More food or better distribution? Reviewing food policy options in developing countries

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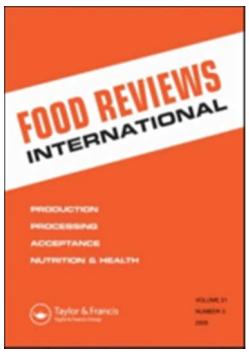

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More Food or Better Distribution?

Reviewing Food Policy Options in Developing Countries

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Abstract

As most of the undernourished people in the world live in developing countries, achieving food security plays a major role on the daily agenda of policy makers. For achieving food security, there exist various strategies such as supply management, demand management or better food distribution. This paper aims to analyze different scenarios in a developing country context and seeks for providing an overview which could be the most suitable approach to achieve food security. In this context, not only producing more food is being considered but also the environmental and social implications that come along with a higher production. Some of the existing options for achieving food security seem not to be appropriate anymore, for example cultivation expansion, as they could be achieved at high social and environmental costs. Other options, such as sustainable intensification or waste management, seem to be more appropriate. The paper concludes that there exists no stand-alone solution to the food security problem. Instead, an integrated approach which combines different options might rather be the key to sustainable food security.

Keywords: food security; food distribution; undernourishment; food justice; sustainable intensification.

1. Introduction

Maintaining food security at the national and household level is a major priority for most developing countries in terms of both welfare of the poor as well as political stability (Del Ninno

et al. 2007). However, despite continued efforts to provide a more stable, sustainable and predictable food supply, a great proportion of the population in developing world still suffers from chronic under-nutrition (Ahmed and Lorica 2002; Lin 2009). According to the Food and Agriculture Organization of the United Nations (FAO 2015), at the present time, approximately 795 million people around the world – mostly women and children in developing countries – experience hunger as a defining characteristic of their lives. The flip side of the coin is sustainability. Many scholars stressed that both food security and achieving sustainability should be considered at the same time (e.g. Hanson 2013; Giovannucci et al. 2012). The United Nations Conference on Trade and Development (UNCTAD 2011) underlines the importance of sustainable agriculture in addressing hunger and poverty. Productivity of agriculture in developing countries is relatively low because of land degradation, unsustainable agricultural practices, low adoption rates of suitable technologies and inadequate use of agricultural inputs (World Bank 2012).

Furthermore, the situation will exacerbate with ongoing and new challenges such as a decline in available food per capita since 1984 (FAO 2003), changing food prices (House of Commons 2009; FAO 2008), water scarcity (Gerbens-Leenes and Nonhebel 2004), the political challenge of using gene technologies (Carlos Popelka et al. 2004), climate change (Edame et al. 2011) and increasing human population (Pimentel 2007; Gerbens-Leenes and Nonhebel 2004). According to FAO estimates (2008), the high food prices between 2003 and 2005 and in 2007 contributed to an increase of 75 million undernourished people worldwide, for example. Higher prices for food may create or a possible food security problem, especially for poor countries in which income levels are low (Schmidhuber and Tubiello 2007).

In many developing countries, arable cropland is scarce and land expansion is in competition with environmental protection initiatives (Godfray et al. 2010). For example, the scarcity of arable cropland in sub-Saharan Africa helps to explain the region's declining agricultural production per capita in recent decades. In Nigeria, Africa's most populated country, the population quadrupled since 1950 while the grain land area only doubled at the same time, which means that the available grain land per person has halved effectively. In northern Nigeria, pastoralists and farmers fleeing the encroaching Sahara, which annually claims 350,000 hectares of land (about half size of the Delaware State in the US), have increased demands on the already scarce land elsewhere in the country, resulting in sparking ethnic tensions (Coulter 2003; Larsen 2002; Larsen 2003).

With regard to the future development, food security will remain a global concern for the next 50 years and beyond. By 2050, it is estimated that global population will reach 9 billion (Kings and Ilbery 2011). Global food production will need to feed these additional people as well and take into account the already existing 3.7 billion malnourished people (Azadi et al. 2011). As shown in Figure 1, the World Resources Institute (WRI 2013) illustrated that the world will need to produce 69 percent more food calories in 2050 compared to 2006.

