SCHWERPUNKT

Future Food Systems: Challenges and Perspectives

Introduction to the Thematic Focus

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Measured against the criteria of sustainability, the current food systems fail: They are a major source of environmental burdens and resource consumption, increase the need for transport, promote the wastage of edible food and cause food scarcity, hunger and malnutrition on the one hand, and obesity and diet-related diseases on the other hand. Although the driving forces responsible for this development are still active, there are also opposing trends seeking to overcome the current failure. These possible pathways towards a more sustainable food system are at the centre of this thematic focus. This includes the concept of sustainable intensification, a radical change in the prevailing consumption patterns, the reduction of food waste, a rethinking of the role of wholesale/retail, a shortening of the supply chains in line with a stronger focus on regional/local food, and a shifting of funds from direct payments to agro-environmental and animal welfare policies within the Common Agricultural Policy.

Gemessen an den Kriterien der Nachhaltigkeit versagen die heutigen Ernährungssysteme: Sie stellen eine der Hauptquellen für Umweltbelastungen und Ressourcenverbrauch dar, steigern die Notwendigkeit von Transporten, fördern die Verschwendung essbarer Lebensmittel und führen zu Lebensmittelknappheit, Hunger und Unterernährung auf der einen Seite sowie zu Übergewicht und ernährungsbedingten Krankheiten auf der anderen Seite. Obwohl die treibenden Kräfte, die für diese Entwicklung verantwortlich waren, weiterhin wirksam bleiben, gibt es auch gegenläufige Trends, die auf die Überwindung der bestehenden Probleme ausgerichtet sind. Diese möglichen Pfade zu einem nachhaltigeren Ernährungssystem stehen im Zentrum dieses Schwerpunkts. Dazu gehören: das Konzept der nachhaltigen Intensivierung, ein radikaler Wandel der vorherrschenden Ernährungsmuster, eine Reduktion der Lebensmittelverschwendung, ein Überdenken der Rolle des Handels, eine Verkürzung der Versorgungsketten verbunden mit einer Konzentration auf regional erzeugte Lebensmittel sowie eine Umschichtung der EU-Fördermittel von Direktzahlungen auf umwelt- und tierschutzbezogene Belange im Rahmen der Gemeinsamen Agrarpolitik.

1 The Challenge of Ensuring Future Food Security

The United Nations' mid-range projection for global population growth suggests that the number of people will reach 9.3 billion by 2050 (UN 2011). The increase in population will be accompanied by a significant shift away from a predominantly grain-based diet towards the consumption of animal-based products, when nations become more affluent. This will exert increasing pressure on natural resources and global food supply. According to the results of the Food and Agriculture Organization of the United Nations food balance projections (FAO 2009), agricultural production needs to increase by 70 percent in order to feed the world in 2050. However, the question of how much and what kind of growth is needed, is highly controversial and the projection of the FAO is subject to considerable criticism (Tomlinson 2013; Grethe et al. 2011). There are certainly opportunities to further increase yields, but they are limited by global environmental change, including land degradation, global warming, changes in hydrology, water scarcity, loss of biodiversity, and finite fuel resources (Ericksen 2009). The land available for food production will be further threatened by growing competition from other land use demands (e.g. biofuels). Against this background, the question arises whether the current food systems will be capable to meet the future demand and to ensure global food security in the long run.

The term "food system" is not restricted to the production of food, but covers all activities along the entire supply chain, from production through processing, packaging, distribution and retail up to final consumption, including aspects of

e.g. food security (in terms of availability, accessibility and affordability), environmental protection and social welfare. The food systems approach highlights the full range of socio-economic and environmental outcomes of food-related activities and helps to identify the specific interactions between bio-geophysical and human environments (Ericksen 2009; HLPE 2014, p. 29). Over the last decades, European food systems have undergone far-reaching changes. A better supply in terms of quantity and diversity has been associated with a strongly increased use of resources, serious environmental impacts and social distortions. Some of the most important characteristics of the current food systems will be sketched below.

