sustainable consumption and production. A sustainable diets approach aims to address at the same time nutrition requirements, both in terms of energy and nutrients and resources used for food production, including local biodiversity, used to produce traditional and local foods with their many nutritionally rich species.

To address the food and nutrition needs of a richer and more urbanized growing world population, while preserving natural and productive resources, food systems have to undergo radical transformation, improving resource efficiency, improving the efficiency and equity in the consumption of food and transitioning towards sustainable diets.

Transformation of food systems is an essential part of the green economy. Not only because vast investments, both public and private are needed to achieve these transformations, but also because they are themselves an extremely powerful way of developing rural areas and creating added value along food chains while preserving resources, particularly in developing countries.

This paper first describes the economic, social and environmental impacts of production and consumption of food, underlining the challenges. Second, it identifies the main ways to address these challenges, examines how to harness the increased demand while adding value for producers and discusses how sustainable diets can be a driver of green economy. The final section envisages policy options for the sustainable consumption and production of good and healthy food within the context of a green economy.



Box 19. Food systems and food chains: definitions

A food chain is the sum of all processes involved in getting a specific food to consumers, and is often described by slogans such as “from farm to fork,” or “from fish to dish”. The sum of all food chains makes up a food system, which involves multiple food chains operating at global, national and local levels. Some of these chains are very short and not very complex, while others circle the globe in an intricate web of interconnecting processes and links. The main conceptual difference between a food system and a food chain is that the system is holistic, comprising a set of simultaneously interacting processes, whereas the chain is linear, involving a sequence of activities that must occur in order for people to obtain food.

Food systems encompass the ecosystem and all activities that relate to the production, processing, distribution, preparation and consumption of food. A food system also includes the inputs needed and outputs generated by each of these activities as well as their outcomes, insofar as they contribute to food and nutrition security. Such outcomes include food availability, access and use. A food system operates within, and is defined by, social, economic and environmental contexts. Interactions between and within those contexts influence both activities and outcomes (adapted from GECAF definition). Esnouf *et al.* (2011) distinguish various types of food systems (domestic, local, territorial, agro-industrial and quality differentiated) and call for assessment of their efficiency and sustainability.

A household food system comprises all of the food chains in which the households participates to meet its consumption requirements and dietary preferences and all of the interactions and feedback loops that connect the different parts of the chains. All households need resources that give them sufficient purchasing power to buy the food that they need but are unable to produce for their own.



Food systems need to change

Impacts of malnutrition and obesity

Undernourishment

According to the *State of Food Insecurity in the World 2010*, a joint report from the Food and Agriculture Organization of the United Nations (FAO) and the World Food Programme (WFP), the total number of undernourished people in the world was estimated at 925 million in 2010. While this figure was down nearly 10 percent from the number of undernourished people in 2009, due to the partial recovery of the global economy, it was still significantly higher than the level that existed in 1996 – 828 million – when the World Food Summit set a target to reduce the number of the world’s hungry by half by the year 2015. Developing countries account for 98 percent of the world’s undernourished people and, as of 2010, had a 16 percent prevalence of undernourishment. Again, this number was an improvement from the 18 percent estimated in 2009 but still well above the target set by the Millennium Development Summit in 2000, to reduce the proportion of people who suffer from hunger by half.

Sub-Saharan Africa has the world’s largest nutrition gap – defined as the difference between food that is available for consumption, and food that is needed for a healthy diet. The United States Department of Agriculture (USDA) estimates that 67 percent of the world’s current nutrition gap can be attributed to sub-Saharan Africa, a gap expected to increase.

Malnutrition

Malnutrition in its multiple forms causes widespread suffering in adults as well as in children. In children, malnutrition commonly leads to poor growth and reduced mental development, increased morbidity and, all too often, early death. According to the World Health Organization (WHO, 2000), malnutrition plays a major role in half of all under-five year old deaths in developing countries each year. In adults, it leads to lethargy, weakened immune response, frequent illness and poor health, decreased cognitive function, increased absenteeism, reduced ability to do work leading to the loss of earning and learning potential and reduced productivity. In pregnant women, it can lead to miscarriage, low birth-weight babies, and both maternal and infant death. Widespread hunger and malnutrition are severe impediments to social and economic development, at both the community and national levels.



Today, micronutrient malnutrition – often referred to as “hidden hunger” – affects around two billion people worldwide, more than one-third of the global population. These vitamin and mineral deficiencies, including iron, iodine, zinc and vitamin A, lead to poor physical growth and development, lowered mental capacities, reduced productivity, impaired immune systems and other health problems. Today, around 2 billion people are anaemic, mainly due to iron deficiency³⁵, 250 million children are at risk of vitamin A deficiency, a condition that can lead to blindness and early death, 800 000 childhood deaths can be attributed to zinc deficiency each year, 200 million people have goitre, and another 20 million are mentally retarded as a result of iodine deficiency.

In the most severely affected countries, individual productivity losses due to malnutrition are equal to 10 percent of lifetime earnings, resulting in gross domestic product (GDP) losses of up to 3 percent each year. In developing countries, one in three children under the age of five in 2010 (171 million children) is stunted due to chronic malnutrition, 55 million suffered from acute malnutrition and 104 million are underweight for their age. Close to 10 million children die before their fifth birthday every year as a consequence of malnutrition³⁶.

The cost of malnutrition includes direct costs, such as lost productivity, lost earnings and the medical costs of treating people suffering from malnutrition and associated diseases, as well as indirect costs, such as compromised cognitive and impaired physical development. FAO attributes up to 14 percent of lost productivity and earnings in adulthood to stunting in childhood.

While the cost of treating the effects of malnutrition, whether in fiscal, economic or human terms, is high, the prevention of malnutrition is much less expensive. Investing in nutrition, therefore, is not only a moral imperative, it also makes good economic sense as it reduces health care costs, improves productivity and economic growth, and promotes education, intellectual capacity and social development.

35 www.who.int/nutrition/topics/ida/en/index.html

36 WHO's global database on child growth and malnutrition, global and regional trend estimates for child malnutrition for 2010 (www.who.int/nutgrowthdb/estimates/en/index.html).



Obesity

Obesity has emerged as the most serious health concern of the twenty-first century and is the leading cause of preventable death. Complications from obesity include cardiovascular risks, hypertension, type 2 diabetes and impaired glucose tolerance, obstructive sleep disorder and orthopaedic complications (Barnes 2007). Once considered only a problem of high-income countries, obesity rates are rising globally and affect both developing and developed countries. A recent analysis by the International Association for the Study of Obesity estimated that approximately one billion adults are currently overweight and a further 475 million are obese. The same study found that 200 million school-aged children were overweight, of which 40–50 million were obese³⁷. WHO give similar global figures with one billion overweight of which at least 300 million are obese. For children under five years of age 43 million (6.7 percent) were overweight and obese in 2010³⁸.

The massive growth in obesity rates in recent years has been largely due to the high levels of dietary energy intakes and reduced physical activity due to poor diet and lifestyle choices. Consumers, particularly in the cities, have come to favour cheap and filling food that is high in fat over fresh fruit, vegetables and unrefined carbohydrates, such as wholemeal bread and brown rice. City dwellers have relatively more sedentary jobs than people in rural areas and expend less physical energy. And as more women join the workforce, they have less time to prepare food and often rely on processed ready-made meals.

While data on obesity in the developing world are limited, the highest rates appear to be in the South Pacific. In Nauru, 70 percent of the population is classified as clinically obese, up from only 15 percent in the mid-1960s. In addition, obesity affects 25–50 percent of the population in countries as diverse as China, Colombia, Kuwait and the Philippines³⁹.

The cost of obesity is staggering: USD 270 billion per year in the USA and USD 30 billion a year in Canada alone. This total USD 300 billion bill results from increased need for medical care (USD 127 billion); loss of worker productivity due to higher rates of death (USD 49 billion); loss of productivity due to disability of active

37 www.iaso.org/iotf/obesity/obesitytheglobalepidemic/

38 https://apps.who.int/hpr/NPH/docs/g_s_obesity.pdf

39 www.worldhunger.org/articles/04/global/burslem.htm



workers (USD 43 billion); and loss of productivity due to total disability (USD 2 billion)⁴⁰. In Britain, obesity now costs the National Health Service USD 6.9 billion annually, and the wider economy USD 6 billion⁴¹.

Healthy diets

Poor people tend to eat large amounts of one or two staple foods daily, which can represent up to 70–85 percent of their total energy intake. Poor monotonous diets high in carbohydrates but poor in quality in terms of variety, diversity and nutrient content are often associated with micronutrient deficiencies. People in high-income countries typically have diets that are high in meat and saturated fat and low in fruits and vegetables and whole grains. There is overwhelming evidence to show that this dietary pattern increases the risk of heart disease, certain types of cancer, stroke and diabetes. On the other hand, high intakes of fruits and vegetables, legumes, whole grains, and fish have been shown to lower the incidence of chronic diet-related disease and risks, including obesity. The latter pattern of eating is a modern nutritional recommendation inspired by the traditional “Mediterranean” diet consumed in southern Italy, Crete and coastal Greece in the 1960s, which was typically high in plant foods and low in red meat. Diets that are lacking in fresh, seasonal, micronutrient-rich fruits and vegetables are considered by some experts to be risk factors for chronic diseases such as obesity, type 2 diabetes, coronary heart disease, hypertension and cancer. Today, these diseases, formerly associated with affluence, are growing fastest in developing countries. Eighty percent of deaths from diabetes occur in low- and middle-income countries (WHO, 2011). Three-quarters of all adult deaths in Latin America and in the developing countries of Asia and the western Pacific are caused by preventable diet-related diseases⁴².

Dietary patterns – the daily combined consumption of foods and beverages – can lead to specific health or disease outcomes. Diets rich in fruits and vegetables, for example, are associated with reduced risk for certain cancers, diets high in saturated fats and energy have been associated with higher incidences of coronary heart disease.

40 www.usatoday.com/yourlife/health/medical/2011-01-12-obesity-costs-300-bilion_N.htm

41 www.bbc.co.uk/news/health-14064561

42 www.who.int/whr/2003/Working paper1/en/index3.html



Nutrients interact differently when presented as foods. The health value of some bioactive non-nutrients present in fresh foods is not yet fully understood, but it is clear that whole foods provide important benefits that supplements and fortificants of individual nutrients do not provide. While supplements and ready-to-use therapeutic foods certainly provide nutrition in emergencies, they are not considered long-term solutions, and are thus not necessarily compatible with sustainable diets.

The environmental consequences of food production and consumption

Global environmental impact of food systems

Agriculture and food production have been identified as among the leading causes of environmental pressure (FAO, 2006, FAO, 2009a, UNEP, 2010). Currently, about half of the world's land is used for agricultural production. Agriculture is a major driver of deforestation and loss of biodiversity, and represents 70 percent of total water use. The FAO projections indicate that the global demand for water withdrawals will increase by 11 percent from a 2006 baseline to 2050 (Bruinsma, 2009). The threats to water security become even more pronounced when climate change, with its implications for water variability and scarcity, and the growing demand for biofuel crops are factored into the equation. By 2050, more than half the world's population will live in countries with severe water constraints, including China, Egypt, Ethiopia, India, Iran, Jordan and Pakistan (Rockström *et al.*, 2008). Agrochemicals are also an important cause of water pollution. Eutrophication is clearly associated with food production, mostly due to the excessive application of synthetic fertilizers and mismanagement of animal manure (see also Working Paper 2 on Availability). Food accounts for between 30 and 40 percent of energy consumption, depending on countries. Producing animal products from vegetal and feed input involves biological processes and associated energy requirements and losses, meaning that 1 calorie of animal product requires the production upstream of more than 1 calorie of plant origin to feed the animal. Increasing demand for livestock products thus has a considerable effect on natural resources, mainly through increased demand on feed.



