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Economics of Food Security: Selected Issues

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Abstract. The present article reviews selected key challenges regarding food security from both an academic and policy-oriented angle. In the analysis of the main constraints to achieve food access and availability in low and high-income societies, a detailed distinction is made between technological and institutional aspects. In the case of low-income economies, the emphasis is placed on the socio-economic situation and performance of small-scale farmers while in high-income economies the focus is shifted towards issues of price volatility, market stability and food waste. In both scenarios, productivity and efficiency in the use of resources are also considered. The objective of this assessment is to identify the type of policy support which would be most suitable to fulfil the increasing food demand. Innovation programmes and policies which integrate institutional coordination and technical support are put forward as strategic tools in the achievement of food security goals at regional and global level.

Key words. Food security, technology and innovation policies, small-scale farmers, market stabilization

JEL codes. Q18, Q16, Q01

1. Introduction

«Food security exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life. The four pillars of food security are availability, access, utilisation and stability. The nutritional dimension is integral to the concept of food security» (World Summit on Food Security, Rome, November 2009).

The concept of food security has been present in the policy agenda for many years now and in this particular context, it appears to have evolved into two yet complementing themes as the world is said to be in a status of post-food surplus disposal (World Food Programme, 2007). On one hand, there is the urgent issue of under-nourished people that are mainly located in rural areas of low-income countries, where local access to food, technology and natural/agri-resources is the major constraint. On the other hand, high-income countries feel threatened by volatile food markets (e.g. meeting G20 Agriculture Ministers, 2011) and are primarily concerned with long-term strategies that will guarantee

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food availability and affordability in the medium and long run as the competition on limited resources continues to increase.

From an academic outlook, the discussion on food security touches on several aspects. One relevant subject is that of how to increase agricultural productivity where the role of technology adoption, the declining effects of the green revolution, the potential benefits of incorporating biotechnology, among others, are assessed (Pingali, 2007; Otsuka and Kalirajan, 2005; Estudillo and Otsuka, 2004; Pingali and Traxler, 2002; Evenson, 2001, 2003; Lipton, 2001). Another thematic trend in the scientific literature is concerned with the macroeconomic analysis of price volatility, trade and market stability (Gilbert and Morgan, 2010; Apergis and Rezitis, 2011). Likewise, the effects of the demand for biofuels, farmland acquisition/investments and the food price crisis on small-scale farmers have also been well-documented topics (Swinnen and Squicciarini, 2012; Dauvergne and Neville, 2010; Deininger, 2008; Ivanic and Martin, 2008).

The aim of this paper is to explore the two main policy angles to food security briefly introduced above and assess their related obstacles under the light of academic findings. For this purpose, section 2 examines the most pressing food security challenges from the respective view of low and high-income countries. Section 3 discusses potential opportunities and focuses on initiatives which may contribute to reducing hunger and malnourishment while also securing food availability and environmental sustainability at a global level. This section concludes by highlighting the strategic relevance of integrating institutional and technological innovations to achieve food security goals in the short and long term.

2. Analysis of food security challenges in high and low-income countries

About one billion people globally do not have adequate food to meet their basic nutritional needs (FAO, 2010a) and according to the IFAD 2011 Rural Poverty Report, the under-nourished mainly belong to the poorest households in rural areas. If we take into consideration that over 80 percent of rural households are said to depend directly on farming and agriculture (IFAD, 2011), the development of the rural and agricultural economy becomes pivotal to reduce poverty and hunger worldwide. In addition, there is evidence that the proportion of farmland cultivated in small holdings has been growing since 1960's, particularly in Africa and Asia (Lipton, 2006).

Sen (1998) and others (Tomlinson, 2011; Smith et al., 2000) argue that the dynamics of income earning and of purchasing power may indeed be the most important component of food insecurity and starvation. In this respect, Smith et al. (2000) analyse fifty-eight developing countries with high prevalence of food insecurity. Their findings indicate that there was little correlation between national food availabilities and food insecurity. In their study, food availability is measured in terms of daily per capita dietary energy supply and balance while food insecurity is defined following the guidelines established by FAO. Interestingly, the group of countries which exhibited the highest severity of food insecurity were those with high poverty, yet, high food surpluses. The latter is consistent with the view that poverty is the most widespread cause of food insecurity for the selected countries in the time period covered by this study (1990's). The emphasis in the academic literature is thus placed on food access (or the capacity of households to fulfil their minimum dietary needs) as the main limiting factor of food security.