It was a concern of the editors of this thematic focus to address the major problems of the current food systems, following the individual stages of the food supply chain and taking into account different viewpoints. In order to cover the full range of relevant opinions, experts from different scientific disciplines as well as stakeholders were invited to contribute.

2 Characteristics of Current Food Systems

Food production is one of the industries with the highest consumption of resources and the largest environmental footprint. The Intergovernmental Panel on Climate Change (IPCC) estimates that the agricultural sector is responsible for about 14 percent of global greenhouse gas emissions. When adding to the direct emissions also indirect effects through land use changes (e.g. deforestation of primary forests), this figure amounts to 30–35 percent (West et al. 2014). Direct emissions from agriculture occur particularly in the form of methane and nitrous oxide, whose climate change effect is much more pronounced than that of carbon dioxide. The main sources of agricultural greenhouse gas emissions are the use of mineral fertilisers, animal husbandry and the cultivation of rice. Also the conversion of grassland into cropland can lead to the release of significant amounts of greenhouse gases (SRU 2012). Agricultural irrigation accounts for about 70 percent of global fresh water withdrawals and is frequently a driver of water stress and scarcity (Gleick et al. 2014). Depending on how food is produced in the future and on the validity of forecasts for population growth, the global demand for water in food production could reach 10 to 13 trillion m^3 per annum by mid-century. This is 2.5 to 3.5 times greater than the total human use of fresh water today (IMECHE 2013). The application of fertilisers and pesticides and soil compaction from the use of heavy machinery have negative effects on soils and groundwater. The expansion of intensive agriculture, an increase in monocultures and the penetration of agricultural production in environmentally sensitive areas will result in a loss of biodiversity and a decline of ecosystem services (SRU 2012).

Advances in agricultural science and new technologies have enabled massive increases in productivity and falling food prices due to improvements in plant breeding, rationalisation and specialisation. But the benefits of this development are not distributed equally (Watson 2012). Approximately 800 million people globally, especially in sub-Saharan Africa and South East Asia, lack access to safe and sufficient food and suffer from hunger and malnutrition. At the same time, more than one billion people, mainly in industrialised countries, are overweight and suffer from diet-related health problems like cardiovascular diseases and diabetes (Reisch et al. 2013). The increase in diet-related diseases is attributed to a change in food consumption patterns, referred to as "nutrition transition". This includes a shift in the structure of diets towards a higher energy density with greater shares of saturated fat (mostly from animal sources) and added sugars, reduced intake of complex carbohydrates and dietary fibres, as well as reduced intake of fruit and vegetables. These dietary changes are compounded by changes in lifestyle characterised by reduced physical activity at work and during leisure time. The pace of this development seems to be accelerating, mainly in low- and middle-income countries.[1]

The consumption of animal-based products involves much higher environmental impacts than carbohydrate-rich diets. This is because the use of crops for animal feed with the ultimate intention to produce meat and dairy products for human nutrition is correlated with a substantial loss of caloric efficiency. It is estimated that about 70 percent more calories would be available, potentially enough to meet the basic needs

of additional four billion people, if the share of current crop production used for animal feed and other non-food uses (including biofuels) would be targeted to direct human consumption (West et al. 2014). Due to this efficiency gap, meat eaters have a much larger ecological footprint than vegetarians. Assuming an average caloric intake of 2,000 kcal per day, Scarborough et al. (2014) estimate that a meat diet produces 35 percent more greenhouse gas emissions than a vegetarian diet.

Over the last decades, the food supply chain has become longer and increasingly complex due to market globalisation, higher consumer expectations regarding the variety of choices and increasing migration of population from rural to urban areas. This involves growing distances between producer and consumer, longer cold chains, more intermediaries and increased risks of losses. It is estimated that almost one third of the food produced for human consumption – approximately 1.3 billion tonnes per year – is either lost or wasted globally. In developing countries, most food losses occur at the earlier stages of the supply chain as a result of limited harvesting technologies, inadequate storing facilities, adverse climate conditions, poor infrastructure, and badly functioning markets. In industrialised countries, food is wasted mainly at the later stages due to a lack of coordination between different actors of the supply chain and consumer behaviours (see the contribution of Priefer et al. in this issue). The issue of food losses and waste is seen as a symbol of the inefficiency, unfairness and unsustainability of the current food systems. Many experts agree that reducing wastage could be as important to meet the future food demand as increasing yields (HLPE 2014; Tomlinson 2013; FAO 2013).