Assessing diets: carbon footprint

Carbon and water footprints have been put forward recently as methods to assess and compare the environmental impacts of agricultural products. So far no consensus has been reached on how to conduct studies on water footprints (UNEP, 2010). Thus most of the studies using lifecycle analysis for agricultural products concentrate on greenhouse gas emissions. However, there are no studies that quantify greenhouse gas emissions from the global worldwide food system (Garnett 2011). A European Commission study (2006) estimated that 31 percent of the EU's GHG emissions were associated with the food system.

It is generally estimated that half to two-thirds of the greenhouse gases emissions induced by food production and consumption are caused by the agricultural production stage. A recent Finnish study confirms this estimation (Yrjö Virtanen *et al.*, 2010), however the relative contribution of the pre-farm, on-farm and post-farm stages vary considerably depending on the product. For example, in ketchup production in Sweden using Mediterranean tomatoes, agriculture accounts for 14 percent of emissions, transformation 41 percent, packaging 24 percent, transport 9 percent and consumption 12 percent (Andersson 2000). Therefore studies which limit themselves to assessing emissions on the farm, risk giving a false idea of the actual impact of individual products when consumed, which can in turn distort the impact of actual diets on the environment, especially in developed countries. Emissions at the production stage vary widely, as shown for example in an analysis of the dairy sector (FAO, 2010a). Emissions at consumption stage are less studied for two main reasons: i) many life-cycle assessment studies are undertaken for industrialized food producers in order to improve their processes, which is the main purpose of the methodology, and ii) it is extremely difficult and costly to conduct studies at consumer level because it necessitates accounting for the diversity of consumers' behaviour and situations, which both have a strong impact on emissions. A Swedish study (Sonesson *et al.*, 2005a) underlines the importance of consumer transport to buy food and of wastage in the global lifecycle analysis. Analysis of the impact of various preparation modes for meatball (Sonesson *et al.*, 2005b) and chicken (Davies and Sonesson, 2008) shows the implications of the various stages and the importance of emissions at household level. Particularly important is the energy efficiency during conservation and cooking stages. For instance, for some frozen products, even containing beef, post-production stages can represent more than half of the total emissions (Büsser and Jungbluth, 2009).



According to the rare studies on the issue, transport represents only a small part of global food emissions, even if it does vary considerably, depending on the products considered. Transport emissions are estimated to be in the range of 11 percent of total food emissions. This figure takes into account transport at every stage, including the delivery of livestock feed, and of this 11 percent, 6 percent are caused by the consumer's travel to purchase food (Weber 2008). This last result mainly reflects the relative inefficiency of post-retail food transport compared to pre-retail. To illustrate the point, it has been estimated that taking the car for 10 km to buy 1 kg of Kenyan beans emits more GHG than it takes to bring them in the United Kingdom by plane (Smith *et al.*, 2005). Globally it has been estimated that as much energy is required to transport 5 kg of food by car for 1 km, as is required to transport it for 43 km by plane, 740 km by truck, 2 400 km by train or 3 800 km by boat (Brodt, 2007). These are global figures. For fresh products transported by plane, the emissions arising from transport can be significant. A study points out that the carbon footprint of 1 kg of fresh pineapple transported by plane from Zambia to Europe would be ten times its impact in jelly transported by boat (Plassmann *et al.*, 2009).

Food losses and wastage can increase the emissions intensity of products, particularly when they occur at the end of food chains after having embedded transport and conservation emissions. It is especially of concern as consumption of fragile products (fresh vegetables, dairy products, meat, fish, frozen products) is increasing and thus the emissions caused either by their loss or by their preservation (plane transport, fridges) are likely to become increasingly important.

A comparison of the impact of different foods requires consideration of quantity and quality marker nutrients, along with the resource inputs used in producing these nutrients and bringing them to consumers. Just as no single food is able to provide adequate nutrition, no single nutrient indicator, e.g. energy (calories) content, is able to provide a coherent picture when calculating carbon footprints.

Another way to assess the impact of diets is to compare meals, balanced from a nutritional point of view. This approach, adopted by a Finnish project on the environmental consequences of consumers' daily food choices, follows the idea that lunch is a "nutritional whole, in which changeability of components is restricted" (Kurppa *et al.*, 2009). In comparing lunch plates with half vegetables, a quarter protein and a quarter carbohydrates, the study found emissions per lunch plate varied from 570g CO₂ to 3.8 kg CO₂. The main impact was from livestock products, but also from greenhouse vegetables.



Based on its results, the study presented four global recommendations: moderate consumption of livestock products in favour of vegetable sources of proteins such as legumes, eat seasonal products, avoid waste, avoid shopping by car.

Energy intensity

The global food system provides consumers, particularly in developed countries, with convenience, abundant choice, and year-round availability of fresh produce. However, such benefits come at a price: they are very energy intensive. Energy intensity – the total energy input per total food energy output – is commonly used to determine the energy efficiency of food production. In recent decades, agricultural development has led to increased yields, but also to less efficient energy use (Schneider and Smith, 2009).

A number of factors influence the energy intensity of production and the resulting environmental impacts along the food chain. In developed countries, the use of energy in the food system typically amounts to 12 to 20 percent of the total energy consumed nationally (Carlsson-Kanyama, 2004). Energy is used during crop, livestock and fish production, either directly or indirectly as embedded energy in input manufacturing and transport (Woods, 2010). Energy also plays a crucial role in processing and packaging, distribution and transportation and last, but not least, consumption.

Energy intensity at the production stage has decreased in the last 20 years in OECD countries, while it has increased in developing and newly-industrialized countries, especially China and India. The use of fertilizer and heavy machinery has intensified in developing countries over the past few decades, while developed countries' use of such inputs has declined since the mid-1980s. (Schneider and Smith, 2009). This is partly due to the fact that industrialized countries have adopted improved crop varieties, more efficient machinery and irrigation systems as well as improved input management. Such measures significantly increase energy efficiency per kilogram of output. However, they do require significant capital investment and are therefore out of reach for most farmers in poor countries.

Although it has received relatively minor attention, recent figures from the developed world indicate that the consumption stage of the food chain is the least energy efficient of all. Food consumption involves storing, preparing, serving and eating food, either at home or in a restaurant. A study (Canning *et al.*, 2010) found that food processing and consumption together accounted for about 60 percent of total 2002 food-related energy



flows in the USA, up from 55 percent in 1997. This was partly due to the increasing use of technologies such as refrigeration, but also because households and restaurants have come to rely more heavily on processed foods which use high energy consumption technologies for production. Similar results were shown by a 2000 Swedish study, which found that household energy use for cooking and storing food was 28 percent of the total energy used and that processing contributed another 25 percent (Carlsson-Kanyama, 2004).

Food losses and waste

Food losses are staggering. About one-third of the food produced for human consumption is lost or wasted every year, amounting to about 1.3 billion tonnes annually (FAO, 2011a). Reducing food losses and food waste is highly relevant to efforts to combat hunger, raise income and improve food security in the world's poorest countries. Food losses and waste also represent a waste of resources used in production, transformation and transport, such as land, water, inputs and energy, especially at the end of the food chain, considering that food gradually embeds emissions of transport and conservation.

Food losses and their distribution along the food chain – occurring at the production, harvest, post-harvest and processing phases – are very different, depending on the regions and the products. It is especially a challenge in developing countries, due to poor infrastructure, low levels of technology and low investment in food production systems. Food loss during harvest and during storage translates into lost income for small farmers and into higher prices for poor consumers. It becomes obvious that reducing losses could have an “immediate and significant” impact on their livelihoods and food security. Food waste is more of a problem in industrialized countries, often caused by both retailers and consumers throwing away perfectly edible foodstuffs.

Overall, on a per capita basis, much more food is wasted in the industrialized world than in developing countries. It is estimated that the per capita food waste by consumers in Europe and North America is 95-115 kg/year, while this figure in sub-Saharan Africa and south/southeast Asia is only 6-11 kg/year (FAO, 2011a).

Global differences between regions for the same type of products indicate the potential for improvement (FAO, 2011a). Losses of cereals are approximately 50 percent higher in Europe than in sub-Saharan Africa. Loss of milk is twice as high in sub-Saharan Africa than in Europe.



The distributions of the losses along the food chain also vary among regions. For instance, in Africa, cereals are lost in the first stages while in Europe, they are lost mostly at the consumer stage: consumer-level losses are 25 percent in Europe and 1 percent in Africa. For fruits and vegetables, the differences between regions are also striking. In Africa processing and distribution are the weak links, while in Europe most losses occur at production and consumption stages. This pinpoints areas where investments could be helpful and show possibilities of improvement.

Food losses and waste represent also a waste of resources. The resources used to produce, transform, preserve, transport lost or wasted food are effectively used in vain.

Box 20. The case of fish

Fish is a highly perishable food. Post-harvest losses in small-scale fisheries are among the highest for any commodity in the food production system. Fish loss due to spoilage is estimated at 10 to 12 million tonnes per year, accounting for around 10 percent of total production from capture fisheries and aquaculture. Post-harvest loss occurs in various forms. Physical fish loss is caused by poor handling and preservation or by discarding by-catch. Nutritional losses can occur from poor handling and processing. This is particularly true for low-molecular water-soluble vitamins and minerals, which are susceptible to leaching. High temperatures during smoking, cooking, or drying, direct sunlight and pH extremes also can destroy proteins, fatty acids and vitamins. The processing of large quantities of fish catches for livestock and aquaculture feed can be considered a “loss” for human food security. The sustainability of fisheries is an issue of paramount importance for human nutrition. The report of the FAO/WHO consultation on fats and fatty acids recommended an intake of long chained, highly polyunsaturated fatty acids – those found primarily in fish – that cannot meet the requirements of the world’s population. Harvesting nutrients, particularly fatty acids, from fisheries’ waste would help solve the problem.



The more food that is wasted, the more energy that is wasted and the higher the unnecessary emission of greenhouse gases. In Sweden, agriculture accounts for between 10–12 percent of the total emissions of greenhouse gases, while nearly a quarter of agricultural food products are discarded (Politiken, Aftenposten, Svenska Dagbladet, 2010). In the UK, food waste results in 14–15 million tonnes of CO₂eq being emitted while in Australia, household food waste represents about 5.25 million tonnes of CO₂eq emissions, equal to all emissions from the manufacture and supply of iron and steel in the country (Baker, 2009). It is estimated that fully 10 percent of global greenhouse gas emissions result from the production of food that is never eaten (Stuart, 2009).

Food waste now represents the single largest component of the solid waste reaching municipal landfills and incinerators in many developed countries (Hall, 2009). In the USA, less than 3 percent of the 34 million tonnes of food waste generated in 2009 was recovered and recycled⁴³. In Australia, half of all municipal waste going to landfills is comprised of organic waste, most of which is household waste (Baker *et al.*, 2009).

When food is disposed of in a landfill, it becomes a significant source of methane as it decomposes. When emissions from decomposing food in landfills combine with emissions from the production and transport of food, the effective emissions are even greater. According to the US Environmental Protection Agency, landfills account for more than 20 percent of all methane emissions in the USA. And the UK's Department for Environment, Food and Rural Affairs found that the 6.7 million tonnes of food sent to landfills from UK homes each year represent 15 million tonnes of CO₂eq (Hogg, 2007). Landfill leachates can also cause considerable groundwater pollution.

And from a global point of view, consumption of foods and nutrients above requirement levels also represents a waste of resources, particularly high consumption of animal products which puts additional pressure on already scarce resources.