However, the current policy debate on food security is strongly dominated by the issue of food availability and affordability, particularly in high-income societies (although some low-income countries have also taken protective measures such as banning of grain exports to maintain national stocks at times of food price pikes). Reports from both international organisations and the agricultural industry have claimed (and worked under the statement) that in order to meet the food requirements of the nine billion population of 2050, an expansion of food production of 70 per cent is needed (with a base reference of 2006). While Pretty et al. (2010), FAO (2009a; 2009b) and Godfrey et al (2010) work with the «70%» figure, others such as Tilman et al. (2011) have forecasted that a much higher increase in global crop supply will be needed, i.e. 100-110 per cent increase from 2005 to 2050.

It is worthwhile to dwell on the origins of the rather quoted estimate of 70 per cent increase of food production. Tomlinson (2011) offers a critique by arguing that this «70 per cent» figure does not correspond to an increase in actual tonnes of production or yields but the aggregate volume produced within the crop and livestock sectors, which is calculated by multiplying the different quantities by the price of each commodity. In this estimation, fruit and vegetables are excluded and if the weight of the actual production was used, the figure would, for instance, be reduced by 6 per cent. Another fundamental issue is that the 70 per cent estimate does not account for wasted food or matters related to unequal food distribution and access. Regarding food waste, it is estimated that the loss may rise to almost one third of harvested crops. The average current global edible crop harvest is said to be about 4600 kcal per person per day, but harvest and distribution losses along with post-consumer waste cause the loss of 1400 kcal (Smith, 2000 and Lundqvist et al., 2008; cited by Tomlinson, 2011). If reductions on food waste could be effectively implemented, it is plausible to assume that the «70 per cent» level estimations could be lowered.

Despite the limitations of this quite fragile figure, it cannot be ignored that feeding a growing population with limited resources and in a sustainable manner is undoubtedly a challenge and it is clearly justified to plan ahead and to be proactive in designing preventive measures. Yet, a balance must be sought since the focus on the estimation of future food requirements should not lessen the importance of addressing the particular challenges of the food vulnerable or the (semi-)subsistence / small-scale farmer located in low-income areas. It is therefore necessary to establish a common starting point for an analysis based on institutional coherence, technology transfer and support aimed at achieving food security for low and high-income societies.

In sub-section 2.1, food (and nutrition) insecurity is assessed at the rural sector and farm level of low-income countries. The emphasis on the rural areas of developing countries is based on the fact that notwithstanding the changing demographic trends (increasing displacement to urban centres), nowadays the majority of the food-insecure and poor still belong to the rural economies and are highly dependent on farming. In sub-section 2.2, the food security challenges from a high-income society perspective are addressed. Instability brought about by volatile food markets in recent years is discussed along with an examination of key drivers for future demand and supply. In addition, the less obvious aspect of over-nourishment is also briefly discussed.

2.1 Food security in low-income countries: the rural and farm level perspective

A natural starting point of analysis of the food access question is that of rural and agrarian economies in low-income areas and the ability of their population to secure higher income, improve production and enhance livelihoods. (Semi) Subsistence farmers often rely on their production to secure only partially their household consumption, which is far from reaching the nutritional balance required for a healthy life. Therefore, the focus of this section is now on to the main technological and institutional obstacles preventing rural farm households from meeting their dietary needs. First, the technological and physical (including the pressures on the fragile natural resource base) constraints are taken into consideration before moving on to the institutional barriers.