Agriculture and food trade have always been subject to political intervention and governmental regulation. The multilateral WTO negotiations over the last decades were focused on liberalisation, but to varying degrees. On the one hand, they put forward little change to the current system that allows rich countries to continue to broadly support their farmers, thus exposing poor countries to subsidised agricultural imports from Europe and the United States, which undermines the competitiveness of local products (Pritchard 2012). On the other hand, they fostered liberalisation of the agricultural sector in the developing world. This process has triggered a shift away from traditional crops suited to local ecological conditions and farmers' knowledge towards cash crops that rely on purchased inputs. Small-scale and subsistence farmers have come under increasing pressure, whereas larger and more globally acting companies have benefited. The cultivation of cash crops (also for non-food uses) for export has been expanded using the most productive land to grow these crops, while staple foods are increasingly imported from abroad (Tomlinson 2013). This development has been accelerated by the phenomenon of "land grabbing" which was intensified by the declining trust in the stability of the global agricultural market after the global food price crisis of 2007/2008. As a result, many governments and private commodity traders purchase or rent land abroad, either directly or through sovereign wealth funds or publicly-owned companies. The motivation for these acquisitions is either to ensure a continuous supply of the own population or speculation on rising prices for farmland and agricultural commodities. All in all, the liberalisation of markets contributes to a weakening of local economies, increasing rural poverty and worsening the availability of food (De Schutter 2011).

Another consequence of the opening of markets since the start of the millennium is that farmland and agricultural commodities have increasingly become subject to international financial speculation. With the liberalisation of financial markets, different kinds of financial investment products were offered by banks and financial companies, including funds investing in farmland and agricultural firms located in Asia and Latin America (Clapp 2013). Also large food retailers launched a diversification strategy to enter the financial business, while financial actors started to play a more important role in food sales. This development has blurred the line between the financial and the retail sector (Isakson 2013).

The opening of markets, the deregulation of international trade and the increasing freedom to move capital, goods and services around the world has also increased the influence of the European food sector on a global level. The food industry is the second largest industry in EU-27 (after metal), employing about five million people and achiev-

ing a manufacturing turnover of more than 900 billion € per year. Nevertheless, the European food industry is highly fragmented. The vast majority of companies (99 %) are small and medium-sized enterprises with less than twenty employees, while only very few are multinational companies that participate in the global market.[2] In contrast to the food industry, the retail sector is characterised by a high level of concentration, with a few large internationally operating retail chains sharing the market and competing primarily on the basis of prices (see the contribution of Hallier in the thematic focus). Retailers such as Walmart in the United States, Carrefour in France, Tesco in the UK, and Metro Group in Germany rank among the largest companies in their home countries. Due to their market power, they exert significant influence on the upstream players in the supply chain, such as agricultural producers and food processors. Under the given conditions, farmers are more likely compelled to deliver their products to large retail chains rather than to local markets (see the contribution of Albrecht et al. in the thematic focus).

3 Requirements of Sustainable Food Systems

Measured against the criteria of sustainability, the current food systems fail: They are a major source of greenhouse gas emissions, nutrient loading, land degradation, water stress, and loss of biodiversity. They increase the need for transport with the accompanying adverse environmental effects and promote the wastage of edible food. They lead to a loss of income for farmers and to the progressive disappearance of smallholders and subsistence farmers. Although they produce enough food to feed the world, measured in calories per capita, the unfair distribution evokes food shortage, hunger and malnutrition on the one hand, and escalating rates of obesity and diet-related diseases on the other hand (SDC 2009). Efficient, well-managed und sustainable food systems are seen as essential to stop hunger and malnutrition as well as to protect the natural resource base and maintain its long-term production capacity (HLPE 2014; Freibauer et al. 2011, p. 120).

