

SCHWERPUNKT

Feeding the World: Challenges and Opportunities

Introduction to the Thematic Focus

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The global food crisis is back, after only three years, showing how vulnerable the global food system has become. Even before, hunger has remained high and pervasive. After two decades of neglecting agricultural investments, the importance of agriculture for development was reaffirmed in recent years. But political intentions and commitments are only on the way to become implemented. Beside the task to regain lost time, a number of new challenges to food and nutrition security has to be addressed urgently. There is no deficit of analyses and proposed strategies to go forward. But corresponding with the highly complex issue, different perspectives are applied and alternative strategies are brought into discussion. Understanding the alternatives is necessary to develop and implement best possible solutions. Important interconnections and common points are: emphasis on principles and system approaches, avoidance of fixed strategies, adaptation of solutions to local contexts, and combination of bottom-up and top-down activities.

Access to sufficient, safe, and nutritious food is a fundamental human right (UN Human Rights 2010), yet the number of undernourished people worldwide is unacceptably high and pervasive. Increased investments in agriculture from the 1960s to the 1980s in the developing world and the associated growth in food production and decrease in relative food prices enabled a remarkable decrease in the proportion and total number of hungry people, despite a strong growing world population. But since the mid-1990s, the overall number

of undernourished has increased once again, and with the food and economic crisis from 2007 to 2009, the percentage of hungry people worldwide increased as well. In 2009, more than one billion people were undernourished, more than 40 years ago (FAO 2010a). The Millennium Development Goal of halving hunger and poverty (between 1990 and 2015) will probably not be achieved. In recent months, international food prices have once again soared to levels seen during the previous food crisis. The demand for cereals continues to increase so that the harvest 2011, even at record levels, is expected to barely meet consumption needs, providing further support to high prices (FAO 2011).

1 Challenges Ahead

The future perspectives of food security – respectively sufficient food supply – are at least uncertain. Major challenges ahead are:

- *Population increase:* In 2050, food for around nine billion people will be demanded. Projections indicate that global agricultural production will need to be raised by at least 70 percent to meet this future demands. In the developing world, doubling of food production is called for. The required global increase is unprecedented in terms of the time period over which the absolute production must be achieved, and its distribution and market system organised.
- *Nutrition transition:* With economic development and increasing incomes of people particularly in emerging countries, their diets will become more “urban” and similar to the industrialised “western” diet, with higher consumption of animal products and vegetable oils in processed foods, from which a much more intensified agriculture and a higher land demand, contributing to the further destruction of natural habitats, and more overnutrition, with its negative health impacts, are expected.
- *Growing overall demand for biomass:* Beside food and feed, the demand for fibre and biofuel is expected to become more important in the next decades. Established politically defined biofuel targets and concepts of a bio-economy will put additional pressure on agricultural land base and the agricultural commodity markets.

- *Food prices*: Declining food prices could become a thing of the past. In the future, food prices will be likely more coupled with the development of the energy prices. At the same time, higher volatility of agricultural prices can hinder growing investment in agriculture, with the possible consequence of insufficient production and productivity increases. The poorest are most strongly affected by increasing food prices.
- *Climate change*: On the one hand, agriculture is a significant contributor to greenhouse gas emissions, and on the other hand, climate change will probably reduce agricultural output, productivity (efficiency), production stability, and incomes, especially in many tropical and subtropical areas that already have high levels of food insecurity. Therefore, mitigation and adaptation in the agriculture production sector have to be achieved at the same time.
- *Natural resource management*: Natural resources such as soil, water, and biodiversity are essential to agriculture and already under severe threat from degradation. They will become increasingly threatened and scarce if the current high disturbance methods of farming continue to intensify, particularly in developing countries in the tropics. Conflicts and competition over access to and the use of these resources are likely to increase in many regions.
- *Pro-poor development with focus on small-holders*: The vast majority of farmers in developing countries are small-scale farmers, producing on fewer than two hectares, and most of the poor in developing countries live in rural areas, although an increasing number is located in urban and peri-urban areas. Improvements in small-scale farming and in socio-cultural organisations of farmers and their communities, including producers in peri-urban areas, are essential in meeting food security and sustainable development goals as part of the global sustainable development efforts.