43 www.epa.gov/osw/conservematerials/organics/food/fd-basic.htm



Trends towards 2050

Traditional food systems are threatened

Traditional food systems are based on a rich array of cereals, legumes, vegetables, indigenous fruits and animal-source foods that are cultivated and gathered from uncultivated lands or the forest (e.g. leafy plants, roots, berries, small rodents, and insects) and from aquatic environments (e.g. fish, frogs and snails). They are often threatened by deforestation, environmental degradation and climate change. Traditional food systems are also threatened by economic and cultural changes, leading to the erosion of traditional food resources and knowledge. This began during the period of European colonization, but has been accelerated by agricultural technology, urbanization, the introduction of foreign foods and cultures, commercialization and globalization.

In recent years, reduced access to land and natural resources, globalization and the westernization of diets and lifestyles have dramatically affected the role of traditional foods in the lives of small farmers and indigenous societies (FAO/CINE, 2009). The perception of traditional food as old-fashioned or destined for the poor has had a negative impact on their consumption, especially by young people. Studies have linked these changes to a wide range of negative consequences, including food insecurity, poor health, nutrition deficiencies, ecosystem deterioration and cultural erosion. The consequences of this shift in production and consumption patterns are significant. It generally goes with a shift towards foods which are often highly refined and processed, have higher concentrations of saturated fats, salt and sugar and are lower in micronutrients. Yet these foods are attractive, they often come ready to eat and are easy to prepare and also often tend to be inexpensive, a major appeal since many small farmers come from low-income households.

Today, only about 150 plant species are grown commercially around the world and global crop production concentrates on 12 plant species.⁴⁴ Although farmers have domesticated at least 5 000 plant species over time, the industrial food chain uses only 3 percent of them (ETC Group, 2009). Only three crops – maize, wheat, rice – supply the bulk of human energy needs. This dependence on a limited number of crops goes with many local food plants being abandoned or neglected. In a similar vein, although

⁴⁴ Maize, rice, wheat, soybeans, potatoes, sweet potatoes, banana and plantain, sorghum, cassava, millets, sunflowers and canola.



farmers have domesticated 40 livestock species over time, the food industry has focused its attention on just five species – bovines, chickens, pigs, sheep and goats (ETC Group, 2009). Likewise, nearly two-thirds of global fish consumption comes from only a few groups – finfish families, marine crustaceans and bivalve molluscs (FAO, 2011). As a result, these groups are overexploited and endangered, while ocean trawlers discard a large portion of their annual catch because it does not contain the preferred species. In industrialized countries, discard rates range between 9–15 percent of marine catches (FAO, 2010). By contrast, coastal and inland fishers use a far greater range of species and discard very little.

The importance of wild food resources is often underestimated as they are only rarely included in food availability estimates. ETC Group (2009) estimates that about 15 percent of the annual food supply of rural farmers in developing countries comes from uncultivated lands, yet wild foods are only rarely included when global food availability is considered. Scoones *et al.* (1992) identified several other examples, such as:

- farmer communities in Borneo that gather nourishment from over 800 different plants and more than 100 species of ground fauna, along with hundreds of bird species; only one third of farmer communities' diet comes from cultivated crops;
- Kenyan farmers draw a quarter of their annual food supply from the wild, rising to almost half during the dry months;
- farmer women in Uttar Pradesh, India, who derive nearly half of their income from forest species;
- the Mende of Sierra Leone who gather more than half of their food from forests, streams and fallow fields.

During staple crop shortages, in some parts of Africa, wild resources provide up to 80 percent of household food needs (FAO, 2008).

Threats to traditional food systems can endanger food security and nutrition of vulnerable populations.

Changes in food systems, led by growing urbanization

Today, half the world's population lives in urban areas and that number is climbing rapidly. Almost all population growth over the next decades will be urban. Urbanization is particularly rapid in sub-Saharan Africa and East Asia, which have urbanization rates greater than 4 percent and 3 percent respectively (Kearney, 2010). By 2050, about 70 percent of the global population of nine billion is expected to live in cities, which will have important



consequences on consumption patterns and food chains (Foresight, 2011; Esnouf, 2011). Most urban consumers are net buyers, meaning that they buy more than they sell, often purchasing everything they eat. This gives them an important influence on the structure and orientation of food systems, an influence that will grow as their numbers increase. In addition, consumption patterns in the peri-urban and rural areas tend to mimic those in urban areas, giving the cities an even greater authority over local food systems.

Urbanization drives profound modifications in diets. It facilitates access to richer products, often imported, which replace traditional foods. With a greater intake of animal products, diets become poorer in fibre and in many micronutrients and higher in energy and fat. This leads to a higher caloric intake which, combined with the fact that urban people have usually lower energy demanding jobs than rural people and thus burn fewer calories, causes obesity.

Developed countries place growing importance on information and logistics technologies, and food safety and quality standards. Food systems are increasingly linked from producer to consumer with an increasingly dominant role played by highly concentrated agro-industrial firms and retailers. These trends are expected to expand to developing countries, along with the expansion of supermarkets and hypermarkets (OECD, 2011).

To feed the cities requires the gathering of supply in sufficient quantities that meet more stringent quality standards set by retailers and consumers, which would usually exclude smallholder producers. Companies tend to delist suppliers who do not meet expectations in terms of volume, quality and delivery. Farmers wishing to supply supermarkets must accept to deliver fresh products, often every day, and they must accept the fact that buyers will consider part of their produce as of unacceptable quality (FAO, 2005).

Adequate transport infrastructure and forms of organization are needed to ensure access to market for smallholders. Establishing groups and associations of smallholder farmers or fishers can facilitate their meeting the quantity, quality and timing goals of food processors and food retailers. Membership in such groups also improves returns to the farmers and fishers and can help them access training, information, technology and financial support.

Increasing urbanization, the growth of the middle class, rising per capita income, the growing distances between home and the workplace, and an upsurge in the number of working women are all factors that lead to a growing demand for processed food products



that meet stringent quality and safety requirements. This offers new opportunities provided that adequate means are available to establish the processing technologies and industrial operations needed to deliver compliant products.

As food chains become longer, the risk of losses in quantity and quality increases, as does the consumption of energy for conservation, transformation, packaging and transport. Longer food chains also require the establishment of quality and traceability standards to satisfy the requirements of richer and more informed consumers.

Adapting food systems to increased urbanization requires important transformations which provide considerable opportunities in the frame of a green economy.

An increasing demand

Demand for food is directly driven by the increase of total population and changing patterns of consumption. These are influenced by income and various factors such as urbanization, education, culture.

Demand is set to increase significantly towards 2050 because of population growth. Income growth in low-income countries and emerging economies will drive demand even higher (Foresight, 2011). There will be a shift to high-status and non-seasonal foods, including more meat consumption, particularly in countries with rising income. It is projected that by 2050, 2.3 times more poultry meat and between 1.4 and 1.8 times more of the meat of the other livestock products will be consumed as in 2010 (FAO, 2009a). According to FAO's estimations (FAO, 2009a), increase in consumption of livestock products will cause a 553 million tonne increase in the demand for feed, which represents half of the total demand increase for coarse grain between 2000 and 2050.

Food price has an increasingly different effect on demand depending on countries. In high income countries, food prices have steadily declined, relative to income, thanks to competition on price, subsidies for agricultural production, and a low level of integration of negative externalities in costs. In poor countries, food is still a very important part of most household budgets. For example, the budget share of food expenditure is about 70 percent in Tanzania and 45 percent in Pakistan against an average of 10 percent in the USA (HLPE, 2011).

Increased demand for agricultural products for food, feed, and non-feed uses such as biofuels is a driver of price increase (HLPE, 2011). As incomes increase, food demand becomes less sensitive to price changes and, as income is increasing in most of the world,



global food demand is becoming less and less sensitive to price changes. Price increase will not reduce global demand but it will have disproportionate effects on the poor (HLPE, 2011).

Given the interactions among various factors, projections are inherently uncertain and can be used only to identify trends (Foresight, 2011, Working Paper 2 - Availability). The FAO baseline projection (Bruinsma, 2009) of an increase of 70 percent in 2050, business as usual, has been widely cited and commented (Grethe *et al.*, 2011). Other authors have attempted to describe various scenarios. For instance Agrimonde (2009) describes a business-as-usual scenario, Agrimonde 0, with an increase of global demand of calories of 83 percent, and a scenario Agrimonde 1, where the increase is 28 percent. This last scenario supposes radical changes in consumption patterns and behaviours and in worldwide distribution of food, including a decrease of 25 percent of the per capita consumption in OECD countries between 2000–2050, without any income reduction, and a slowdown in the increase of per capita consumption in emerging countries. It would require radical changes in consumers' behaviours, reduction in waste, and implementation of efficient public policies to promote more balanced and healthy diets. Another study (Erb *et al.*, 2009) compares various scenarios based on diets – “western high meat”, “current trend”, “less meat”, and “far less meat”, concluding that it would probably be possible to feed the world with organic crops and an organic livestock system with a very equitable distribution and an average daily intake of 2 800 kcal per capita with 20 percent of protein from animal origin. The “western high meat” diet, with 44 percent of protein intake of animal origin would also probably be feasible, but only with a cropland expansion of 20 percent, intensive yields and intensive livestock production.

Business-as-usual projections point to a considerable increase in demand, driving increasing impacts on resources. Alternative scenarios show how impact on resources is dependent on the evolution of diets (Agrimonde, 2009, Erb *et al.*, 2009, Grethe *et al.* 2011).



Improving the sustainable efficiency of food systems

Preserving the diversity of traditional food systems

The food systems of indigenous peoples show the value of diversified diets based on local plant and animal species. In many developing countries, the rural and peri-urban poor collect and manage uncultivated medicinal plants, vegetables, nuts, fruits, and fungi on common lands. These plants provide irreplaceable nutrients and are essential for food security, especially in the weeks and months leading up to harvest when family food stocks are at their lowest (ETC, 2009).

The use of indigenous plant and animal diversity can make an important contribution to nutrition, environmental sustainability and the protection of biodiversity. There is ample evidence that a diverse diet based on local foods can supply significant amounts of macro- and micronutrients and ensure household food and nutrition security (Frison *et al.*, 2006).

Countries, communities and cultures that maintain their own traditional food systems tend to consume foods involving a higher diversity of crops and animal breeds. They are also less likely to exhibit a high prevalence of diet-related diseases. Unfortunately, food consumption data on wild, indigenous and traditional plant and animal foods are limited and fragmented. Dietary assessment surveys have generally been designed to capture information on the habitual intake of generic foods, rather than detailed information at the taxonomic level of species, subspecies and variety or breed. The corresponding compositional data are rarely available. It is also widely believed that survey participants are not able to recognize foods at the taxonomic level below species, although evidence exists that this belief is not accurate.

Producing a range of diverse crops and varieties buffers yields. Total harvests may be lower in a diversified production system but they are more stable from year to year. This suits small farmers in rural areas, who seek to minimize risk – ensuring that there is some food for their families – rather than to maximize productivity.

Climate change provides a strong argument for favouring diverse production systems, including indigenous crops. Farming systems will definitely have to adapt as weather patterns change. The most diverse systems – those that have and use the most diversity – are



likely to be the most adaptable. Crop diversity provides the key for adaptation: the genetic resources that can be used by plant breeders and farmers to adapt food crops to climate changes, ensuring they are productive while withstanding new pests, diseases and climate conditions. Using a range of local crops and varieties can also help adapt to climate change by maintaining ecosystem resilience. In the Pacific islands of Tuvalu, domestically grown food remains the main source of nutrition, with *pulaka*, (a root similar to taro) playing an important role as staple crop. However, increasing saltwater intrusion has destroyed more than 60 percent of *pulaka* pit plantations in Tuvalu, and the remaining 40 percent remains highly sensitive to saltwater intrusion. It is assumed that an absolute destruction of pulaka crops is imminent in the near future for all islands of Tuvalu – possibly in the next decade – which would increase dependence on imports and have important nutritional consequences. To avoid it, the National Adaptation Plan of Tuvalu plans to introduce a salt-tolerant *pulaka* species in the region (Tuvalu, 2006).