[insert Figure 1]

FAO projections (Alexandratos and Bruinsma 2012) indicate that the annual global food demand per capita will increase by 1.1% until 2050. Having a closer look on the developing countries (excluding China), this figure is even higher (1.6%). This is, among others also a result of environmental degradation (Scanlan 2004; Gerbens-Leenes and Nonhebel 2004), growing urbanization (Lin et al. 2009; Scanlan 2004) and extreme climate events (Gregory et al. 2005). The current world hunger and shortages of nutrients for so many people and other ongoing

challenges raise alert to the growing insecurity of world food supplies and the vulnerability of human health and productivity (Pimentel 2007). Godfray et al. (2010) suggest that the world will need 70 to 100% more food by 2050. Other projections for 2025 highlight the importance of water scarcity on food security and indicate that more than half of the world's population will live in regions dependent on food imports as a result of limited access to water (Falkenmark 1997). "Water for food" has become an important slogan in current debates on poverty reduction and climate change (Allouche 2011).

With regard to the current situation and the projections for the future, we seek answers to the following question: Which is the best strategy for improving global food security? More precisely, this study focuses on the two following topics: 1) The assessment of different strategies for achieving food security, and 2) the identification of the pros and cons of each strategy.

This paper first gives a brief overview of the concept of food security and then compares three main food policy strategies and their related scenarios: a) supply management, b) demand management, and c) better distribution.

2. Food security

Food security and insecurity are terms used to describe whether or not people have access to sufficient quantity of food. Food is secured when all people at all times have physically and socially acceptable access to sufficient, safe and nutritious food to meet their dietary needs for a productive and healthy life. Food security has three dimensions: i) availability of sufficient quantities of food with appropriate quality, supplied through domestic production or imports; ii) access of households and individuals to adequate resources to acquire appropriate food for a

nutritious diet; and iii) utilization of food through adequate diet, water, sanitation, and health care. The accessibility is affected by many factors such as poverty, health, food production, political stability, infrastructure, access to markets, climate change and natural hazards (Schmidhuber and Tubiello 2007; IPCC 2007).

The main challenges of people who suffered from hunger between 1990 and 2015 are: (1) food insecurity and (2) the inability of agricultural production to keep up with global food demands. Forecasts suggest that technological advances or expansions of cultivated area would boost production sufficiently to meet rising demands. Nevertheless, land and water are the most limiting resources for food production. At a first glance, there seems to be only one option: to increase yields and efficiency on the already available land. However, there is a growing concern that the expansion and intensification of agriculture in the least developed and development countries may lead to degradation of the natural resources (soil, water, biodiversity) and consequently to a decrease in agricultural production.

Although agro-ecological approaches offer some promise for improving yields, food security in developing countries could substantially be improved by increased investment and policy reforms that integrate different approaches such as organic farming, GM crops and precision farming (Azadi et al. 2011). Furthermore, increasing investment in human capital is essential to accelerate food security improvements. In agricultural areas, education and training can effectively enhance the ability of farmers to adopt more advanced technologies and crop-management techniques and to achieve higher rates of return on land, thus increasing household incomes (Burkart 2012).

Developing countries account for 98 percent of the world's undernourished people (FAO 2010). Asian countries that have been most successful in providing food security have based

their strategies on two elements of their domestic food systems over which they have some degree of policy control: the sectoral composition of income growth and food prices. The rate and distribution of economic growth are primarily matters of macroeconomic and trade policy (once asset distributions are given as an initial condition). In the second element of the strategy, the Asian governments sought to stabilize food prices. Rather than replacing private marketing, government efforts should be aimed at enhancing private markets through improving transportation, enforcing standards and measures in grain transactions, and implementing small-scale storage technologies (Anderson and Roumasset 1996).

Agricultural policies should be devised to increase dietary diversity, provide more production, improve food quality, and promote better food processing, preservation and distribution. The development and support of inclusive business models plays a major role in developing countries, as agricultural production is based to a large extent on smallholder systems. Possible policy actions that can enhance access to food include reducing transaction costs for small-scale producers, strengthening local markets and improving food safety and quality. Food insecurity is not a one-dimensional issue. Several solutions and approaches should be carefully considered. With regard to this, the present article reviews three main strategies to achieve food security for developing countries and discusses the pros and cons of more food production versus better food distribution, for being able to make recommendations on which scenarios serve best for both food security and sustainability.