Therewith, the unsatisfactory and fragile current situation could aggravate in a dramatic way, if adequate actions are not implemented. The *contribution of Ismail Serageldin* (Bibliotheca Alexandrina, Egypt) makes a strong call to abolish hunger. He underlines our moral obligation and the need of political will to eradicate hunger, and

argues that science, technology, and knowledge can be made available in a short time to ensure food security for all people and to achieve a sustainable use of our resources.

2 Perspectives and Alternative Strategies

During the last years, a number of major assessments (World Bank 2007; IAASTD 2009; Royal Society 2009; Foresight 2011; Worldwatch Institute 2011) have addressed the world food problem, with great congruency in the analysis of the current situation and the emerging challenges. But the proposed strategies to go forward generally originate more or less from a specific perspective and often tell a straight story of a best solution, without discussing alternatives.

In contrast, the benefit of a problem-oriented technology assessment (TA) approach is to recognise the high complexity of the problem “feeding the world” (Dusseldorp, Sauter 2011) which has many causes and compromises in multiple layers, while proposed solutions are associated with a variety of unintended impacts. The task of an inter- and transdisciplinary TA perspective is to:

- bring different framings of the problem and varying perspectives on solutions together,
- discuss alternatives,
- include preconditions and impacts, and
- assess the strengths and weaknesses of different options.

Making the complexity transparent should build a good ground for informed decision-making. A recurrent topic is that no technology should be ruled out (e.g. Royal Society 2009, p. ix). But this open approach obscures the fact that decision-making is necessary due to restricted funding budgets and scientific resources, different time horizons for development, and varying impacts (some negative) of technology options on ecological sustainability and factor productivity.

This special issue cannot be comprehensive, but presents important perspectives and discusses some main alternatives. Nonetheless, some important points are not covered, for example the distorted global regime for trade in agricultural products, with one of its roots in the agricultural subsidies of OECD countries, and its negative

impacts on small-scale farmers in developing countries (see IFAD 2011, p. 229).

3 The Economic Perspective: Strengthening the Public Sector versus New Complexity

In recent years, the importance of agriculture for development was reaffirmed (World Bank 2007; IAASTD 2009; Royal Society 2009; Foresight 2011; IFAD 2011). After more than two decades of decline in development assistance for agriculture and neglecting agricultural investments, sharply increased public funding is a broadly recognised recommendation. Promises and first commitments were made on an international level and by some single countries. For these commitments, *Fan and Breisinger (in this volume)* show that important gaps in implementation remain.

Fulfilling commitments and investing in agriculture and rural development represent only a first step. Fan and Breisinger work out that the new global and national commitments have led to new institutions and arrangements. The growing role of new players (emerging countries and south-south cooperation, private sector) in financing agricultural investments and innovations add an additional dimension. Therewith, the already high complexity of the development architecture becomes even more dynamic and complicated.

With the focus on improving smallholder agriculture, an underlying open controversy is related to which extent a new public sector leadership is needed, or if the complexity of actors established today demands more flexible multi-stakeholder arrangements to fully harness agricultural development possibilities. Independent from this alternative, a common understanding exists that one-size-fits-all strategies will not work. Improved efficiency of public agricultural spending needs country-driven policies, adapted to the local context (see *Fan, Breisinger in this volume*).

4 The Production Perspective: Technology versus Systems Approach

For economic analysis, the mode or the paradigm of agricultural production is more or less an assumed black box. It is not only necessary to spend

more money, and to improve the efficiency within the agencies that provide public investments and services – it is at least equally important to ask the question: for what? To keep it simple, two main approaches or trajectories to increase agricultural productivity are discussed controversially.