Another benefit of traditional food systems relates to the sense of national pride and identity that arises when people come to understand and appreciate the value of their traditional native foods.

Box 21. Reconnecting with food traditions

Today, many NGOs are working to stimulate demand for traditional food as well as to increase local capacity for traditional food production.

Over the past decade, Bioversity International has worked with farmers, NGOs, universities, hospitals, national research institutes and supermarkets across sub-Saharan Africa to improve livelihoods and nutrition by increasing the production and consumption of leafy vegetables. Approximately 900 species of leafy vegetables grow in sub-Saharan Africa. Rich in important micronutrients, such as vitamin A, iron and zinc, these plants were once a fundamental part of people's diets and culture. Then along came foreign crops such as cabbage and kale. Because of their exotic origins, these new crops acquired a special status and, gradually, people stopped growing traditional leafy vegetables in their gardens, and began to grow the fashionable – though less nutritious – modern crops instead.





In **Kenya**, Bioversity International and its partners focused on conservation, capacity building and raising awareness of the nutritional and culture values of traditional vegetables. Demand for leafy vegetables in Kenya now outweighs supply, with an astonishing 1 100 percent increase in sales in just two years. Incomes have increased too, particularly where farmers have been successfully linked to markets, with women, the main producers of leafy vegetables, the main beneficiaries. In almost 80 percent of households surveyed, it was the women who kept the cash from the sale of leafy vegetables and who decided how it would be spent – mostly on more and better food and schooling for the children (Bioversity International, 2010).

In **Marrakech**, the Global Diversity Foundation is restoring a school garden with the help of the staff and students of the Lalla Aouda Saadia School. The garden, which features both ornamental and edible plants, draws on Morocco's rich cultural history. The project, which aims to reach 1 300 schoolgirls, will provide nutritious food for the students while teaching them about the environment and food traditions. The students take part in field research by interviewing Marrakech herbalists about important cultural recipes (<http://tinyurl.com/6k6367p>).

In **the Federated States of Micronesia (FSM)**, a shift from traditional to imported foods over the past three decades has brought serious health problems to the region. Prior to the 1970s, there were no documented instances of vitamin A deficiency in FSM. By 2000, over 50 percent of all children under the age of five were deficient in vitamin A, a condition that often leads to childhood blindness and early death. The Island Food Community of Pohnpe initiated a "Let's Go Local" campaign to promote important elements of nutrient analysis and conservation. It is particularly concerned with promoting foods that are rich in provitamin A carotenoids, especially beta-carotene. It has seen a significant increase in the consumption of indigenous bananas, taro and green vegetables in the target communities (www.islandfood.org/index.htm).



Food-based approaches to nutrition security

Food-based approaches are activities that increase availability and consumption of food through, for example, increasing food production, enabling greater access to and knowledge of healthy diets, dietary diversification and food fortification. They focus on improving diets in quantity as well as in dietary quality in terms of variety, diversity, nutrient content and safety of foods. The importance of providing support for established food-based systems that ensure consumption of a variety of micronutrient-rich foods is clear both for the prevention and control of micronutrient deficiencies as well as for improving nutrition in general. Food-based approaches, by promoting the production and adequate consumption of foods for a healthy diet, are a viable, cost-effective and sustainable solution to ensure food and nutrition security and, by doing so, to achieve the nutrition-related Millennium Development Goals (MDGs).

Food-based approaches to nutrition security include any activities that preserve or fortify the nutritional value of food and support the consumption of nutritional foods. Such activities may take place at any point along the food chain, from seed selection, production, harvest, storage, processing, preservation and meal preparation through to consumption. Food-based approaches include incorporating enhancers of micronutrient absorption into food and reducing absorption inhibitors. They include integrating small-scale horticulture and raising small animals in order to increase dietary quality in terms of variety, diversity, nutrient content and food security. They also include food fortification, including biofortification. Food-based approaches are the vehicle for narrowing the “nutrition gap”; this gap refers to the difference between the food available and the type of food required for a healthy diet. Such approaches are needed to ensure that nutritionally vulnerable people are able to consume the appropriate quality and quantity of food (Thompson B., 2010).

In addition to its intrinsic nutritional value, food has social and economic significance which, for many people, especially those living in developing countries, is commonly mediated through agriculture and agriculture-related activities that sustain rural livelihoods. The multiple social, economic and health benefits associated with successful food-based approaches that lead to year-round availability, access and consumption of nutritionally adequate amounts and varieties of foods are clear. The nutritional well-being and health of individuals is promoted, incomes and livelihoods supported, and community and national wealth created and protected.



Food-based strategies were often overlooked as governments, researchers, the donor community and health-oriented international agencies sought approaches for overcoming micronutrient malnutrition such as supplementation programmes that had rapid start-up times and produced quick and measurable results. Although many lives have been saved and much suffering has been avoided as a result of these efforts, food based approaches are gaining increased attention.

Agriculture-based interventions to improve nutrition security

Agricultural development programmes that aim to increase the production of staple crops are essential for food security, yet, alone, they are insufficient for alleviating hunger and malnutrition. Efforts to improve food security must be joined by efforts to improve nutrition security. Narrowing the nutrition gap will require increasing the availability of and access to the foods necessary for a healthy diet and ensuring that people actually eat them.

The following interventions have been developed with both yield and nutritional goals in mind (Thompson, 2009). Each aims to boost the production or consumption of high quality and diverse foods. While none of these interventions will narrow the gap on its own, each represents a useful step:

- agricultural extension services offer improved inputs to communities, including seed and cultivars that ensure greater crop diversity, animals for small livestock and poultry ventures and fish for marine fisheries and aquaculture;
- agricultural extension services provide nutrition education at the community level;
- research and development programmes selectively breed plants and livestock to enhance their nutritional qualities;
- subsidy programmes increase the availability of fertilizers supplemented with micronutrients;
- research and development focuses on reducing post-harvest losses through improved handling, preservation, storage, preparation and processing techniques.

In addition to being compatible with traditional development objectives, each intervention can be adapted to a wide range of countries, agro-ecological zones and food typologies.

In the warm, arid and semi-arid tropics, the introduction of drought-tolerant cultivars with high micronutrient levels should be a priority. These zones are also good candidates for the involvement of agricultural extension services to promote the consumption of



local or indigenous plants and animals as well as food staples. For example, intercropping cereal crops with drought-resistant legumes, such as cowpea or pigeon pea, improves both nutrition and food security: the former through increased protein intake, the latter through increased nitrogen fixation and, subsequently, higher yields.

A common problem in the warm sub-humid tropics is the inability of farmers to get hold of the fertilizers they need to overcome soil nutrient deficiency, either because the fertilizers are not available or because the farmers cannot afford them. Although fertilizer use is typically associated with increasing production, enhancing the micronutrient and trace element (iodine, zinc, iron) content of crops by applying enriched fertilizers and managing soil acidity may also improve nutritional security. Micronutrient-enriched fertilizers have particular potential where input subsidy schemes already reach large numbers of farmers.

While production and food security goals in the warm humid tropics are often met, diets may still be nutritionally deficient. In Ghana, for example, dietary energy supply meets requirements but the share of protein and lipids in people's diets is lower than recommended. This is at least in part caused by lack of access to markets due to poor infrastructure. Yet, there are many agriculture-based interventions that could improve nutrition outcomes in this zone. These include small livestock production projects to provide an accessible source of fat, protein and essential micronutrients, providing dietary diversification advice such as cereal-legume mixing to maximize protein availability, and horticultural training to improve the availability of micronutrient-rich vegetables and fruit. Horticulture also has the potential to increase incomes through the sale of fruits and vegetables, given access to markets. Selective breeding to increase the protein content of cassava – a central component of diets in this zone – could increase macronutrient intake. Aquaculture also offers income opportunities to small producers and provides a valuable source of high quality protein and essential micronutrients (FAO/CABI).

These interventions all represent excellent investment options and have the capacity to increase women's roles in managing productive assets and their access to services, technology and income generating opportunities. As shown by the World Bank (2007), the resources and income flows that women control wield disproportionately positive impacts on household health and nutrition.



Enhance agricultural biodiversity for balanced diets

The role that agricultural biodiversity can play in nutrition is well acknowledged. However, there is a need for even broader dissemination of scientific evidence on the connection between the two. Recent studies have shown that nutrient values may vary greatly among different varieties of the same foods. For example, sweet potato cultivars can differ in their carotenoid content by a factor of 200 or more; the protein content of rice varieties can range from 5 to 14 percent by weight, and the provitamin A carotenoid content of bananas can be less than 1 µg/100 g for some cultivars up to 8 500 µg/100 g for others.

Nutrient content in crop types varies due to environmental and processing influences such as feed, soil, sunshine, time of harvest, storage conditions, fortification. Differences in recipes and local food traditions also can have an impact on nutrient content. Breeders need to be aware of the nutritional composition of existing cultivars and factor in nutrient content when improving agronomic traits such as yield and disease resistance or sensory characteristics such as flavour, texture and appearance.

In recent years, consumption of animal products has increased due to the growth in emerging economies and urbanization. Today, animal products contribute 15 percent of the energy and 25 percent of the protein consumed globally (FAO 2009a). In addition, they provide a wide range of micronutrients such as iron and zinc in highly bioavailable forms, vitamin A, vitamin B12 and calcium, all of which are vital, but particularly during the critical developmental stages of young children and pregnant women.

Fish are a major provider of animal protein and micronutrients for many coastal populations and an affordable source of essential nutrients in many poor areas. Fish contribute at least 30 percent of animal protein intake for one billion people and at least 15 percent of animal protein intake for 2.9 billion more. Fish provide a unique source of essential fatty acids, such as DHA and EPA, which contribute to optimal brain development and the prevention of coronary heart diseases. They are also a valuable source of micronutrients that are easily absorbed by the body. These include most minerals – such as calcium, iodine, zinc, iron and selenium – as well as the vitamins D, A and B complex (FAO/WHO, 2011).

Food biodiversity is seldom included in nutrition programmes or interventions. This is largely because insufficient data exist on the nutrient composition of many crop varieties and animal breeds, and resources are scarce for generating these data for use in food consumption studies and nutrition programmes. Farmers and consumers are often not aware of the higher nutrient values of certain plant cultivars compared with others, and so do not grow or consume them. Indicators, tools and methodologies for measuring and



monitoring biodiversity-related food composition and consumption have been developed by FAO and will be critical to evaluating the contribution that food biodiversity can make to sustainable diets. Relevant, reliable and up-to-date food composition data are also of fundamental importance in disciplines such as food science, plant breeding, food product development, trade and marketing, and food regulation.

Improving sustainable efficiency of food chains

At the global level, agrifood systems are undergoing rapid changes which impact the food losses in the supply chain. Trends in diet composition, towards a higher percentage of highly perishable food items such as animal products, fruits and vegetables, lead to an increased risk of loss, in both quality and quantity terms, as well as to an increased risk of wastage once the product has reached the final consumer. The increasing distances between the places where food is produced and where it is consumed lead to longer and more complex supply chains within which losses and wastage levels can be high if infrastructure is inappropriate or chains are poorly coordinated. While the growing number of supermarkets offers the consumer a wide range of diverse foods, it also increases the risk of wastage, as not all perishable products can be sold before expiration, an issue exacerbated by increasing consumer food safety and quality concerns. At the final stage in the chain where food is consumed (at homes, restaurants and other food service businesses) significant quantities of food are wasted when left to deteriorate or when discarded even though still fit for consumption.