Up to now, a generally accepted definition of sustainable food systems does not exist. However, there is a broad variety of approaches which illustrate that the term "sustainable food systems" refers to a complex framework of understanding, encompassing different societal, economic and environmental factors, both inside and outside the food systems. Closely following the definition of sustainable development provided by the Brundtland Commission, the High Level Panel of Experts on Food Security and Nutrition (HLPE) defines "sustainable food systems" as "a food system that ensures food security and nutrition for all in such a way that the economic, social and environmental bases to generate food security and nutrition of future generations are not compromised" (HLPE 2014, p. 31).

Under this definition, the most important criterion of sustainable food systems is their ability to provide food security. But ensuring food security and nutrition *today* would not be sufficient for a food system to be called sustainable. The objective not to compromise the ability of future generations to satisfy their own needs entails the necessity to address numerous issues in the economic, social and environmental dimension, at different geographical and time scales. There can be trade-offs between the three dimensions of sustainability, and these trade-offs can manifest themselves differently at different scales. Thus, priorities in determining what makes a sustainable food systems sustainable will depend on the specific context of each country or subsystem (ibid.).

The definition of the Sustainable Development Commission of the UK is also based on the overarching principles of sustainable development, transferring them to the food sector. Starting from this perspective, sustainable food systems include the following needs (SDC 2011, p. 13):

- respect the limits of the planet's resources and address environmental impacts such as greenhouse gas emissions, climate change, loss in biodiversity, water scarcity, waste and land use competition, as well as other productive assets on which food depends,
- contribute to human health by preventing food-related diseases due to either malnutrition or overconsumption,
- deliver good quality of food in order to meet consumer and cultural aspirations,

- embody appropriate social values such as fairness and animal welfare,
- provide decently rewarded employment across the supply chain, with skills and training,
- promote the above-mentioned aspirations through good governance.

The Sustainable Development Commission emphasises that the challenge of the 21st century is how to meet this broad range of requirements in synergy rather than trading off gains in some fields for losses in others. According to the Commission, a sustainable food system should aim to develop a continuous cycle of improvement towards sustainability (ibid.).

4 Possible Pathways to More Sustainable Food Systems

It is rather unlikely that the forces previously driving towards less sustainable food systems will simply fade away in coming years. Additionally, new uncertainties resulting from climate change, resource scarcities, land use competition, and economic as well as political instabilities could emerge in the future. Thus, societal conflicts on food and how to shape food systems can be expected to increase. Nevertheless, there are also tendencies pointing in the direction of more sustainability in the food systems, which are in the focus of this issue.

One possible pathway is provided by the concept of "sustainable intensification", first introduced by the Royal Society in 2009. Sustainable intensification is understood as producing more food from the same area of land while maintaining soil fertility and reducing environmental impacts. The concept is focussed on crop production, chiefly arable crops. The contribution of *Rolf Meyer* deals with different pathways to enhance crop productivity, all falling under the umbrella of sustainable intensification. *High-tech approaches* focus on increasing the efficiency of external inputs (synthetic fertiliser and pesticides), scientific advance in precision farming, plant breeding and genetic engineering, accelerated adoption of new technologies by farmers, and removal of trade barriers. *Agro-ecological approaches*, on the other hand, are targeted at the reduction of external inputs based on a better understanding of ecological interrelations, the use of natural biodiversity, and a case by case adaptation of technologies and farming practices to local conditions. These include abandonment of tillage, cover cropping, crop rotation, intercropping, and new strategies for water conservation, nutrient management and integrated pest management. Given the great heterogeneity of European agriculture, the author highlights that these approaches are not equally suitable for the different farming systems in the EU and are associated with specific opportunities and limitations. Agro-ecological approaches do not only require changes on farm level, but also a move away from the predominant technological paradigm and the development of new business models.