3. First strategy: Increasing the available quantity of food: supply management

3.1. Scenario I: More production through an expansion of land

For a long time, the primary solution to food security has been to bring more land into agriculture. Increasing the cropping area was the main tool to augment food production in the early 20th century, when new regions were dedicated to agriculture across the globe (Boserup 1965; Boserup 1981; Grigg 1987). Mechanization resulting from the industrial revolution had further accelerated the land use change towards agriculture (Grigg 1987). Although Ramankutty et al. (2006) argue that, as a result of increasing intensification, global land expansion for agriculture has declined towards the end of the 20th century, there still exists demand for more land for crop and livestock production. In addition to completely new land that would be needed to match with an increasing demand, agricultural land that was formerly productive has been lost to urbanization and other human uses, as well as to desertification, salinization, soil erosion, and other consequences of unsustainable land management (Nellemann 2009) and thus has to be taken into account, too. Kampman et al. (2008) estimate the global agricultural land increase since 1990 to be 34 Mha. Collins (2011) states that in the Asia-Pacific region, land expansion was 6% between 1970 and 2007 and thus higher than for the rest of the world during the same period (1%). Gerber et al. (2013) describe that between 1990 and 2006, maize and soybean were the main drivers for global cropland expansion but also the expansion of pasture plays a role in land transformation. Kampman et al. (2008) name food and feed production as the main drivers for land transformation and point out that the demand for both will still grow in the future. Although they argue that most of this demand will be met by intensification, new technologies or higher efficiency in production, models suggest that the demand for new agricultural land will be 200-500 Mha until 2020. FAO (2003) estimates that 20% of the additional food production in 2030 will be the result of land expansion. Alexandratos and Bruinsma (2012) project that compared to 2005/07, 69 Mha of new arable land will be necessary on a global scale by 2050,

which means a 0.1% annual increase. This increase will happen in developing countries (0.24% annual increase), whereas in developed countries a decrease of arable land-in-use will occur (0.14% annual decrease). According to the UNDP (2013), by 2050, India and Nigeria are estimated to cultivate 0.06 hectares of grain land per capita, less than one tenth the size of a soccer field. Pakistan, Bangladesh, and Ethiopia would show even lower rates, with 0.04-0.05 hectares per capita. Egypt and Afghanistan with 0.02 hectares, as well as Yemen, the Democratic Republic of the Congo, and Uganda, with just 0.01 hectares would are among the countries with least crop area per capita. These numbers are in strong contrast to those of the less densely populated grain exporters, which may have up to 10 times as much grain land per person available (e.g., the U.S. with 0.21 hectares of highly productive grain land per capita).

As these projections show, for matching the increasing demand for food and feed, it might be necessary to bring new land into agriculture in the future. However, competition for land with other human activities would make this an increasingly unlikely and costly solution, in particular if biodiversity and public goods are provided by natural ecosystems and being protected (Godfray et al. 2010). In this regard, it also has to be taken into account that land expansion will be at the expense of nature, i.e., forests. This is especially valid for sub-Saharan Africa, Latin America (FAO 2003), Southeast Asia and Central America (Lepers et al. 2005). Global net deforestation between 2000 and 2005 reached 7.3 Mha annually, out of which 24% occurred in Brazil (FAO 2006). Lepers et al. (2005) describe the existence of deforestation “hotspots”, mostly located in the tropics, among which the Amazon region is affected to the largest extent. Land transformation also comes along with a loss of biological biodiversity (Sala et al. 2000) and might accelerate climate change (Vitousek et al. 1997; Schmidhuber and Tubiello 2007; IPCC 2007) as it is affecting the N-cycle, the hydrological cycle, and the C-cycle (Helms and Aiking

2003 in Helms 2004). As an example might serve the CO_2 emissions related to land use change in beef production, which make up 15.5% (14.8% for pasture expansion, 0.7% for soybean expansion) of the overall CO_2 emitted in beef production (Gerber et al. 2013). In addition to that, land (e.g., forests, remote areas) which is being converted into agricultural land, often lacks the required infrastructure and inputs necessary for sustainable agricultural production (FAO 2003). According to FAO (2003; 2009), irrigation will be of increasing importance for agricultural activities in developing countries. Another important factor is soil degradation (Ruttan 1999 in Helms 2004). These factors will result in additional pressure on limited natural resources and thus further reduce natural capital. Concern is expressed on the sustainability of ecosystem services in general (Tilman et al. 2002; Helms 2004). These concerns result in an important challenge: Is the expansion of agricultural land a sustainable solution to food security, given the possible loss of ecosystem services and biodiversity and considering the effects on the global climate? Scenario II deals with a different approach: more production through increasing intensification.