With reference to successes of the past, a still popular approach is the extension of industrialised agriculture and a new Green Revolution (e.g. Diao et al. 2008), with the application of new technologies as its main aspect.¹

At the same time, there is a growing international consensus that “business as usual” (or “more of the same”, see *Uphoff* and *Kassam et al. in this volume*) will not provide solutions to future needs and 21st century realities. New production system paradigms with greater ecological sustainability and efficiency as well as offering “more for less” are being envisaged as appropriate for the future. These must permit the simultaneous harnessing of improved productivity and ecosystem services. Such alternative approaches are discussed under different terms such as “sustainable intensification” (FAO 2010b; see also Royal Society 2009; Foresight 2011; IFAD 2011), “eco-functional intensification” (GIZ 2011) or “low-input intensification” (Meyer 2010). The goals are higher input efficiency by making better use of existing resources (e.g. soil, crop, water, nutrients, landscape, biodiversity) and technologies (Pretty 2008), and higher crop yields and better ecosystem services through improved agro-ecological and biological productivity (Meyer 2010). Such intensification has the potential to address in particular the needs and possibilities of small-scale farmers. Starting points could be the adoption of principles and practices of Conservation Agriculture (Kassam et al. 2009; *Kassam et al. in this volume*), System of Rice Intensification (Uphoff, Kassam 2009; *Uphoff in this volume*), Organic Farming, and Agroforestry systems. At present, additional concepts are presented, such as Conservation Agriculture with trees or Evergreen Agriculture (Garrity et al. 2010) or Climate-Smart Agriculture (FAO 2010b).

The general approach that all these systems share is to formulate fundamental principles and highlight key sustainability elements, that can be translated into locally-devised farming practices,

as well as system-level stakeholder support, instead of fixed technology packages or a standardised best practice approach pushed down through a linear extension approach. Hence, when it comes to concrete applications in specific contexts, the principles have to be translated on a case-by-case basis into production technologies and farmer practices adapted to local agro-ecological and socio-economic conditions associated with farming in general and with less favourable areas and smallholders in particular (Meyer 2010). This is also characterised as a “more systematic approach” or “system-based shift” (Butler Flora 2010) which focuses on an understanding of agriculture as complex adaptive and nested systems.

With the latter approach, changes in the innovation system emerge. Non-governmental organisations and farmers get involved in research and development. Involving communities and farmer groups in local consultations, policy deliberations, scientific research, and experimentation is all part of building from the bottom up to achieve success (Spielman, Pandya-Lorch 2009, p. 13). Local agricultural research committees and farmer field schools are concrete examples. This is summarised also as participatory development concepts and transdisciplinary agricultural research.

Conservation Agriculture (CA) is an example of an innovative no-till farming system for harnessing sustainable production intensification which was formulated by farmers in America some decades ago. No-till farming was a response to severe land degradation and erosion, both from runoff and wind, associated with the use of tillage at all levels and agrochemicals in more advanced farming systems to increase production. Currently, 117 million hectares of global crop land is under Conservation Agriculture, spread across all continents and agro-ecologies. The upscaling of no-till systems to achieve local area and national impact requires a dynamic complement of enabling policies and institutional support to producers and supply chain service providers. The extent of CA is expanding at the rate of six million hectares per annum and is expected to accelerate as more development effort is directed towards mainstreaming this alternate agro-ecological approach to sustainable production intensification (Kassam et al. 2010; *Kassam et al. in this volume*).

The System of Rice Intensification is another example where civil society (NGOs and local farmers) was the key actor in the innovation process (*Uphoff in this volume*), with only later inclusion of academic and governmental actors. Uphoff shows that such a civil society innovation can provoke controversies with established research, which handicap funding of promoting and adaptation projects and programmes and of evaluation research by donor agencies and foundations.