2.1.1 Technological, scientific and physical constraints

African countries are said to currently achieve less than 30 percent of their potential yield (World Bank, 2010; Deininger, 2011). This would imply that substantial increases in cultivated land may not be an absolute requirement and forest cover need not be substantially reduced in order to effectively increase agricultural output (a positive announcement, particularly in terms of climate change impact reduction). In fact, it is estimated that «in developing countries, 80 percent of the necessary production increases would come from increases in yields and cropping intensity and only 20 percent from expansion of arable land» (FAO, 2009a). In other words, the current technology level in the agricultural sector of most low-income areas has substantial room for improvement without necessarily expanding arable land area. This, however, entails that technology must be not only developed and adapted to the needs of non-temperate climates in low-income countries but that an effective diffusion mechanism must be in place along with timely access to agricultural inputs. Likewise, agricultural practices must be adapted so that a sustainable use of natural resources is ensured. Each of these obstacles is next explored in detail.

Regarding the development and access to yield-improving technology which is tailored to the specific agro-ecological setting of low-income countries several aspects must be considered. According to Pingali (2007) recent developments in genetically modified crops are promoted by large multinationals that focus on relatively few (tempered weather-based) crops excluding crops in tropical, arid, marginal or stress-prone environments. Simultaneously, other academics are in favour of greater precaution in the application of biotechnology outside the contexts of high-income countries and temperate climate and advocate for more research on its unknown effects, especially in tropical regions (McAffee, 2004; Serageldin and Persley, 2000). Currently, many low-income countries do not have the technical and regulatory capacities to assess the benefits and costs of modern biotechnology in their domestic agriculture and eventually to monitor the inclusion of transgenic crops in their agriculture (FAO, 2009a). In the meantime, academic findings suggest that the positive effects of the green revolution technology on the yields of the main three cereals (maize, wheat and rice) have started to stagnate or decline. Adlas and Alchot (2006) analyse long-term yield growth of rice in various ecosystems and states of India between 1967 and 1999. Their findings indicate that yield growth (of areas where adoption of modern varieties and irrigation coverage were nearly complete) slowed down during the late green revolution period (i.e. after 1985). Pingali (2007) argues that the decline in the productivity

growth rates of the three primary cereals may be attributed to: 1) Degradation of the land resource base due to intensive cultivation 2) Declining infrastructure and research investment and 3) Increasing opportunity cost of labor (mainly arising from the off-farm sector). FAO (2009a) has also recorded a (at global level) decline of the rate of growth in yields of the major cereal crops from 3.2 percent per year in 1960 to 1.5 percent in 2000; although the decrease may be higher in climate or resource-stressed areas. The challenge for technology is to reverse this trend and to re-focus agricultural research on the particular physical and technological constraints of farmers in low-income countries in order to close the yield gap while attempting to promote a sustainable use of natural resources.

Other obstacles are related to the elimination or substitution of agricultural practices which hinder sustainable and productive processes. The latter are mainly related to the adequate management and use of land, water, pesticide and fertilizer. For instance, the reduction of land degradation would require not only the introduction of minimum/zero tillage and the prevention of soil erosion but also a balanced nutrient and water access. In the case of tropical agriculture, efforts should be targeted to securing sustainable alternatives to the «slash and burn» system. Water management is also of great importance. Irrigated agriculture covers one fifth of arable land and contributes nearly 50 percent of crop production (FAO, 2009a). Water scarcity could turn into a major problem if deforestation rates are not controlled or if irrigation systems are not efficient (i.e. water logging and salinity resulting from excessive water use and poorly designed drainage systems) (Ali and Byerlee, 2001). Adequate pesticide use and research on potential effects are pending tasks for most agricultural sectors in low-income areas. According to Ruttan (2000) there are shortcomings (some of which may be even unforeseeable at this point) in the use of pesticides and pathogen resistant crop varieties since an appropriate assessment of long-term impact for tropical and other non-tempered environments has not been fully undertaken. Clearly, uncontrolled use of chemical methods to deal with plant or animal pests may induce to the evolution of more resistant pathogens which nowadays are able to spread worldwide due to international travel and trade. As a consequence, there will be a substantial need to constantly update and replace pesticides in order to deal with environment specific constraints (Ruttan, 2000). Supply, access and use of macro nutrients/fertilisers constitute another risk factor for agricultural production worldwide. The scarcity of macro nutrients especially nitrogen and phosphorous is acknowledged in both policy and scientific literature. Undersupply of nitrogen and phosphorus poses a critical constraint to yields in least developed regions. In the case of humid regions, nitrogen is leached to surface waters and groundwater. Inefficient N input to agriculture (too little or too much) leads to land degradation (SCAR, 2011). Phosphorus is the major non-renewable and non-replaceable input to agriculture. Grain yields are highly sensitive to phosphorus deficiency. Phosphorus is mainly lost from cropland by erosion and washed into rivers and the sea where it becomes lethal to coastal and marine ecosystems leading to the loss of freshwater as well (SCAR, 2011). A recent paper published by Keyzer (2010) addresses the issue of upcoming scarcity of phosphorus. The author argues that the shortage of this macro-nutrient in the next 80 or 100 years (due to lack of recycling) will affect not only yields but production costs in agriculture and other industries. In other words, phosphorous scarcity will have an impact on rising food prices, growing food insecurity and widening inequalities between rich and poor countries.