3.2. Scenario II: More production through increasing intensification

At present, over 1.5 billion hectares of the global land surface (13.4 billion ha) are being used for crop production (Bruinsma 2009). An increase in the cultivated area, as discussed in the above chapter, is considered undesirable because of the adverse effects on the environment (Tilman et al. 2011; Smith 2013) and insufficient inputs such as water (Davies et al. 2009). According to the Royal Society (2009), the necessary production growth has to be achieved mainly without land expansion. In this sense, increasing intensification is another option in the context of achieving food security. Agricultural intensification means "increasing agricultural inputs to improve per-

hectare yields rather than expanding land under cultivation" (Phelps et al. 2013, p: 7601). The increase of yield per unit area has been the main factor of the food production boost during last decades: The mean global wheat yields increased by 288% between 1900 and 2000 (Slafer 1994), barley yields increased by 103% between 1950 and 1980 in India (Evans 1993), and the annual wheat yield increased by 1.5% in the United States during 1960 and 1980 (Cox et al. 1988). Feyerherm et al. (1984) and Evans (1993) have reviewed historical trends of crop yield improvement and found out that under former yield per area production levels, almost three times more land would have been required to produce the necessary amount of crops that can sustain the present global population – land that does not exist (Smith 2013).

Agricultural intensification can basically be achieved through two mechanisms: yield increases and increases in cropping intensity (Alexandratos and Bruinsma 2012; Smith 2013). Alexandratos and Bruinsma (2012) describe that approximately 90% of the required global additional crop production by 2050 will be the result of intensification (80% yield increases and 10% increases in cropping intensity), whereas only 10% will be obtained through land expansion. For developing countries, 80% will be achieved through intensification (73% yield increases and 6% increases in cropping intensity), whereas 20% will be the result of land expansion. In most developing countries, an important share of the yield gap is attributed to a lack or deficiency of agricultural input application. In Sub-Saharan Africa, for example, Sheahan and Barrett (2014) argue that 65% of the farmers do not use any kind of inorganic fertilizers. However, in general the potential for increasing food production with conventional intensification of agriculture is geared towards a high-input agriculture (Tscharntke et al. 2012). Professor Bob Watson, Director of IAASTD, claimed that 'continuing to focus on production

alone will undermine our agricultural capital …' (Kings and Ilbery 2011). Conventional intensification therefore creates pressure on limited natural resources.

Godfray et al. (2010) highlight, that sustainable intensification should be taken into consideration in order to produce more food on the same area of land while reducing the environmental impacts at the same time. According to the Royal Society (2009, p: 47), "sustainable intensification of global agriculture requires systems that are resilient in the face of changing climates across diverse economic, social and political conditions. It is likely that there will be trade-offs between intensification and biodiversity but the long-term goal should be to increase global food production without damage to societies or the environment." After a strong increase in the application of agrochemicals in agriculture between the 1970s and 1990s, for example, a decrease could be observed during the last decades. This was achieved through improving the input use efficiency and input quality as well as through policies on mineral fertilizer and pesticide application (e.g. pollution taxes, physical limits for fertilizer use, pesticide safety information) and extension services (FAO 2003). Research in the livestock sector for example shows that with sustainably intensified forage-based livestock systems in the Latin American tropics, various economic and environmental benefits can be achieved compared to traditional extensive production systems. These include, among others, higher per area productivity, improved soil quality, or increased water infiltration (Rao et al. 2015).

Sustainable intensification seems to be a suitable approach for achieving food security while at the same time considering environmental impacts. Especially for developing countries, where inputs often are scarce, the application of adequate sustainable production systems could help to increase productivity levels with lesser amounts of inputs such as fertilizer, water or pesticides and reducing negative impacts on the environment.

3.3. Scenario III: Increasing efficiency through the reduction of post-harvest losses

Waste reduction is often considered as a way of mitigating food security concerns (Godfray et al. 2010; Foley et al. 2011; Foresight 2011; Smith 2013). About 30–40% of all available food in both developed and developing countries is currently being wasted. In developing countries, this is dominated by post-harvest losses whilst in developed countries food waste is dominated by post-consumer losses (Smith 2013). Globally, about 1.3 billion tons of food is being wasted each year (Gustavsson et al. 2011). According to Hanson (2013), in terms of caloric content, 24 percent of all food produced is lost or wasted in the respective production chains or by the consumer. Among the different categories of harvested crops, roots and tubers, fruits and vegetables as well as cereals have the greatest amount of loss and waste (Figure 2).