Low-input intensification activities are characterised by a vast number of projects, small programmes, and parallel activities, with many successful examples. While public involvement in agriculture was de-organised and re-organised in the 1980s and 1990s with the dismantling of financial services and input parastatals, it was re-organising as public or NGO projects which are, essentially, mini packages of policies that affect smaller groups on a temporary basis (Reardon et al. 1999). An enabling policy environment and adequate sector-level policies are often lacking.

5 Labour Productivity: Extension of Land per Farm versus Additional Labour Capacity for Intensification

Beside land productivity, the performance of agricultural production systems is shaped by labour productivity. One-third of the world's population working in agriculture uses only manual tools. The difference in productivity between the least efficient agriculture with manual implements (hoe, spade, digging stick, machete, harvest knife, sickle) and the best-equipped, most efficient industrialised agriculture has increased dramatically in the last decades to 1 to 2000 (Mazoyer, Roudart 2006, pp. 11, 13). Farmers working at hand level can only feed three other persons on average. With animal traction one farmer can already feed six other persons and with a tractor the number further increases to 50 or more persons (Legg et al. 1993). Labour output levels vary widely according to the mechanisation level and climatic conditions, and there is a clear correlation between the production levels and the farm power input (Giles 1975; Wieneke, Friedrich 1988). They also depend on the kind of farming system used (Zweier 1985; Doets et al. 2000).

Improvement of labour productivity opens up different perspectives. In western industrialised countries, the increase in labour productivity in the last decades led to an ongoing rat race: all different steps of mechanisation were associated with an increase in farm size and a reduction in the number of farms. Therefore, this trajectory should not be a role model for many developing countries. The restricted capacity of non-agricultural and urban labour markets is a strong argument against a modernization process like in Europe or the US. Additionally, most means of mechanisation exceed the investment and working capacity of single small-scale farmers. Therefore, sharing equipment among farmers as a group will be the better option for the majority of peasants. In this context, the aim is not to farm more land, but to set free labour capacity for a sustainable intensification of land use.

6 Land Transactions: Growth Poles versus Land Grabbing

Since the food crisis 2007/2008 with the surge of international prices for major cereals, export restrictions, and hoarding (Headey, Fan 2010), a tightened struggle for agricultural land has emerged. Motivations for large-scale land acquisitions are to secure a stable and steady food supply for wealthy nations with high net-food imports and the promise of profitable investments for private-sector financiers. Especially those developing countries which are land rich are sanctioning the sale or transfer of user rights of large tracts of farmland for foreign investment (Cotula et al. 2009; Daniel, Mittal 2009; Kugelman, Levenstein 2009; Robertson, Pinstrup-Andersen 2010). Poor developing countries with high food insecurity are the most important net sellers of farmland. *Briinstrup (in this volume)* analyses the associated opportunities and threats. Foreign direct investments in agricultural land and production can open access to specific markets, technology, management, and finance for poor countries, and therewith be a development opportunity if a fair benefit-sharing for all stakeholders is achieved. But early assessments highlight predominantly critical points: Land involved in these transactions is often characterised by governments that are leasing land as

“underutilised” or “uncultivated”, but much of this (often marginal) land is currently used by poor smallholder farmers without formal land titles and by users of natural resources. The threat for smallholders and local food security is reflected in the term “land grabbing”. Beyond that, the model of industrialised agricultural production here again is confronted with approaches of sustainable intensification centred on small-scale farmers.

7 Urban Agriculture: Livelihood Improvement versus Vertical Farming

Future population growth will be mainly concentrated in urban areas. As a result, the urbanisation process is accompanied by a phenomenon referred to as the “urbanisation of poverty”: a shift in the locus of poverty from rural to urban areas (Zeeuw, Dubbeling 2009). Urban and peri-urban agriculture is a not negligible activity in developing countries, performed by 10–70 percent of households. However, in terms of income generation and overall agricultural production, its role usually is quite limited. Important exceptions are several African countries and the poorest urban households where urban agriculture provides a substantial share of income and constitutes an important source of livelihoods (Zezza, Tasciotti 2010). Urban and peri-urban agriculture can provide an important safety net for the urban poor in times of economic and food crisis, and will have to feature prominently in urban food security strategies of developing and emerging countries, contributing to more resilient and sustainable cities (Zeeuw, Dubbeling 2009; FAO 2010c).