Another issue to consider in the development of yield-improving technology is the impact on biodiversity. A potential trade-off between protecting biodiversity through traditional agriculture and securing the highest yields possible per hectare may arise for farmers in low-income countries. Currently, a dozen species of animals provide 90 percent of the animal protein consumed globally and just four crop species provide half of plant-based calories in the human diet (FAO, 2009a) but in (semi)subsistence farming, households rely in a great diversity of plants and crops to fulfil very basic needs. Although the yield potential and yield gaps for rainfed crops per country and agro-ecological zone have been calculated by the International Institute for Applied Systems Analysis (World Bank, 2010), one key challenge is to learn how to exploit the technical advantages of different farm structures (i.e. size, production mix, input mix, food chain coordination, etc.) and their economic potentials within each agro-ecological zone while protecting the biodiversity. In this respect, the challenge is to incorporate a joint techno-economic and ecological dimension to the management of natural resources and biodiversity in agricultural practices.

Rural infrastructures, harvest equipment and storage facilities also represent a handicap for the agricultural sector in low-income countries. Inadequate or absent harvest equipment and storage facilities constitute key factors in the high percentage of output losses at farm level. In the case of African tropical agriculture, the percentages of harvest losses are estimated above 30 per cent and in the case of Sierra Leone, estimations indicate up to 40 per cent (MAFFS, 2009; NSADP, 2009). Transport and communication costs besides restricting the ability of rural producers to engage in more effective trading arrangements also contribute to high percentages of harvested output losses, due to long travel distances and/or poor roads and vehicles (Holloway et al., 2000; Renkow et al., 2002). Likewise, fuels prices also increase production costs through the increased prices of imported factors of production (such as pesticides, herbicides or fertilisers). The reduction in harvest losses and the physical connection of remote areas to sale points or local development poles (airports, harbours, and country capitals) is therefore a key issue for improving rural livelihoods. The development of an adequate network of rural infrastructures is an essential prerequisite for the improvement of food commercialisation and for the viability/sustainability of food producers located in isolated regions.

Furthermore, according to CCAFS Report (2010) changes in the mean and variability of climate will affect the hydrological cycle, crop production and land degradation, particularly in regions where the most of the world's hungry are (i.e. Sub-Saharan Africa and South Asia). Moreover, the report underscores that climate change (through variable rainfall and temperature) has the potential to transform food production, especially the patterns and productivity of crop, livestock and fishery systems. Currently, small farmers in high-risk areas do not have wide access to monitoring or information services, which could help them prepare for climate variability and extreme events. In this respect, Barrios et al. (2008) analyse the impact of climatic change on agricultural production for the case of Sub-Saharan Africa between 1961 and 1997. Their results indicate that changes in country-wide rainfall and temperature have been major determinants of agricultural output in the region. In fact, the authors' simulations indicated that if rainfall and temperatures had remained at their pre-1960's means then the agricultural output gap between Sub-Saharan Africa and other developing countries by the end of the 20th century would have been approximately one third of its actual magnitude.