[insert Figure 2]

Lin et al. (2009) stress that "there is an urgent need to shift our focus from food production towards waste and resource management" (Lin et al. 2009: p541). This raises the question why the focus should be on increasing food production while the efficiency of food usage is low (Tscharntke et al. 2012). While these food losses occur in both industrialized and developing countries almost to the same extent, in developing countries 40% losses occur at post-harvest and processing levels, and in industrialized countries 40% occur at retail and consumer levels (Gustavsson et al. 2011). Therefore, improving post-harvest technologies (in particular for smallholders and small-scale enterprises) and reducing food waste are among the major challenges for future food security in developing countries. For example, in Africa, due to a lack

of transporting, storing and processing technology and infrastructure, large amounts of food are thrown away before even reaching the final consumer (Lin et al. 2009). Some innovations such as nanoplastic packaging can provide opportunities to reduce waste and food spoilage (Lin et al. 2009). But also more simplistic improvements of value chain facilities (e.g., slaughterhouses, cold chains, adequate transport) can help to substantially reduce post-harvest losses. Given the high amounts of post-harvest losses presented above, such improvements could play an important role in promoting food security (Foley et al. 2011).

While the development of knowledge and technologies in transporting, storing and processing infrastructure are important options for reducing post-harvest losses, reducing food waste by consumers is crucial, too (Beddington 2011). This can be tackled by education and sensitization campaigns for consumers but also by demand management, which is the subject of the second strategy presented below.

4. Second strategy: Demand management

Apart from the above mentioned options for food security, demand management has been taken into account as an important alternative (Smith 2013; Wirsenius et al. 2010). In this strategy, the focus is set on changing the consumer behavior instead of increasing production. There have been substantial changes in human food consumption reflected in dietary and nutritional changes over the recent decades (Schmidhuber and Tubiello 2007). It is important to improve our understanding of the demand-side drivers and examination of food demand patterns over time (Regmi and Meade 2013). There is an increasing demand for livestock products (Livestock Revolution; Delgado et al. 1999) that would result in the intensification of agriculture, particularly in South-central Africa (Smith et al. 2007). As Stehfest et al. (2009) report, the

production of beef protein requires several times the amount of land than the production of vegetable proteins. As such, reduced meat demand could significantly reduce the demand for agricultural land and the need for (sustainable) intensification (Wirsenius et al. 2010; Smith 2013). Stehfest et al. (2009) examined how changes in the human diet may affect sustainability in food production and found a global food transition towards less meat, or even a complete switch to plant-based protein food to have a dramatic effect on land use. However, in this context, it has to be considered that not all land used for livestock production can be equally used for crop cultivation. Livestock production often works in marginal and resource-poor environments (e.g., on poor soils, under adverse environmental conditions and with little or no inputs) (Chandel and Malhotra 2006), whereas crop production would require high investments in inputs (e.g., water and fertilizer) for being competitive under the same conditions (Viloria de la Hoz 2003), making livestock an alternative that provides income and assets, especially for poor smallholders in developing countries (FAO/ILRI 1995).

Despite the fact that this strategy receives more attention recently, its potential largely depends on the willingness of consumers to change their habits and on feasible land use alternatives. This strategy can be complemented with the last strategy presented in this paper: better food distribution.

5. Third strategy: Making available food accessible through better distribution

As Tscharntke et al. (2012) describe, the first goal of the Millennium Development Goals (i.e., to eradicate extreme poverty and hunger) is more related to food distribution than to agricultural intensification. Several scientists support the idea that global food production is sufficient and that the available food is not distributed equally to all individuals worldwide (e.g., Tscharntke et