Another route to ensure future food security and to reduce environmental risks is to make better use of the food already produced under the current system. Using the available food more efficiently, means to exhaust all possibilities for reducing food waste along the supply chain. The UK foresight report (2011, p. 18) estimates that halving the total amount of food waste by 2050 could reduce the food required in 2050 by an amount approximately equal to 25 percent of today's production.[3] Although the estimates of global losses along the supply chain are based on highly uncertain data, there is no doubt that considerable quantities are involved which would be sufficient, measured in calories per capita, to curb global hunger. The contribution of *Carmen Priefer, Juliane Jörissen* and *Klaus-Rainer Bräutigam* gives an overview on the scale, patterns and impacts of food wastage in EU-27 and addresses appropriate prevention measures. The focus is on instruments that are considered particularly useful in the current debate or that have already proven their effectiveness in practice. The authors come to the conclusion that, up to now, mainly soft instruments such as awareness campaigns, round tables and information platforms have been implemented, whereas more rigorous approaches like amendments to EU regulations and financial incentives have been bypassed.

A radical change in the prevailing food consumption patterns is seen as a third important pathway towards more sustainability in the food system (see the contribution of *Ulrike Eberle)*. Since the beginning of the 1950s, the intake of carbohy-

drate-rich food like cereals, roots and tubers has declined and the intake of animal derived products has increased, mainly in industrialised countries. With rising prosperity, this dietary shift can also be seen in developing countries and is predicted to continue. In parallel to dietary patterns, also eating habits have changed a lot in recent years. For example, the demand for convenience food, fast food and out-of-home consumption has significantly increased as a result of societal developments like urbanisation, rising employment of women, and shrinking household size. The dietary transition is not only accompanied by negative health impacts, but also by much higher environmental burdens. The author stresses that, despite the global spread of Western diet patterns, also opposite trends can be observed, such as the growing demand for organically grown food, the slow food movement, vegetarianism and veganism, which contribute to more sustainability. Up to now, these trends are rather a niche phenomenon. Whether they will be powerful enough to slow down or even stop the current nutrition transition, remains to be seen.

A further route to overcome the problems of the current food system, presented in the contribution of *Stephan Albrecht, Susanne Stirn* and *Rolf Meyer*, might be the shortening of food supply chains in line with new patterns of distribution and a stronger focus on regional/local food. Shortening the supply chain by opening more direct marketing channels offers the opportunity to reduce the number of intermediaries, to establish a closer link between producers and consumers and to improve the income situation of farmers. Examples of direct marketing systems are farm shops, farmers' markets, farm-based delivery schemes, Community Supported Agriculture, and food cooperatives. Local food systems or networks that restrict production, processing and retail to a limited geographical area are seen as counterbalance to industrialised mass production and uniformed food products. They re-link agricultural production to the regional social, cultural and ecological particularities that have often been the origin of special traditional and artisanal processing modes. Furthermore, locally sourced food meets consumer demands for better traceability and transparency of food production and for products with distinct qualities. The authors conclude that supporting policies on national and international level are required to facilitate and promote sustainable and vibrant food cultures.

The contribution of *Bernd Hallier* deals with the dramatic changes in the wholesale/retail sector over the last decades. These changes manifest themselves in increasing store sizes, broadening of the range and diversity of the assortment which is increasingly based on highly processed food, shifting of the procurement from local and national to global sources, number of stores run by the same retailer, and absolute sizes of individual companies, ranging from regional and national up to multinational levels. Also the character of distribution has changed towards the reintegration of production and marketing by the setting of benchmarks and standards that are accepted along the whole supply chain from farm to fork. The author highlights the important role of technologies in this development. Examples are improvements in cooling and freezing as well as innovations in the packaging and manufacturing industry (e.g. long shelf products) that help keep products fresh for a long time. Innovations in IT technologies, such as barcode scanners and QR codes, have enabled retailers to steadily improve their internal organisation process and to introduce new marketing models (e.g. internet shopping). Due to the high level of concentration and the absolute size of big players, retail business has achieved an outstanding position in the supply chain, also politically. This is reflected, inter alia, by the strong influence of private norms set by retail in the field of food safety which is a genuine responsibility of the state.