2.1.2 Institutional constraints

During the 2008 food price rise, small semi-subsistence farmers were not found to be supply responsive (FAO, 2009b). According to FAO (2009b) this behaviour is partly explained by simultaneously increasing production costs (i.e. fuel and fertilisers) faced by small producers during this period. Likewise, it was emphasised that the occurrence of a price shock (even if it is the highest in many years) does not create enough incentives to increase production in face of the downward price trend that has dominated the agricultural scene in the last decades. In any case, it should be stated that most (semi)subsistence farmers are only marginally integrated in the market systems and as stated by Evenson and Gollin (2003) their participation largely depends on the relative difference between prices and costs. In other words, transaction costs play an important role in the decision to self-consume or engage in trading (De Janvry et al., 1991), especially as they are mostly household-specific.

Moreover, given that smallholders are likely to follow both risk-reducing and coping strategies (Ellis 2000), timely access to market information, credit and extension services can allow them to benefit from market opportunities. However, resource constraints (at national and local levels) and the limited existence or absence of socio-economic mechanisms (such as farmer associations, producer cooperatives or integrated food chains) which would enable a faster and more efficient access to this type of institutional support and ultimately increase market participation, constitute important practical obstacles.

Another institutional constraint is related to issues of contract enforcement (Benham and Benham, 2000; Dorward, 2001). This is essential to foster economic interaction and organization not only within the agricultural sectors but across other sectors (mainly industrial) as a way to promote agri-business activities. The latter is also relevant when it comes to land access and management in low-income countries, particularly in the light of the recent and increasing trend of large-scale investment in farmland (also referred to as land grabbing). Both policy documents and academic articles have pointed out to the potential negative effects of these land transactions for small-scale farmers (Deininger, 2011; Hallan 2011). In this respect, major considerations include the adequate valuation of land, the respect for traditional/informal property rights, the impact on local labour market and the ability to flexibly reallocate land in case an investment fails (World Bank, 2011). Lastly, as stated by von Braun and Meinzen-Dick (2009) it is in the long-run interest of investors, host governments and the local people involved to ensure that any land arrangement is properly negotiated, practices are sustainable and benefits are shared. The latter also implies an adequate evaluation of water (and other resources) management and distribution.

Finally, the agricultural productivity of smallholders also depends on the adequate provision of public goods. Access to education and health services for the rural population are seen as key aspects to increase agricultural productivity (Yúnez-Naude and Taylor, 2001; Appleton and Balihuta, 1996). In the case of Africa, particular attention should be given to the AIDS pandemic, which will entail dramatic changes to the composition of rural communities (FAO, 2010a). Civil conflict and war periods are also factors which erode the livelihoods systems of both urban and rural populations.

2.2 Food security in high-income countries: the global and market level perspective

The outlook given to food security in high-income countries is mainly concerned with sustainability, long-term availability, and consequently, affordability of food. For example, the Global Food Security Programme, which is the UK's main public funders of food-related research and training, is aimed at «meeting the challenge of providing the world's growing population with a sustainable and secure supply of safe, nutritious and affordable high quality food. That food will need to be produced and supplied from less land and with lower inputs and in the context of global climate change, other environmental changes and declining resources» (Global Food Security, 2011). In other words, the focus from this viewpoint is to meet the rising demand for food in ways that are environmentally, socially and economically sustainable while keeping affordable prices.