Reducing food losses

Food losses occur all along food chains, but there also are techniques available to reduce them. Improving the availability and effectiveness of storage in developing countries will reduce post-harvest losses and improve food safety. Storage accommodates delays and constraints in logistics and ensures the availability of food throughout the year.

It both reduces seasonal gluts on the market and enables farmers and producers to delay sales until the lean season when they can command higher prices. Storage also enables farmers, producers and traders to get credit using their food stocks as collateral. The availability of adequate storage facilities becomes particularly critical during emergency and rehabilitation situations when the food and nutrition security of the population may be at greater risk than under normal circumstances.



For instance, household metallic silos for conservation of cereals or tubers are actively promoted by organizations such as FAO and various NGOs. Metallic silos in Afghanistan have reduced storage loss from 15–20 percent to less than 1–2 percent. Their fabrication is local, creating jobs, small enterprises and possibilities of diversification. They enable farmers to preserve food, therefore making them less vulnerable, either as sellers or buyers, to price fluctuations on local markets.

For fresh products, cold storage can be an option but its cost and energy inefficiency make it a less appropriate solution in certain contexts. In some cases, a better option might be to encourage the production of fresh foods locally. In others, solar refrigeration might be a technically and economically feasible option.

Develop local processing

Processing reduces post-harvest losses, and allows food to be preserved and transported more energy efficiently when realized locally. Preservation also contributes to more balanced diets throughout the year, enabling food to be consumed in more convenient and nutritious forms. Food processing operations increase and diversify incomes and provide employment and entrepreneurial opportunities in both rural and urban areas. Food processing is also an excellent method for women in rural communities to generate income and employment.

Small-scale processors have to contend with increasingly strict industry standards and – in global markets – with tough competition from large manufacturers in developed and transition countries. To compete, processing enterprises will need environmentally friendly technologies and the ability to use them effectively. They will also need to have the capacity for providing quality and safety assurance and expertise in business management and marketing. Potable water, electricity and waste disposal facilities must be available on site. A supporting infrastructure in the form of roads, warehouses and information and communication technologies must also be available to underpin processing operations and facilitate links between processors and input and output markets.

Many developing countries lack the regulatory and institutional frameworks needed to support the food-processing sector. These frameworks are critical. Regulatory frameworks are needed to protect intellectual property rights and to control the registration of enterprises, land tenure, foreign and domestic investment, contracts, operation of commodity markets and employment of personnel. Institutional frameworks are needed to set and enforce quality, safety and other standards and to support research and training.



Develop sustainable packaging

Packaging has an important role to play in reducing food loss and a clearer understanding of its protective and marketing functions can help to promote its use. Advances in packaging not only lead to better food quality and safety but can also help enhance the livelihoods of small producers by attracting better market share and value through increased visibility (FAO, 2011b).

In developing countries, the food packaging industry has limited solutions for meeting international market requirements and a relative lack of domestic demand for packaging materials. This results in low investment by the packaging industry, which in turn, limits the ability of manufacturers to enhance product quality to meet the standards of increasingly discriminating consumers, both in domestic and international markets.

Improving traditional technologies or importing new ones may help expand the packaging industry in developing countries. Relaxing packaging regulations, for example on the use of recycled materials when they pose no threat of contamination, may assist in the development of the industry while being good for the environment. Innovations in food packaging can play an important role in reducing food losses and improving food safety and quality. For instance, active and intelligent packaging extends the shelf life of food and provides information on its freshness and intelligent or smart packaging can monitor and communicate information about food quality (Brody *et al.*, 2008).

Improve energy efficiency

There are options for achieving greater energy efficiency at every stage of food chains. Each link along the food chains, until consumption, has potential to improve energy efficiency – in transport, conservation, transformation and cooking. However there could be trade-offs between reducing losses and reducing energy consumption, especially for fresh perishable products whose consumption is increasing, such as meat, dairy products, fish, fruits and vegetables. The analysis shall therefore encompass the whole food chain in order to consider all impacts and all potential solutions. For instance, transforming fresh products transported on long distances into less perishable products can reduce losses and emissions induced by conservation and transport as slower more energy efficient transportation means can be used.

Some 2.7 billion people – almost half of humanity – rely on traditional biomass for cooking and heating and more than two billion people depend on wood energy for



cooking and/or heating⁴⁵ particularly in households in developing countries. Solid biomass represents the only domestically available and affordable source of energy. Private households' cooking and heating with fuelwood represents one third of the global renewable energy consumption⁴⁶. There are many ways to increase efficiency and sustainability of fuelwood and charcoal production and consumption patterns. However, these are often not applied by the local population due to uncertain or unfavourable legal, political or social framework conditions.

Charcoal is the fuel of choice of urban dwellers in developing countries. Its consumption increased strongly in Africa (+29.8 percent) and Asia (+10.2 percent) and at global level (+8.9 percent) between 2004 and 2009 (Lanly, 2003). Main drivers are the increasing rate of urbanization in developing countries as well as the high prices for fossil fuels such as kerosene, LPG and natural gas. In many parts of the world, charcoal production is managed in a sustainable fashion. However, in developing countries, fuelwood collection and charcoal are often not sustainably managed and are estimated to be responsible for 8 percent to 11 percent of the global deforestation.

Coppicing, involving cutting trees back periodically to stimulate growth can reduce the pressure on tree and forest resources, on the production side. This process yields fuelwood and can be even carbon-negative, since each time a tree is coppiced, some of its root mass dies to compensate for the loss of photosynthetic surface. Integrating and intensifying food and energy production has the potential to improve food and energy security in rural villages and also at national level.

Many people use polluting stoves or three stone fireplaces which contribute to severe respiratory problems notably for women and children. The World Health Organization (WHO) estimated that “every year, indoor air pollution is responsible for the death of 1.6 million people⁴⁷”. Clean cooking stoves offer a significant improvement of indoor air quality reducing respiratory problems and saving lives, improving livelihoods of women, by reducing time spent for fuel collection and reducing climate relevant emissions, such as CO₂ and black carbon emissions (soot). FAO works with the Global Alliance for Clean Cook stoves⁴⁸, a new public-private partnership that calls for 100 million homes to adopt clean and efficient stoves and fuels by 2020. The Alliance partners with public, private

45 UN Foundation (www.sustainableenergyforall.org/about).

46 www.fao.org/forestry/energy/en/

47 www.who.int/mediacentre/factsheets/fs292/en

48 <http://cleancookstoves.org/>



and non-governmental organizations to help overcome the market barriers that currently impede the production, deployment and use of clean cook stoves in the developing world.

More than 200 million Africans eat fish regularly, most often smoked or dried (FARA, 2007). The traditional production of smoked fish and, sometimes dried bivalves, requires extensive use of wood, which is often supplied by mangroves. It is estimated that over 200 000 ha of mangroves were lost between 1990 and 2007, due to the combined demands of construction, smoked fish and agricultural activities. Traditional fish smoking also impacts on human health because it exposes people to toxic fumes and excessive heat. The Chorkor oven – introduced in the late 1960s – decreases fuelwood consumption by more than half and reduces the danger of smoke inhalation and burns.⁴⁹ The quality of the smoked food is also superior. Additional improvements to smoking kilns have further improved food safety by reducing the presence of polyaromatic hydrocarbons, especially benzopyrenes (Nndiaye, 2007).

Integrated food-energy systems can produce food and energy at the same time. Farmers can save money using these integrated systems because they do not have to buy costly fossil fuels for their energy needs, nor chemical fertilizer if they use the slurry from biogas production. Combining food and energy production can also reduce deforestation. Simple systems such as agroforestry or biogas can be easily up-scaled. More complex systems require high levels of knowledge and skills to implement them. A recent study by FAO and the Policy Innovation Systems for Clean Energy Security (PISCES) of 15 bioenergy initiatives in developing countries found that such initiatives bring real and sustainable benefits to poor communities in rural areas. The study also shows that environmental and social risks are minimized when such initiatives are small-scale and participatory (FAO-PISCES, 2009, FAO, 2010b).

Food safety and traceability

Every step along the supply chain is susceptible to contamination of food products. Poor or unhygienic handling of foods, inadequate cold storage systems, poor road systems that delay the delivery of perishable products, unhygienic processing equipment or packaging that does not adequately protect its contents: any one of these factors can result in the delivery of spoiled or unsafe food to markets – if it reaches the markets at all. And the longer the supply chain, the more likely it is that a problem will occur along the way.

49 www.fao.org/bestpractices/content/06/06_02_en.htm



Some have voiced the concern that by raising the bar for the safety and quality of food and agricultural products traded globally, international requirements will create new challenges for developing countries that want to maintain their exports or enter new markets. For example, it is often difficult for exporters in developing countries to comply with international standards and requirements imposed by importing countries. Others believe that WTO's Sanitary and Phytosanitary (SPS) and Technical Barriers to Trade (TBT) Agreements, which address health-related trade restrictions, have created new opportunities for developing countries, many of which rely heavily on food and agricultural production to generate economic development and reduce poverty through trade. Indeed, some countries and sectors have successfully expanded their exports of high-value and value-added food and agricultural products with spectacular results.

Traceability – the ability to follow the movement of a food through specified stage(s) of production, processing, and distribution (FAO/WHO, 2011b) – can be used to track products up and down the value chain. Traceability has become an integral element of national and regional food laws across the globe and is a fundamental component of the EU Rapid Alert System for Food and Feed.

Establishing preventive approaches and safe food practices at every point along the food chain is essential. The assurance of safe food requires following an integrated risk-based approach at all stages by which food passes to reach the consumer, including feed production, primary production, food processing, storage, transport and retail sale.

To this end, national assessments are needed to identify existing capacities and gaps in food safety processes. It is recognized that this can be a significant challenge, especially in many developing countries where food safety competes with several other important priorities for national attention and resources. Nevertheless, many governments now recognize the benefits of robust, multistakeholder discussions and, in some cases, collective decision-making in order to achieve sound food safety policies and programmes. Civil society, the private sector and other non-state actors have a stake in food and nutrition security and have much to contribute towards ensuring the effectiveness and safety of food chains.

Governments need to be able to demonstrate to their own populations as well as to their trading partners that they can guarantee a safe food supply. The need for public awareness about food safety and quality issues, particularly in developed countries, has never been higher. Consumers are growing more selective about the food they buy. They want safe food as a minimum but they also want a greater choice of food. Consumers' increasing demands are transforming the food and agriculture sectors.



Sustainable consumption driver of the green economy

Harnessing food demand increase

Rich consumer's growing demand for food products has a major impact on natural resources and drives prices increases which have a disproportionate effect on poor consumers. Poorest countries absorb a larger proportion of the quantitative adjustment necessary to balance supply and demand (HLPE, 2011). This is due to unequal repartition of elasticity of food demand to prices between countries: the richer countries have the lowest elasticity to price, meaning that they have more capacity to increase their food spending to maintain food consumption levels when prices go up. It appears that the difference in food price elasticity in the poorest and richest countries is increasing over time, and progressively puts a higher burden on the poorest countries in the global quantitative adjustment. This is why the High Level Panel of Experts on food security and nutrition (HLPE), in its report on price volatility to the Committee on World Food Security (CFS), recommends to curb the growth of global demand, including by reducing food waste.