In recent years, corresponding developments have emerged in western industrialised countries, in form of “urban gardening” (Müller 2011). Different types of community gardens with focus on vegetable production were established, as pure “grass root” activities or in cooperation with local authorities. The associated objectives range from community building, intercultural dialogue, multi-generation communities, local food production, and subsistence to food sovereignty.

At the same time and in total contrast, high-tech approaches like vertical farming are promoted as sustainable solutions for urban agriculture (Despommier 2010). The aim is a year-

round crop production in a protected, managed environment over many stories. Objectives are to reduce transport and to make agricultural production independent from land demand. Additionally, the transformation of urban architecture is a key element (Wagner 2010). The idea is to bring an industrialised agriculture to urban areas, and to produce in an artificial environment, independent from natural agro-ecological conditions. Up to now, the whole approach is still in a conceptual state, the fundamental possibility and time frame of realisation are open, and *several points of criticism* (e.g. high energy and light demand) *already turned up* (see Roach 2009).

8 The Nutrition Perspective: Paternalistic versus Empowerment Approaches

For solving world food problems, a nutrition or demand side perspective is at least as important as the production perspective discussed above. Higher agricultural production does not automatically translate into an improved nutrition. So far, there is only restricted concrete evidence how the linkages of agriculture and nutrition work (IFPRI 2011). Nonetheless, local food access will remain essential for food and nutrition security of the urban and rural poor. Questions of malnourishment (beside undernourishment) can be addressed only in a nutrition perspective.

Lemke and Bellows (in this volume) review the shortcomings of the currently dominating separated food security and nutrition security approaches. Both approaches are conceptualised as products of trade, neglecting possibilities of local food governance. Current measures to address malnutrition and hunger are favouring paternalistic approaches that perpetuate aid, neediness, and dependency. An example is the initiative for the large-scale distribution of Ready-to-Use Supplement Food (RUSF), high-energy nutritional food supplements fortified with vitamins and minerals. The main criticism is that the global circulation of RUSF is over-emphasized to the advantage of trade interests, but to the detriment of developing capacity and autonomy in community and national based food and nutrition systems.

As alternative frames, Lemke and Bellows suggest to integrate food and nutrition security in

a food systems and rights-based self-empowerment approach, namely through sustainable livelihoods and agro-ecology, and including a gender perspective that has been missing so far. This perspective promotes a systems approach, the integration of food production and nutrition objectives and local governance that foreground inclusive participation of all members of society.

9 International Agricultural Research System: Changes and Chances

International agricultural research – the international agricultural research centres IRRI and CIMMYT, and the build-up of the CGIAR (Consultative Group on International Agricultural Research) system and its partners – were essential for the Green Revolution in the 1960s and 1970s, providing productivity-enhancing research (improved germplasm and related technologies). Over the course of the last four decades, the CGIAR's mandate has increased significantly, growing from four centres with a narrow focus on productivity to 15 centres with an expanded agenda that also address natural resource management and conservation issues critical to sustainable development. During the same time, the system has evolved into an increasingly complex entity, characterised by complicated governance structures. While funding has increased in nominal terms, it has stagnated in constant dollars, and the part of unrestricted funding has decreased dramatically. In addition, a lack of coordination among the funding bodies resulted in sub-optimal resource use (CGIAR 2008).

Furthermore, the global landscape of agricultural research changed dramatically in different aspects. As one point, the capacities of national agricultural systems grew in emerging countries (as Brazil, China, India and South Africa) whereas the agricultural research is lagging behind in many smaller and poorer countries (CGIAR 2008). The consequence is a new complexity in research partnerships.