2.2.1 Technological, scientific and physical constraints

Higher competition on limited resources such as energy, land, macro-nutrients or fresh water, leads to higher costs for the environment and for food production and manufacturing. Although farmers in high-income countries maintain high productivity in the use of agricultural inputs, the transport and retailing practices need to become more efficient and effective in both in their provision of safer and healthier food and in the reduction of food waste. Although evidence on waste estimation is relatively weak, arguably, there is a significant proportion of food grown which is lost or wasted after farm gate before and after consumption. The latter is said to be equivalent to 30 per cent of food grown and if this estimated total amount of food waste could be halved in 2050, it would correspond to a 25 per cent increase of today's production (Global Food Security, 2011). Hodges et al. (2011) estimate that from the 222 million tonnes of edible food supply in 2008 in the USA 9 per cent (19.5 million tonnes) were lost at the retail level and 17 per cent (37.7 million tonnes) at the consumer level. The total proportion of food lost was thus 26per cent or 57.1 million tonnes. Their estimate for on-farm and between the farm and retailer was of 3 per cent, reaching an overall figure of 30 per cent food loss. Similarly, Hall et al. (2009) estimate for the USA a food waste per capita of 1400kcal which corresponds to one third of the average current global edible crop harvest. The authors also highlight that food waste contributes to excess consumption of freshwater and fossil fuels which, along with methane and CO_2 emissions from decomposing food, impacts global climate change. Food waste under their calculations would account in the USA for more than one quarter of the total freshwater consumption and approximately 300 million barrels of oil per year. The resulting environmental degradation calls for increasing efficiency not only in the agricultural sector but in the sub-sequent steps of food manufacturing, including consumption.

Recently, the increase in demand for bio-fuels has potentially exerted pressures not only on world prices for agricultural commodities but on land use, i.e. how much planting area could be diverted from producing other crops to those used as feedstock for the production of bio-fuels (FAO, 2009b). This issue is also connected to land grabbing/acquisition in low-income countries, as many projects foresee the cultivation of sugar cane, maize or palm oil to produce bio-fuels. To illustrate this, in 2008 the total area under biofuel crops was estimated at 36 million hectares, more than twice the 2004 level (World

Bank, 2010). According to FAO (2009b) the development of the bio-energy market will also determine how far it will be possible to meet the growing demand with the available resources and at affordable prices.

2.2.2 Institutional and market aspects

Volatility refers to variations in economic variables over time and the emphasis is placed on whether these variations are predictable or unpredictable (Gilbert and Morgan, 2010). The variations in prices become problematic when they are large and cannot be anticipated and, as a result, create a level of uncertainty which increases risks for producers, traders, consumers and governments and may lead to sub-optimal decisions (FAO et al., 2011b).

Volatility in prices for many agricultural products is connected to a range of factors. Lower global stocks (associated to higher transport and storage costs), high fuel prices, poor harvests in export countries (many of these related to major climatic events), rising demand for bio/agro-fuels and increased demand for meat and milk products are all elements which may influence price volatility. Likewise, the UN Special Rapporteur on the right to food has underscored the emergence of a speculative bubble on food commodities (De Schutter, 2010). These different aspects affecting food/agricultural price volatility deserve some additional remarks. For instance, stocks play a key role in equilibrating markets and smoothing price variations (FAO, 2009b). Since the 1995 high price situation, global stock levels have on average declined by 3.4 percent per year (particularly in cereals) and Uruguay Round Agreements are said to have been instrumental in reducing stock levels in major exporting countries. The global economy is also strongly vulnerable to any major climatic event affecting one or several of the main «grain belts». One example is the impact of the extreme drought which affected Russia in 2010, followed by floods in Australia (Soares et al., 2011). Fuel prices not only affect the prices of agricultural inputs but have been an important determinant in the increase of bio-fuel production. Bio-fuels are as well considered an important factor in the determination of agricultural prices. For example, out of the increase of nearly 40 million tonnes in total world maize use in 2007, almost 30 million tonnes were absorbed by ethanol plants alone. Yet, a more permanent effect of the food and financial crisis of 2008, according to the World Bank (2010), was that it prompted some food import-dependent countries to reconsider their policies to reduce vulnerability from what is considered to be an «undue-dependence» on imports, while other export countries have relied on export bans as protectionist measures of national food levels.

Another type of issues mainly related to over-nourishment, obesity and diet-related ill heath have started to get further attention in both policy and academic papers (Lipton, 2001; Global Food Security, 2011). According to Tomlinson (2011) who quotes FAO reports (2006) the world food economy is being increasingly driven by the shift of diets and food consumption patterns towards livestock products. In high-income countries, meat consumption is projected to increase from 90.2 kg/person/year in 1999 to 103 kg/person/year in 2050 while consumption of dairy products is also expected to increase from 214 to 227 kg/person/year for the same time period. The result is a highly obese population with increasing health problems (Lipton, 2011; Hodges et al., 2011). Consequently, food availability and affordability must also contemplate parallel programmes of

public health and consumer education along with the improvement of production and retailing processes.