In all scenarios where demand's increase is slowed compared to business as usual, consumers' behaviour is the driving factor (Agrimonde 2009, Erb *et al.* 2009, Grethe *et al.* 2011). Concerns for a more healthy and balanced diet and for a more sustainable way of life is leading to a shift towards "sustainable diets".

Reducing food waste

Abundance and consumer attitudes lead to high food waste in industrialized countries. Unlike in the developing world, people in rich countries can afford to waste food. In Europe and the USA, many restaurants serve buffets at fixed prices, a practice that encourages people to fill their plates with more food than they can actually eat. Retail stores offer large packages and "buy one, get one free" bargains. Likewise, food manufactures produce oversized ready to eat meals (Stuart, 2009).

Public awareness and education on the extent and impact of food waste could help change people attitudes and, eventually, their behaviour with regard to wasting food. Voluntary initiatives such as "Stop wasting food" in Denmark or "Waste not want not"



in the UK⁵⁰ give guidance to consumers on how to avoid wasting food by shopping according to daily needs of households, through promoting better household planning and shopping patterns in order to move from impulsive to rational food shopping and consumption patterns. Governments, through ministries of health, education, industry and trade, have programmes on how to combat unhealthy eating habits leading to food wastes in countries especially those with high levels of obesity. For instance, in 2000, the UK government created the Waste & Resources Action Programme (WRAP), a government-funded, not-for-profit company that advises people on how to reduce waste and use resources efficiently. In 2007, WRAP launched the “Love Food, Hate Waste” campaign and returned food waste to the forefront of the news and onto the public agenda. Opportunities could be explored to raise consumer awareness of food wastes by including information of losses and wastage as part of a labelling system or as information on strategic consumer food items. Public programmes should include a dialogue with the private sector, which plays an important role in influencing consumer choices in regards to shopping, preparation, consumption and waste.

High standards for appearance lead to food waste. Large portions of harvests are rejected by supermarkets in industrialized countries due to rigorous standards concerning weight, size, shape and appearance of foods. Even though some rejected crops are used as animal feed, food originally aimed for human consumption is wasted. High appearance standards also seriously affect the fruits and vegetables produced in developing countries for export to industrialized countries. Consumers could be questioned and offered a broader quality range of products in the retail stores. In addition, selling produce closer to the consumers, e.g. in farmers’ markets, without having to pass the strict quality standards set up by supermarkets on weight, size and appearance would possibly reduce the amount that is rejected (Stuart, 2009).

Unsafe food is not fit for human consumption and therefore is wasted. Failure to comply with minimum food safety standards can lead to food losses and, in extreme cases, have an impact on the food security of an entire country. Food must be produced, handled and stored in accordance with food safety standards. This requires the application of good agricultural and hygienic practices by all food chain operators.

Industrialized country attitudes that “disposing is cheaper than using or reusing” leads to food waste. Industrialized food processors lines often trim food products to achieve a standard shape and size and then throw away the trimmings. Food is also lost

50 www.lovefoodhatewaste.com/about_food_waste



when processing results in products in the wrong weight, shape or appearance or damaged packaging. In a standardized production line, these products often end up as waste (Stuart, 2009; SEPA, 2008). Both commercial and charity organizations could arrange to collect, sell or use “substandard” products that are still safe and have good taste and nutritional value.

There are also solutions to be found in the way products are marketed. Large quantities on display and a wide range and supply of product brands cause food waste in industrialized countries. Retail stores typically order a variety of food types and brands from the same manufacturer to get good prices. Consumers also expect a wide range of products to be available to them. Having a large quantity of products increases the likelihood of some of them becoming outdated before they are sold, and thereby wasted. This is a particular problem for small retail stores (SEPA, 2008).

Inadequate market systems cause high food losses in developing countries. Wholesale and retail markets in developing countries are often small, overcrowded, and unsanitary, and lack cooling and storage equipment. There may also be limited room for handling loading, unloading and ripening food (Kader, 2005). Marketing cooperatives provide a central point for assembling commodity produce from small farmers and preparing it for transportation to markets and other distribution channels. The marketing cooperatives reduce food losses by increasing the efficiency of these activities. Although the development of wholesale and retail markets should preferably be done by the private sector as commercial enterprises, local governments and marketing cooperatives can be instrumental in establishing and improving market facilities

In addition to reducing food waste *per se*, actions such as donating food, recycling, and converting organic waste into compost, animal feed or energy can all play a role in decreasing landfill emissions from food waste – although this would require safeguards against food safety risks. Grassroots movements have been taking a stand against food waste for years.

Until now, a lack of infrastructure has hindered large-scale efforts to reduce food waste. Recently, however, there have been some positive signs of change which may influence other actors along the food chain. In 2009, Wal-Mart, the world’s largest retailer, announced its goal to eliminate the landfill waste generated by its 4 400 USA stores by 2025.⁵¹ Two years later, the company confirmed that it had successfully diverted 80 percent of the waste from its California operations from landfills. Achieving a similar reduction in landfill waste across the country would help Wal-Mart prevent more than 11.8 million

51 www.greenbiz.com/news/2011/03/18/walmart-cuts-landfill-waste-80-percent-california



metric tonnes of carbon dioxide emissions every year. In 2010, Imperial College London formulated a plan to redirect food waste from the College's three restaurants from landfills to their newly designed composting unit. The unit turns the waste into compost, which is used to enhance the green spaces of the campus.⁵²

In 1999, the European Union laid down strict requirements for landfills to reduce their negative impacts on the environment, particularly on surface water, groundwater, soil, air and human health. The enforcement of the so-called Landfill Directive is expected to reduce the amount of organic material in landfill sites across the continent to 35 percent by 2016.

Recently, a Joint Declaration against Food Waste by representatives of universities and civil society was presented to the United Nations and the European Parliament. The declaration contains proposals for the sustainable use of food and calls for a commitment to the global reduction of food waste by at least 50 percent by 2025. It also suggests that reduction of food waste should be a new target within UN Millennium Development Goal 7: to ensure environmental sustainability.

Promoting sustainable diets

FAO defines sustainable diets as “those diets with low environmental impacts that contribute to food and nutrition security and to healthy lives for present and future generations. Sustainable diets are protective and respectful of biodiversity and ecosystems, culturally acceptable, accessible, economically fair and affordable, nutritionally adequate, safe and healthy, while optimizing natural and human resources” (FAO, 2010c).

In the early 1980s, the notion of “sustainable diets” was described by Gussow and Clancy (1986) to recommend diets healthier for the environment as well as for consumers. The concept of “sustainable diet”, borrowed from “sustainable agriculture,” refers to diets that minimize waste of natural resources and encourage consumption of local and seasonal products. With the food globalization process and the increased industrialization of agricultural systems that pays no attention to the sustainability of ecosystems, the sustainable diet's concept was neglected for many years. Recently, the interest on sustainable diets has again been raised by international scientific societies, institutions and governments (Esnouf *et al.*, 2011).

52 www.nextgenerationfood.com/news/imperial-college-works-to-reduce-food-waste



Consumer choice is strongly influenced by income, social and cultural factors, education and physical access to food. Major marketing campaigns by the private sector also can play a significant role, targeting particular sectors of society, for example women and young people. Information campaigns and labelling that promote awareness of the implications of food choices for nutrition, health and the environment can contribute to sustainable diets.

Informing the consumer on nutritional value of foods

National food-based dietary guidelines (FBDG) should counsel the need to reduce the consumption of highly processed energy-dense foods that have fewer health benefits than do fruit and vegetables or fresh fish. In addition, national guidelines should promote reducing the consumption of meat and dairy products and less reducing food wastage by consumers. The biological effects of food and food patterns can be greater than the sum of the parts but, to be effective, FBDG must take a number of factors into account: food/health patterns; relative comprehensiveness of the food-based versus the nutrient-based approach; practicality of the proposed goals for the guidelines; nutrition labelling that leads consumers to an over-simplified view of foods; shifting paradigms on the nutritional basis for diseases and health.

The study of energy balance and metabolism, along with macro- and micronutrient physiology, is already well established and has now evolved to take account of non-nutrient components in food. As far as energy is concerned, the next generation of FBDG can take account of both the lower limits of energy intake and the ways that energy balance can be achieved, with the emphasis placed on strategies to either decrease the energy density of diets or to increase energy expenditure. In this way, concerns about chronic energy deficit and excess body fat can be addressed through FBDG.

Micronutrient-rich foods are recognized as having an important contribution to prevent deficiency disorders and improve host defences to communicable diseases and may play a role in avoiding non-communicable diseases. Therefore, the formulation of FBDG in all food cultures with varying health patterns should take all nutrients into account. The development of informed dietary guidelines can help counteract the simplification of diets and the over-consumption of meat, and promote the consumption of a variety of foods, including local and traditional foods, as sources of food-biodiversity and good nutrition. However, the 2007 United States National Institutes of Health



(NIH) panel concluded that “the present evidence is insufficient to recommend either for or against the use of multivitamins and minerals by the American public to prevent chronic disease”.

Informing the consumer on environmental and social impact of food

There are increasing social expectations and consumer demands for more information about the environmental and social impact of food, which is also very symbolic of consumption as a whole even if it represents, in developed countries, a small and decreasing part of household budgets.

Public information can be dispensed through general communication, such as the “Guidelines for climate-friendly food choices” released in 2009 by the Swedish authorities which recommend that citizens reduce their meat and rice consumption as a way of reducing greenhouse gas emissions. Recommendations also include eating seasonal, locally-produced fruits, vegetables and berries, avoiding bottled water, soda and palm oil. This is also an aim of the Finnish project on the evaluation of the carbon footprint of meals mentioned earlier.

France has adopted a very ambitious law which would make mandatory information on the environmental impact of every product, including food.

NGOs periodically communicate about the environmental or social impact of certain products, often in relation to their origin, which is successful in raising awareness on a particular issue. It is said that NGO actions played a role in the evolution of the Brazilian beef industry and the reduction of deforestation.

Most of the information conveyed to the consumer about food is communicated by producers, either individuals or brands and by retailers. This information can be conveyed directly, in markets or in small shops where personal contact creates confidence. However, in longer food chains, information has to be transmitted all along the chain. In that case it sometimes includes only information about initial stages or gathers information about all the transformation process. To answer consumer demand, there are a growing number of private standards, implemented by industrials and retailers, sometimes with the involvement of NGOs. Most of them concern either social or environmental issues, or some environmental issue such as biodiversity or climate change. There is for instance a growing number of carbon footprint schemes (OECD, 2009).



Opening consumer choices

Consumer choice can play a leading role in Greening the Economy, by selecting certain types of products, according to their place of origin, process of production, or producers. By accepting to pay a little more for these qualities, consumers can both drive sustainable production and create value for small producers. By selecting and by accepting to pay more, they also acknowledge more symbolic and economic value to food, thus harnessing demand and reducing waste while adding value for producers.

In many developed countries, consumers have lost the daily perception of food being produced by farmers, using natural resources and managing landscapes (Sissons, 2001).

This is largely due to globalization and increased consumption of transformed products. There is now a trend to rediscover the link of food to its area of production, to the people who produce it and the way they produce it. This trend manifests itself in various forms: growth of local markets, development of geographical indication schemes, voluntary sustainability standards, including fair trade and organic. All of these also convey the image of farming and farmers and of the cultural and social values associated to food production and consumption.

Local food

The newfound growth in local food systems suggests that significant demand exists for locally produced foods (USDA, 2010). Interchangeable terms such as “local food,” “local food system” and “(re)localization” refer to food produced near its point of consumption (Peters *et al.*, 2008).