As mentioned above, the agricultural sector in Europe is a highly regulated market which has been, at least in earlier times, primarily targeted to foster productivity and augment production. However, environmental objectives have become more prominent over time. The contribution of *Andre Deppermann, Harald Grethe* and *Jonas Luckmann* gives an overview of the development of the Common Agricultural Policy (CAP) from its beginnings in the 1960s up to now and analyses key policies regarding their performance in triggering a shift towards more sustainable food systems. Environmental sustainability requires overcoming market failure, inter alia by the internalisation of positive (e.g. provision of public goods) and negative (e.g. wastage of food) ex-

ternal effects. Regulatory instruments as well as financial incentives such as environmental taxes and subsidies can play an important role in this process by providing for a fair burden-sharing among the involved stakeholders along the food supply chain. Other instruments like education, awareness campaigns, consumer information and research can help to overcome market failure resulting from incomplete information. The authors call for a substantial re-allocation of EU funds among different policy domains: firstly, within the CAP, from direct payments to agro-environmental and animal welfare policies, and secondly, from the current measures available under the CAP to policies aiming at more sustainable consumption patterns. Finally, the current bioenergy policy should be revised and financial support of biofuels should be phased out over the next few years.

5 Outlook

As demonstrated by the contributions in the thematic focus, the current food systems are characterised by a variety of competing trends: limited corrections to the production system against in-depth transformations of the prevailing economic and technological paradigms, industrial versus agro-ecological crop production, global versus local food procurement, complex versus short supply chains, standardised industrial foods versus traditional artisanal processed products, global spread of the "average western diet" versus more varied, healthier and environmental friendly nutrition. These opposing tendencies get mixed up at different points of the food chain and influence each other. It will remain a continuous challenge for sustainability research and technology assessment to analyse the impacts and trade-offs of different development pathways and to provide sound policy options in order to achieve more sustainable food systems.

Notes

1) WHO: Global and regional food consumption patterns and trends; http://www.who.int/nutrition/topics/3_foodconsumption/en/ (download 25.9.14)
2) EU-Commission, DG Enterprise and Industry: EU food market overview; http://ec.europa.eu/enterprise/sectors/food/eu-market/index_en.htm (download 25.9.14)
3) The actual saving will depend upon a number of uncertain factors, not least the size of demand in 2050. However, the figure of 25 % is considered to give an approximate estimate of the magnitude of savings that may by achieved, based on the current estimate of 30 % food waste (Foresight 2011, p. 19).

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Diversity of European Farming Systems and Pathways to Sustainable Intensification

by Rolf Meyer, ITAS

European agriculture is confronted with a number of ongoing and new challenges. At the level of crop production, sustainable intensification is proposed as the way forward. Two different pathways for improvement of crop production are grouped under the umbrella of sustainable intensification: high-tech approaches and agro-ecological approaches. Because of the high heterogeneity of agriculture in the EU, these approaches are not equally appropriate for all European farming systems and are associated with specific opportunities and limitations. Agro-ecological approaches of sustainable intensification demand not only changes at farm level but also include a transition of the currently dominating technological paradigm and development trajectory.

Die Landwirtschaft in Europa muss sich einer Reihe von bereits bestehenden, aber auch neuen Herausforderungen stellen. Im Bereich der landwirtschaftlichen Produktion wird eine „nachhaltige Intensivierung" als notwendige Weiterentwicklung vorgeschlagen. Unter diesem Begriff werden zwei verschiedene Wege zur Verbesserung der landwirtschaftlichen Produktion diskutiert: hochtechnisierte Ansätze und agrarökologische Ansätze. Aufgrund der hohen Heterogenität der Landwirtschaft in der EU sind diese Ansätze nicht für alle europäischen Landwirtschaftssysteme gleichermaßen geeignet. Sie sind jeweils mit bestimmten Chancen und Einschränkungen verbunden. Agrarökologische Ansätze der nachhaltigen Intensivierung erfordern nicht nur Veränderungen in der Praxis der landwirtschaftlichen Betriebe, sondern auch einen Wandel des gegenwärtig vorherrschenden technologischen Paradigmas und Entwicklungspfads.

1 Introduction

Since the 1950s, the intensification of European agricultural production was driven by farm mechanisation and the strong increase in external (purchased) input, increasing the dependency on