3. Possible opportunities and policy alternatives

This section now addresses the technological and institutional opportunities as well as policy alternatives which could be considered in order to address food security challenges concerning both access and availability. The discussion is structured in two parts: (i) technology (which increases productivity and reduces environmental damage) and institutional coordination (to integrate small scale farmers) (ii) market stabilization and the role of governments and international agencies (to promote transparency in foreign land investment, research on climate change and technology, provision of market information).

3.1 Technology & institutional coordination: research and access beyond the farm level

It has been recognized that farming in low-income countries has on average the largest room for technical improvement at global level (World Bank, 2010; Deininger, 2011). Technology which adapts to the needs of low-income agricultural areas is therefore of key relevance to achieve general food security objectives. However, the necessary resources to promote research on productivity enhancement (which include genetic improvements or bio-technology) and sustainable management are lacking in low-income countries. The application of improved technology (adapted to the circumstances of non-temperate or environmentally marginalized zones) could increase average yields two to threefold in many parts of Africa, and twofold in the Russian Federation (Government Office for Science, 2011). A primal initiative in the reduction of food insecurity is based on supporting agricultural research for areas with high potential for technical improvement and performance. The spread of current best practices (in terms of extension services and technology adoption) to reduce yield gaps may be consequently expected to play a crucial role in improving food security both in its access and availability dimensions.

For the purpose of dissemination and adoption of new technology, the establishment of public-private partnerships, producer associations and cooperatives which support not only training but guarantee the well-functioning of food chains and access to inputs and services for small and medium producers (i.e. mainly credit, insurance, veterinary services) have proven successful tools (Lipton, 2006; World Bank 2006). The same principle applies for the adoption of environmental friendly practices in the context of low-income countries. The widespread adoption of any of these practices will take place if they are tied to the improvement of rural livelihoods and not only the preservation of natural resources. In the case of recycling of macro nutrients such as phosphorous, further support might be required. In other words, the results of agricultural research to improve productivity must include a dissemination and adoption strategy which is compatible with farmers' utility and profit maximisation decisions. Successful stories in agricultural sectors of low-income areas (which entailed an increase in rural employment, output and value added) illustrate that technology adoption is sustainable when tied to market opportunities (World Bank, 2006; Lipton, 2006). These experiences illustrate that it is possible for small scale farmers who are organized in a cooperative or association to invest and smooth

supply when there is guaranteed access to and stable demand from (domestic or international) markets. Traditionally, a well-established food chain with straightforward contracts becomes a strategic tool and government support varies from funding research and setting up networks of producers (preferably in different stages of the production and export processes) to introducing regulations which enhance international trade opportunities. Financial and insurance schemes would also play relevant roles.

Similarly, agricultural research can also play a role in exploring production models which combine agro-forestry and fishery activities for small and medium farmers. The latter is expected to not only maintain and use different natural resources in a sustainable manner but also to diversify agricultural livelihoods. Diversification both on-farm and off-farm is recognised as suitable strategy to reduce risk and increase food access (Ellis, 2000). For this reason, opportunities through the participation in vertically integrated agri-business structures could also be of relevance to increase rural incomes.

Overall, it is essential to undertake technology improvement programmes in institutional settings which guarantee incentives for the adoption of sustainable food production practices. In other words, technology adoption which increases productivity in a environmentally friendly manner will take place when rewards are easily quantifiable. In the context of a market-economy, pre-requirements include the improvement in market information and transparency (FAO, IFAD, OECD, UNCTAD, WFP, World Bank, WTO, IFPRI and UN HLTF, 2011) which may reduce risk aversion in agricultural production.