al. 2012; Altman et al. 2009; Leathers and Foster 2009). Pinstrup-Andersen (2009) mention, food availability does not assure accessibility of enough food to all people. Smith (2013) pointed out that while enough food is produced globally to feed all humans, there are still 925 million undernourished people (mostly in developing countries). This is mostly related to the debate on food justice and food sovereignty. These concepts focus on the inequitable distribution of food, land, and other productive resources as a main cause of hunger and malnutrition (Windfuhr and Jonsen 2005). Hence, improving food distribution systems should be considered as one central strategy for food security. In this sense, Foresight (2011: 12) suggested "the political and economic governance of the food system must be improved to increase food system productivity and sustainability". Food distribution is about connecting producers with markets on the one hand but on the other hand also about guaranteeing accessibility of those markets to the final consumers. In this context, challenges arise with regard to distribution power and infrastructure and may lead to food inaccessibility either related to cost issues or physical constraints (FAO 2008). This leads to two types of distribution systems: domestic distribution (wet market) and market-oriented distribution. The domestic distribution system is characterized by its remoteness from formal markets. Smallholder producers, due to this distance, are often obliged to sell their produce surplus immediately after harvest to the first buyer that appears, mostly at low prices. Their inputs however, have to be purchased at high prices on formal markets, and many productive assets such as production credit, agricultural inputs, technical information, market information or new technologies may not always be available to them (Agarwal 2011). This food distribution system leads to limited food consumption by the rural poor which depends on what can be produced within a community and which is highly sensitive to short-term shocks (e.g., extreme weather events; FAO 2008) and long-term effects (e.g., climate change; Burke and

Lobell 2009). In this distribution system, physical access to food is the largest constraint for the rural poor but also shock- or input-price-related product price increases are of importance (von Braun 2008). Producers who are located closer to markets and who are in frequent contact with the market tend to produce for the market rather than for domestic purposes. The market-oriented distribution system is characterized by its rather formal structure, in-time supplies, larger quantities and stricter quality controls, and comprises small shops, supermarkets, or restaurants, among others. As a result, products sold on formal markets are normally more costly as on wet-markets, making price the most limiting factor of food accessibility in cities.

As FAO (2003) reports, most African governments initiated programs of agricultural market reforms in the 1980s, in order to (re-)organize their agricultural markets. The public distribution systems for commodity marketing are among the most important components of Sri Lanka's food security strategy, for example (FAO 2003). Scientists describe that market reforms have generally supported agricultural growth and food security (Jayne et al. 2002). In addition to market reforms, changes in supply chains can be helpful. For example, supermarket operators or their agents are becoming increasingly important players in parts of the developing world, especially in Latin America, but also in Asia and Africa (Reardon et al. 2003; Stokke 2009). Buying power is being concentrated in a few hands, mainly in larger cities. Supermarkets are often the initiators of supply chain development based on their client's demand and support producers through technical assistance or short-term training for preparing them to meet quality and quantities required. Stokke (2009) describes that this can involve short-run costs for the supermarkets but at the end can result in a win-win situation for both producers who receive incentives to increase their productivity and for the supermarkets who can increase their market share. The development of adequate supply chains or value chains gains increasing importance.

However, in this context, inclusiveness should be considered. New value chain approaches and business models are necessary that support and promote smallholder producers and connect them to formal markets (Burkart 2012; Vorley et al. 2008; Lundy et al. 2014).

6. Discussion and conclusion

The challenges of attaining sustainable food security in less developed and developing countries were highlighted in this study by comparing three major strategies and various corresponding scenarios that could help to solve food security problems.

First strategy: Increasing the available quantity of food: supply management

Although some projections predict a necessary land expansion in the future, this option seems to be rather a compromise solution in case there is no other option left. Negative side effects of land expansion, such as a loss of biodiversity or forests, or the contribution to the global climate change, result in high social and environmental cost and make this option unsustainable. Nevertheless, in many developing countries large parts of the forests and the related biodiversity are still being destroyed as a result of land expansion (e.g. in the Amazon region). To stop this trend, policies have to be developed, implemented and their compliance has to be monitored strictly.

The second scenario discussed in this paper deals with increasing the intensification of agricultural production and with being able to produce more on the same amount of land. This option can be divided into two sub-options: conventional intensification and sustainable intensification. Whereas conventional intensification was considered an important option during the last decades, sustainable intensification is gaining importance recently. Conventional intensification often means intensification at high environmental and social cost, as e.g., mineral

fertilizers and chemical pesticides are being applied, and thus creates pressure on limited natural resources such as water or soil. Hence, this sub-option does not seem to be adequate anymore in terms of sustainable food security. However, with regard to short-term shocks (e.g., extreme weather events, natural catastrophes) it might be necessary to go back to this option for avoiding human catastrophes. Sustainable intensification on the other hand is about finding an adequate production system that, apart from productivity gains, consider and mitigate negative environmental and social effects. Case studies like the tropical-forage-based cattle production systems in Latin America show that under sustainable intensification scenarios productivity can be increased significantly while at the same time contributing to climate change mitigation. Sustainable intensification seems to be a suitable option for tackling the food security challenge.