In countries such as the USA, the growing interest in local foods has been sparked by a number of social movements:

- the environmental movement encourages people to consider the environmental dimensions of their food choices, based on their advocacy of the sustainable management of resources;
- the food security movement seeks to enhance access of all consumers to safe, healthy and culturally appropriate food;
- the anti-globalization movement challenges the dominance of large food corporations;
- interest in local foods also reflects an increasing interest by consumers in supporting local farmers and in better understanding the origins of the food they eat (Ilbery and Maye, 2005; Pirog, 2009).



The emphasis of local food systems is on geographical location rather than on origin. In the USA, according to the definition adopted by the 2008 US. Farm Act, the total distance that a product can be transported and still be considered a “locally or regionally produced agricultural food product” is less than 400 miles from its origin, or within the state in which it is produced.” However, defining a system as local, based on market arrangements, including direct transactions between farmers and consumers and sales by farmers to restaurants, retail stores, and institutions is well recognized (Martinez, 2010). Direct sales of local foods to consumers can take place in farmers’ markets, fish landing sites or local fish markets, through community-supported agriculture organizations, on-farm sales, and “pick your own” operations and even through direct sales from food-processing operations.

Box 22. Direct sales in the USA

According to the 2007 USA Census, 136 800 farms, or 6 percent of all farms in the United States, sold USD 1.2 billion worth of farm products directly to consumers (USDA, 2010). The number of farmers’ markets around the country rose to 6 132 in 2010, a 16 percent increase from 2009, according to USDA’s Agricultural Marketing Service. In 2005, there were 1 144 CSAs in operation, and by 2010, an online registry estimated that the number exceeded 2 500 (Local Harvest, 2010). Popular Web sites facilitate online purchases of local food. Consumers can learn about the producers, link to their Web sites and place orders, which are paid through Internet payment sites such as PayPal (one example is the www.farmersonlinemarket.net/index.cfm).

As food companies strive to grow or maintain their market share, the mainstream distribution channels for food products are changing as more and more supermarkets install local food sections in their stores (Smith, 2009). In the USA, several leading retailers, such as Wal-Mart, Safeway and Publix, have recently announced local food initiatives. Kenyan supermarkets are struggling to keep up with the demand for African leafy vegetables in the wake of a major promotional campaign launched by Bioversity International in 2000.



Retail food cooperatives are another distribution channel for local foods. These organizations are owned and operated by their consumer members who receive price discounts. Co-ops routinely stock products in bulk and are committed to purchasing organic and locally grown foods. A growing number of restaurants exclusively offer local foods and are willing to have a more limited menu in order to offer in-season products that they believe their customers will prefer.

Farm-to-school programmes are an important part of the institutional market for locally grown produce. School food authorities buy fresh produce directly from local farmers or sponsor school garden projects or field trips to nearby farms as part of a nutrition education curriculum. The supporters of such programmes believe that they provide many benefits to both students and small farmers (Joshi and Azuma, 2009). The National Farm to School Network, a collaboration of groups that support farm to school programmes, estimated that there were 2 051 farm to school programmes in the USA in 2009, twice as many as in 2005.

In the Brazilian Zero Hunger programme, prioritization of direct purchase for school meals from social organizations or settlers of the agrarian reform, indigenous people, quilombolas and women also participates in the main programmes for the development of family, traditional and peasant farmers in situations of social and economic vulnerability (Moreira 2010).

As of 2009, 284 hospital facilities in the USA, including several private corporate hospitals, had signed the Health Care Without Harm Healthy Food Pledge to increase offerings of fruits and vegetables, along with minimally processed foods. The pledge also obligates the hospitals to identify and adopt sustainable food procurement, including purchasing local foods, and to promote and educate their patients about healthy foods (USDA, 2010).⁵³

Environmental benefits of local systems are often presented as a transport issue, as “food miles”. Such a presentation is totally misleading. First because GHG emissions is only one of the environmental impacts of food systems. Second because transport represents a small part of them, and half of the transport emissions are caused by consumers. In fact, the global impact of food production is linked to the efficiency of the food chain as a whole. Being local does play a role, mostly for fresh products, and most of the local systems are

53 For more detail, see: www.noharm.org/us_canada/issues/food/signers.php



adding value, both symbolically and economically in terms of providing food and induced benefits. These include:

- greater availability of more nutritious local fruits and vegetables;
- reduction of food safety risks as a result of decentralized production (Peters *et al.*, 2008);
- conservation of farmland by allowing residential communities to be established on farms in urbanizing areas (Ikerd, 2005);
- provision of incentives for small farmers to stay in rural areas, instead of moving to the cities without employment;
- development of a sense of pride and social cohesion in a community;
- protection of agricultural biodiversity (Goland and Bauer, 2004).

Research has found that expanding local food systems in a community can increase employment and income (USDA, 2010). It also can have a positive impact on overall economic activity through import substitution and localizing processing activities.

However, expanding local food systems may be difficult for local food producers who most often run small-scale farms and cannot easily meet demands for high volumes while ensuring consistent quality, timely deliveries, and out-of-season availability (Shipman, 2009; Abate, 2008; Gregoire *et al.*, 2005). It may also be difficult for small growers to scale-up production, because much of their time is spent away from the farm selling their products.

In developing countries, high levels of poverty, unemployment and food insecurity often prompt urban migration, yet these conditions persist for rural people who settle in the cities. Poor urban households spend up to 80 percent of their income on food, making them extremely vulnerable when food prices rise or their incomes fall. Urban and peri-urban agriculture (UPA) – the production, processing and marketing of food in and around cities – can contribute to hardier urban food systems, while providing significant additional benefits, thus increasing food security. Growing a wide range of fruits and vegetables in and around cities increases the access of the urban poor to fresh, nutritious produce. By diversifying urban income sources (from production, processing, value-addition and marketing), UPA enhances the resilience of livelihoods to economic downturns and food price hikes and contributes to the economic development of cities. The relative proximity of urban markets to the production site allows for a daily supply of produce with lower transport and storage expenses and reduced post-harvest losses. UPA also creates employment for the jobless.



UPA can also contribute to a safe environment and a healthy community. Linking waste management to agriculture (e.g. by recycling organic waste materials as mulch or compost) helps keep the urban environment clean, reduces health hazards from waste, and boosts the production of fresh food. Because UPA eliminates the need to transport produce from distant rural areas, it can generate fuel savings and reduce carbon dioxide emissions and air pollution. Moreover, UPA lowers city temperatures by using available land for green surface including shade trees and fruit trees. When appropriately practised on greenbelts, it also can stabilize environmentally fragile lands, such as hillsides and riverbanks, thus preventing landslides and flooding. Finally, UPA provides an innovative approach to urban development and an example of good governance in action.

Quality associated to the place of origin

Some agricultural and food products are distinguished from one another by certain characteristics, qualities or reputations resulting essentially from their geographic origin. This differentiation can be attributed to the unique local features of the product, its history or its distinctive character linked to natural or human factors such as soil, climate, local know-how and traditions, which all are covered by the term “*terroir*”. These products of origin-linked quality can increase food security, as much as they contribute to rural development and the preservation of food diversity, while also offering consumers a wider choice. Indeed, thanks to the link between such products and their areas of origin, they can help preserve local resources, maintain traditions and strengthen the organization of local stakeholders.

Strengthening the ties among local stakeholders, places and agricultural and food products is a major step towards sustainable rural development. These relations are based on local capacities to create value within a global market, while remaining anchored in a specific place. Origin-linked products have specific quality attributes that are inseparably linked to the places where they are produced and that build up a reputation over time, associated with a geographical indication (GI) that identifies them.

These differentiated products can thus meet a specific and remunerative demand. Consumers are increasingly concerned with the specific attributes of agricultural and food products, particularly in terms of their culture, identity and means of sustainable production. Moreover, such products can contribute to biodiversity preservation, cultural heritage protection, sociocultural development and rural poverty reduction.



The identity of GI products as differentiated origin-linked products reflects the unique combination of local natural resources (e.g. climate, soil, local animal breeds and plant species, traditional equipment) and cultural assets (traditions, know-how and skills) often handed down from generation to generation in a given territory, thus establishing specific links between the product, local stakeholders and the territory.

An origin-linked product can become the pivotal point of a specific-quality virtuous circle within a territorial approach, meaning that its promotion as a GI product can have positive effects that are reinforced over time, allowing preservation of the agrifood system and related social networks. This, in turn, contributes to economic, sociocultural and environmental sustainability (FAO, 2010d).

Box 23. Nakornchaisri Pummelo (Thailand)

The pummelo, a tropical or near-tropical fruit native of Southeast Asia, is the principal ancestor of the grapefruit. It flourishes naturally at low altitudes close to the sea, but because of its restricted cultivated areas, its production is often overshadowed by that of grapefruit. It is well-known to be a luscious fresh fruit and is more popular than grapefruit for many consumers in the Far East. It is claimed that the Nakornchaisri pummelo's (Thailand) quality attributes stem from human intervention through specific farming traditions and production skills, coupled with unique geographical conditions. Nakornchaisri pummelo is sought out by discerning consumers and growers who are willing to pay a high market price. In 2005, the Nakornpathom Chamber of Commerce established a GI for the fruit, to identify the product and to protect and promote its market value.

GIs can be a very important determinant for higher market prices. For export, purchasing price and fruit quality, Nakornchaisri pummelo have been used as a benchmark for fruit from other regions. Although supply from other regions of the country is increasing, consumers currently are willing to pay a higher price for fruit claimed to come from the GI-designated area of Nakornchaisri. Traders rely mainly on consolidators to ensure the origin of the area of production, thanks to the trust that has been established through a long-term working relationship between exporters and consolidators (RAP, 2010).



Voluntary sustainability standards

There is a growing number of voluntary sustainability standards, generally focused on a single dimension of sustainability. An ecolabelling fisheries scheme promoted by the Marine Stewardship Council (MSC), an international NGO, is an environmental standard for sustainable and well-managed fisheries and uses a product label to reward environmentally responsible fishery management and practices. It is now increasingly adopted by retailers worldwide. Other NGOs such as the Rainforest Alliance are involved in development of various standards and certification programmes, including sustainable agriculture, forestry and tourism.

Good Agricultural Practices (GAP) standards have recently been developed by the public and the private sector. Many countries have developed national GAP programmes, with the objective of improving the basic agricultural practices in the country, such as the Chile GAP, China GAP, Kenya GAP, Viet Nam GAP, SALM in Malaysia.

Integrated Pest Management (IPM) programmes set standards developed by producer organizations (usually in a participatory manner) to reduce use of pesticides in farming systems. The standards developed are then integrated into other schemes, or used as an extension method with a local certification system. The focus of these programmes is often on local markets, depending on market opportunities.

Fair trade is seen as international trading relationships that offer more favourable terms of trade to producers than conventional trade. This permits them to develop a socially and environmentally sustainable production system. In 2001 the main actors adopted the following definition for fair trade: “Fair Trade is a trading partnership, based on dialogue, transparency and respect, which seeks greater equity in international trade. It contributes to sustainable development by offering better trading conditions to, and securing the rights of, marginalized producers and workers – especially in the South.” New fair-trade certification systems have been developed by various actors, including importer groups (e.g. Bio-équitable by French importers) and certification bodies (e.g. IMO and Ecocert). In addition, public authorities in some countries have started establishing regulations for fair trade (e.g. France and in the European Union).