Risk-reducing strategies are one of the main differentiators between small/medium family based farms and large commercial farms, particularly in low-income economies. The primacy and the gap between the two types of farming also depend on a number of factors including technology level, production mix and agrarian management. One way forward is to promote pro-poor investment in agricultural sectors. Falcon and Naylor (2005) propose to focus on crops produced and consumed by those who are food insecure. As argued above, private-public partnerships are innovative mechanisms to organise input supply and smooth output production among small and medium farmers.

3.2 Market stabilization and the role of governments and international organizations

In the attempt of reducing price volatility, it is crucial to highlight the importance of creating a world trading system and incentive structures for the agricultural sector that not only maintains stable food prices but keeps agricultural producers motivated to stay in business and invest in updated technology and sustainable agricultural practices. Adequate price signals are therefore essential to push investment both in high- and low-income countries' agriculture. Simultaneously, global markets have to function effectively for an increasing number of countries to join in active international trade and have access to a stable supply of imports (FAO, 2009a; FAO, 2011a). In the same line, export bans at times of food stress (which exacerbated the 2007-2008 food price spike) should be avoided and thus food self-sufficiency as a viable option to contribute to global food security should be further revised in both high and low-income countries (Foresight, The Future of Food and Farming 2011).

Countries may consider combined measures to be better prepared for future shocks to the global food system, through coordinated action in case of food crises, reform of trade rules and joint finance to assist people affected by a new price spike or localised disaster.

In other words, the focus should be not only on increasing food supply and availability but also on access of the world's poor to the food they need to live active and healthy lives (FAO, 2009a). Increased opportunities (through the diversification of farm-household income) in the rural areas would also contribute to reverting or decreasing the pressure of migration on urban centres (it is estimated that by 2050, 70 percent of the world population will reside in urban areas). The reversal or containment of this trend would also bring positive effects in terms of urban pollution or increase in the number of settlement in environmentally risky disaster-prone zones (landslides, floods). A complementing measure would also include incentives which relieve pressures on the future balance between supply and demand. For example, support waste reduction programs can be undertaken (via education, campaigns). In parallel to waste reduction, it is also possible to affect people's diets via taxation, campaigns or regulatory actions.

In particular, it is important to better assess the needs and the associated consequences of food assistance in the long run. In extreme situations, food aid allows ensuring short-term food security. However, it has been criticised for generating potential perverse effects on long-term development of markets and private agents. In order to limit such negative effects, agencies and donors can inform market agents about their intentions for food aid distribution and limit the duration of such activities (WFP, 2005). International Organizations may also contribute in setting coordinated institutional frameworks to reduce other specific food security threats. For instance, joint efforts could be increased in order to provide timely and accurate information on climate change risks and forecasts of natural disaster and their impact on agricultural production. Another important role relates to the emerging trend of farmland investment contracts in low-income countries. In this respect, land contracts could be publicly available as a way to certify their transparency and fairness in the allocation of property rights (Hallam, 2011). Their involvement could promote investments which not only protect local land rights but also provide technological spill over to smaller farmers as well as market access/opportunities.

3.3 Concluding remarks

In summary, food security at the rural or farm level is directly linked to the attainment of the 1st of the Millennium Development Goals: Eradicate extreme poverty and hunger (United Nations, 2009). But, assuming a continuation of current trends in key factors such as agricultural production and income, the number of food-insecure people would not significantly decrease over the next ten years (Shapouri et al.; USDA, 2010). Therefore, simply planning for an increase in overall production which does not focus on distribution and access is inadequate. Special attention is clearly needed in areas where highest productivity increases are possible, thus promoting an integrated course of action to deal with food access and availability.

To conclude, it is essential to re-focus and coordinate food security research agenda and policy making in order to deal with both high-income and low-income perspectives on food security through the creation of initiatives which address both technological and institutional constraints. As FAO (2009a) states, adequate supply of food at the aggregate level, globally or nationally, does not guarantee that all people have enough to eat and that hunger will be eliminated. But if the global food trade scenario creates incentives

and opportunities for individuals in low and high-income countries to effectively engage in sustainable production and consumption patterns an important step towards securing food access and availability is likely to be made.

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