However, increasing production should not be considered as the only option to achieve food security. As discussed studies show, much of what is currently produced is being lost either before (post-harvest losses) or during retail and consumption (post-consumption losses). This is related to inadequate transport, processing, storage or packaging facilities and technologies on the one hand, and to consumer behavior on the other hand. Investments in research and dissemination of new technologies and infrastructure can help to reduce post-harvest losses to a large extent. Education and sensitization campaigns directed towards consumers can lead to less post-consumption losses. The option of waste reduction in each value chain segment should be considered for achieving sustainable food security.

Second strategy: Demand management

Various studies show that consumer demand is changing over time. The demand for livestock products, for example, is continuously increasing, i.e. in developing countries (Livestock Revolution). If such trends continue to grow, intensification and land expansion will be

indispensable. Recent debates about demand management suggest that parts of the food security problem can be solved by influencing consumer demand towards more vegetable- and crop-based diets and away from meat consumption. Although it is often highlighted that most of the land currently used for livestock production can and should be used for crop production, there are also studies that show that in many areas crop production is only competitive with large amounts of inputs (e.g. water, fertilizer). This suggests that a re-orientation of production could make sense but not in all regions. Demand management thus can contribute to solving the food security problem but is not considered to be a stand-alone solution.

Third strategy: Making available food accessible through better distribution

Studies show that theoretically there would be enough food available to feed all people. However, the access to food is not guaranteed to everyone. Especially rural poor challenge physical and financial access problems to sufficient food and balanced diets. In cities, access is rather related to financial constraints as packaged and high-quality products are often more expensive. The development of inclusive distribution systems and value chains can help to overcome problems in accessibility. Supermarkets can play a key role in this process by investing in smallholder agriculture through capacity building and technical assistance. On the one hand this assures inclusiveness. On the other hand it helps to develop higher quality products and to achieve accessibility to all. Inclusive value chain and distribution system development can be a suitable but not stand-alone solution to the food security problem.

After revising the different strategies and their corresponding scenarios, we can conclude that for achieving food security, it is not possible to build on only one of the available options. Moreover, focus should be on holistic approaches that combine more production through sustainable intensification with the development of new technologies and facilities that reduce

food losses, consumer education, demand management and new inclusive approaches for value chains and food distribution systems. At the same time, effective policies should be put into place that support the reduction of land expansion at environmental and social cost as well as unsustainable intensification of existing production systems.

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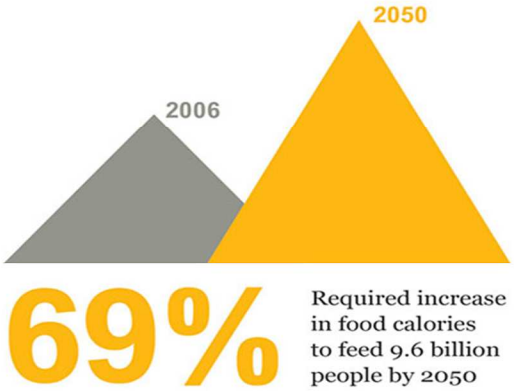

Figure 1. The Food Gap (Source: WRI, 2013; http://www.wri.org)

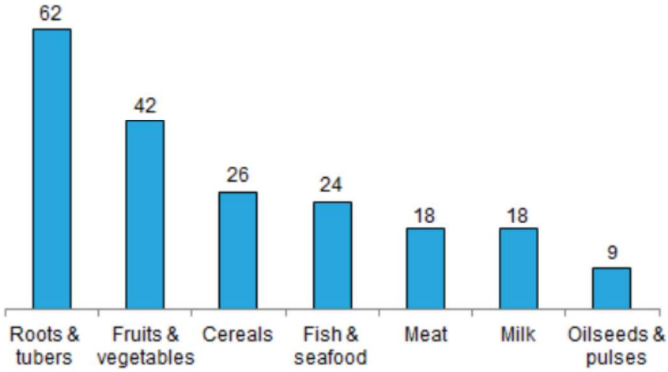

Figure 2. Loss and waste of different commodities (sources: Hanson, 2013)