Organic agriculture

The market for organic products is still relatively small (2 percent of global retails), but growing significantly worldwide, thus providing trading opportunities for developing countries. Consumer attitudes to organic foods are complex, often linking food to health, the environment, ethics and identity. Some consumers also believe that organic foods are more nutritious and are ready to pay higher prices (Kearney, 2010). The global organic market size was USD 55 billion in 2009, a threefold increase from USD 18 billion in 2000, with double-digit growth rates each year, except in 2009, when it still grew by 5 percent in spite of the financial crisis. Growth is expected to pick up again, due in part to increasing organic conversions in developing countries (China, India) (FIB and IFOAM, 2011). Many governments in both developed and developing countries have announced their objectives of increasing organic farming practices. However, while there are significant government subsidies in developed countries, there is little financing for organic farming in developing countries. More pro-active measures are required in developing countries to promote organic farming and to overcome obstacles to production, marketing and trade.⁵⁴

The first problem is the absence of, or grossly inadequate, public-sector financial or technical support for organic agriculture.⁵⁵ This is in contrast with the situation in some developed countries, where subsidies are provided to agriculture in general, including to organic farmers. Another major problem involves the difficulties faced by developing-country producers in adherence to standards for organic foods. This is not so much an issue at the national level, but is a major problem for potential exporters. At local markets in Asian developing countries, the personal guarantee of organic farmers (and in producer-consumer partnerships) is usually considered sufficient, a common practice in small towns and villages across Asia (UNCTAD, 2004). However, compliance with many standards and certification systems is needed when the organic foods are to be exported. As UNCTAD (2004) points out, it is important to find a balance between the need for harmonization for trade and fair competition, and the need to take account of local and regional conditions and requirements.

54 Many of the points that follow are made in UNCTAD (2004), Trading opportunities for organic food products from developing countries; UNEP/UNCTAD (2008), Best practices for organic policy; UNEP/UNCTAD (2008), Organic agriculture and food security in Africa.

55 UNCTAD (2008) notes that the early drivers of organic farming in developing countries are NGOs and the private sector, with governments rarely playing any role in the early stages.



A related constraint on exports is the lack of assured markets and price premiums. Developing country exporters face obstacles in the form of certification costs, technical standards and sanitary and phytosanitary requirements. Also, the organic vegetable and fruit markets in developed countries tend to rely on locally produced foods, which is a barrier to exports from developing countries.

The lack of marketing networks and partners is another major problem facing potential exporters in developing countries. They need to design marketing strategies, seek more direct links to retailers in importing countries and create partnerships. This could begin with fair trade organizations, which are helping small producers to benefit from trade.

UNCTAD (2004) has proposed steps to reduce certification costs in developing countries, including development aid to assist governments in poor developing countries to meet certification standards of developed countries, and encouraging countries with large potential to set up their own national standards and national certification systems.

To overcome the expense of third party certification faced by small farmers in developing countries, schemes have been developed such as participatory guarantee systems and group certification. These alternatives are more accessible to smallholder farmers in developing countries, but also can provide the quality assurance that consumers need, and should therefore be further promoted.

Empowering smallholders to access global markets

Over the past couple of decades, income growth and rising populations in developing countries have greatly expanded the demand for high-value food products (HVFPs), including meat, dairy products and a wide variety of fruits and vegetables. A rapid growth in urbanization has exposed people to new food options and urban lifestyles have led to increased purchases of prepared foods.

As the domestic demand for HVFPs has grown in developing countries, so too have the net exports of HVFPs – including fruits, vegetables, poultry and fish – to industrialized countries. The export of fish has become a major growth industry in recent years, often exceeding the combined value of net exports of coffee, tea, cocoa, bananas, and sugar. Today, the HVFP sector has a dynamic global market presence. The challenge is to ensure that small-scale farmers in developing countries are able to participate in this rapidly growing sector and that artificial advantages benefiting large domestic enterprises do not drive them out of business.



Small-scale producers face many challenges. These include being able to anticipate market demand for products and to find the right market niche. Markets can be volatile and staying on top of demand requires gaining access to timely and accurate information, often a difficult task in developing countries. Many small-scale producers lack the technical capacity to, for example, process a high quality product while complying with food hygiene and quality requirements, and meeting customer demands. They may also lack the human capacity to negotiate and fulfil contracts with buyers.

Small-scale participation in the livestock and fisheries sectors can be problematic. Investment in technologies for ensuring the required quality standards and controlling animal diseases is often beyond the means of independent small-scale producers, effectively keeping them out of export markets since private quality standards disease-free certification is often required for export. Without proactive development support and policies to keep smallholders involved, large-scale livestock and fish sectors will dominate export markets, while a static smallholder sector will compete for the low end of the domestic market.

The establishment of marketing cooperatives and contract farming schemes has proven to be an effective strategy for supporting small-scale producer involvement in HVFP markets. The commitment of governments to facilitating smallholder production and the active participation of smallholder farmers in the management of smallholder schemes are key success factors.



Box 24. Private initiatives and public-private partnerships

Côte d'Ivoire. A public-private partnership involving Kraft Foods and cocoa producers in Cote d'Ivoire helped six Ivorian cooperatives, representing over 2 000 farmers, gain the Rainforest Alliance Certified (TM) seal. The seal attests that the cocoa products meet rigorous international standards, increasing their appeal among customers seeking green goods and services. The project trained nearly 6 000 farmers in sustainable production practices and almost 6 000 tonnes of cocoa were certified, for which the farmers received a total of USD 1.2 million as price premiums.

Viet Nam. The multinational dairy company, Royal Friesland Campina, has established 39 collection points throughout Viet Nam where farmers can sell their milk directly to the company. The collected milk passes through one of three cooling centres before being transported for processing under the Dutch Lady brand. The company also helps local farmers improve and increase their milk production by, for example, advising on matters of hygiene. By the end of 2006, there were about 2 300 farmers participating in the programme and they supplied more than 90 tonnes of fresh milk per day.

Kenya. Starting in 1989, Frigoken, a company of the Aga Khan Fund for Economic Development, began providing a number of services to Kenyan bean farmers, including price guarantees, seeds, quality control, processing, transport and marketing. The company works with a network of small, individually owned plots. Beans are cultivated throughout the year, guaranteeing a steady income to farmers. Today, Frigoken is the largest exporter of processed green beans from Kenya, accounting for over 80 percent of total exports. Most of the beans are sold on European markets under well-known brand names. The company currently provides direct employment to over 2 700 people, most of whom are women, and supports over 20 000 small-scale farmers in rural areas of Kenya.





Colombia. The Federación Nacional de Cafeteros de Colombia was founded in 1927 as a non-profit business association to promote the production and exportation of Colombia coffee. Best known for its Juan Valdez marketing campaign, the Federation currently represents more than 500 000 local farmers and small producers. The Federation promotes fair trade and ensures that farmers are able to receive reasonable benefits. Today, Colombia is the largest producer of coffee in the world.

India. SABMiller's investment in the "Progress through Partnership" programme provides rural smallholder Indian barley farmers with access to the beer manufacturer's supply chain. Farmers receive a preferential price by selling directly to SABMiller rather than going through agricultural middlemen. These higher prices translate into a real income hike for the farmers involved in the programme. In the 2008–2009 growing season, farmers earned approximately 10 percent more than they had the year before. In addition, all 8 000 member farmers receive technical advice and assistance from trained agriculturists.



Conclusion: towards improved food systems and sustainable diets

The environmental, economic and social impacts of food systems vary widely, depending on the products and resources concerned and the countries where they occur. Improving food systems for sustainable diets, while stemming the degradation of ecosystems and the erosion of biodiversity, is a huge challenge. It requires programmes and policies that support ecologically balanced food production, distribution, supply and consumption. It requires identifying leverage points in supply chains that can be used to direct the choices and behaviour of consumers towards more sustainable diets, including encouraging shorter chains based on locally produced food. This approach taps into the green economy by connecting the nutritional wellbeing of the individual and the community to the environmental sustainability of feeding the planet. It promises a major contribution to the achievement of the MDGs on hunger and environmental sustainability.

Improving food systems for sustainable diets worldwide requires worldwide action, because food systems are both local and global, because they have local and global environmental, economic and social impacts. Global increase of demand for food and feed has a huge impact on the environment. Overconsumption causes wastage, overweight and obesity, but also drives price increases and represents a major cause of hunger and malnutrition.

Restoring balanced diets is not only indispensable for individual human health, it is also essential to restore a balanced consumption worldwide, to protect ecosystems and natural resources. Sustainable diets are key to sustainable production and consumption of food.

To progress towards sustainable diets, nutrition has to be integrated as a core concern of every policy directed to food systems. Agricultural policies and programmes should be designed at every level to improve diets, not only on quantity but on quality, nutrient content and food safety, and on diversity, taking account of the nutritional value and complementarities of productions. This will require more knowledge on the nutritional value of species and varieties, and of the interactions both in the field and in diets. It will also require integration of nutrition as an integral part of knowledge dissemination, education and extension. Preserving nutritional qualities all along food chains needs



to be a primary concern. Informing and educating consumers should involve not only governments but also agro-industry and retailers.

Demand tends to be presented as an external, exogenous variable, on which no control is possible. But this is not true. Demand is influenced by policy choices, including the issue of biofuels (HLPE, 2011). In developed countries where spending on food is low compared to incomes, there might be a margin to integrate negative externalities in the cost of food, as well as for the reorientation of distortive subsidies towards sustainable production (Foresight, 2011, Grethe *et al.*, 2011, McMahon, 2011, HLPE, 2011).

Reducing losses and waste and increasing overall efficiency of food chains can go a long way towards increasing food availability and reducing environmental impacts. It will necessitate a holistic approach, involving governments and all actors along food chains. In developing countries, better organization of economic actors and development of appropriate practices and technologies can add value at every stage while increasing availability to consumers. In developed countries, consumer behaviour is key to reducing waste at consumer level and to addressing some of the losses which are provoked by anticipation of consumers' supposed wishes. Raising awareness through information and communication should involve all stakeholders concerned.

Voluntary standards on sustainability can play a key role in enhancing sustainable consumption as a driver of sustainable production. However, making them effective requires more accurate tools to assess sustainability and transparency, and comparability in the way the information is communicated. Mutual recognition of schemes should be pursued, as this will facilitate their adoption by the various actors and reduce costs.

Acknowledging the true value of food – nutritionally, symbolically and economically – is a major driver towards more sustainable diets.

To satisfy the needs, in quantity, quality and diversity while preserving fragile resources, requires considerable changes in food systems. This includes working towards greater resource and nutritional efficiency at every stage, from agricultural production to consumption. It requires empowering consumers, by giving them choices and means to exert them, including accurate and comparable information on nutritional value and environmental impacts of food. When all are taken together, they can improve sustainability of diets by harnessing demand, improving health and preserving resources while creating value for producers. It requires enabling policies and the strong involvement of the private actors.



G E A - U T I L I Z A T I O N

Achieving these aims requires the involvement of all actors concerned. FAO and UNEP have formed a joint Sustainable Food Systems Programme to improve resource use efficiency and reduce the pollution intensity of food systems from production to consumption, while at the same time addressing issues of food and nutrition security. The programme brings together a broad coalition of stakeholders concerned, including governments, food and fish producers, agro-industry, retailers and consumers. This action is emblematic of the necessity for a very strong involvement of all stakeholders, including the private sector, supported by public policies, to achieve the necessary transformation of food systems.

The Green Economy will go a long way to facilitate the needed transformations of the food systems towards sustainable diets. Transforming food systems is at the very centre of the Green Economy, considering their impact on natural resources, on human well-being and the importance of the sector in rural economies and in developing countries.



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GEA

Greening the Economy with Agriculture refers to ensuring the right to adequate food, as well as food and nutrition security – in terms of food availability, access, stability and utilization – and contributing to the quality of rural livelihoods, while efficiently managing natural resources and improving resilience and equity throughout the food supply chain, taking into account countries' individual circumstances. FAO Council, 2011