In answer to the changes and challenges, CGIAR last year adopted a new institutional model with clearly delineated responsibilities for researchers and donors, a common vision, and strategic objectives for all centres, and a portfolio of mega programmes (still in the approval

process) with legally binding funding and performance agreements. The revitalised CGIAR is too new to assess its success. Nonetheless, *Meyer (in this volume)* identifies a number of remaining questions which will probably also accompany the international agricultural research system in the coming years. These controversial issues are plant genetic improvement versus agro-ecological production system research, international research for wide adaptability versus local production system development, scientific excellence versus networking, and top-down transfer model versus participatory research for development.

10 Conclusions

Business as usual is not enough to meet the growing global development challenges and to achieve sustainable food and nutrition security for everyone. The complexity of the issue “feeding the world” entails different perspectives and divergent proposals for strategies and actions. The TA perspective implicates a certain emphasis on science and technology, their preconditions and implications. Regarding agricultural production systems and their intensification, important criteria for their assessment are:

- Short-term availability to enable in-time reactions to the challenges
- Scale-neutral capacity to include a pro-poor perspective
- Adaptability to local agro-ecological and socio-economic conditions
- Qualification for climate change adaptation and mitigation
- Compatibility with overall livelihood and nutrition improvement
- Suitability for public-private-community engagement in the face of steadily increasing development actor complexity

Despite the complexity and ongoing need for assessment, first strong messages for a shorter-term and pro-poor addressing of the challenges, based on the criteria mentioned above, can be concluded:

- *Higher investment in agriculture*, with a strong role of the public sector in the agricultural innovation system: The reverse of the last decades’ underinvestment in agriculture is an important

precondition. Public sector leadership is needed for many issues of agricultural research, development and investment which will not be sufficiently addressed by the private sector. For the transformation to sustainability, the “proactive state” is a key element (WBGU 2011).

- *Mainstreaming of agro-ecological approaches*: The preservation and enhancement of the natural production potentials of agriculture (such as soil fertility, water conservation, biodiversity sustainment) are not only an add-on activity, they are essential to stabilise the high yield levels achieved in favourable areas, to realise more of existing yield potentials, and to increase the resilience of farming systems.
- *Shift to systems approaches*: New high-yielding varieties or single low-external input technologies can make only restricted contributions. Thus, instead of single technologies or fixed technology packages, system-based principles and approaches with local adaptations and integration have the potential to address the specific agro-ecological, social, and economic conditions of farmers at their specific locations. The problem-oriented combination of local knowledge and resources and scientific research is needed to address the specific problems of farmers within this systems contexts.
- *Bringing food and nutrition security together*: Increasing production of food is not enough. Under- and malnourishment is also connected to health aspects, social rights and gender disparities. Interlinks between agriculture and nutrition and health should be harnessed. Local governance approaches for local food systems are a prominent tool to bring food and nutrition security together.
- *Combine bottom-up and top-down approaches*: Local adaptations of policies and actions are seen as highly important in different areas. This applies for economic development policies, sustainable intensification of agricultural production systems as well as food governance for nutrition security. But a piecemeal of local projects and actions is not enough for national and cross-boarder upscaling. National policies (and international knowledge exchange) are essential to promote and spread local activities.

All in all, “feeding the world” represents one of the most fundamental missions of international and national politics. This task cannot be reduced to a question of science and technology or economics alone, due to its irresolvable amalgamation with the problem of reducing poverty and improving the social, environmental, and political situation. Not only for TA, but for each policy and action directed towards improving the world food situation in a sustainable manner, the interdependency of many very different levels poses an extremely complex challenge. The following papers reflect this complexity. Hopefully they can provide fundamental orientation for non-expert readers from the TA community and impulses for those who are more familiar with the issue.

Note

- 1) Genetic engineering and transgenic crops are regarded as an element or a major component of a *new Green Revolution*. Their chances and risks, and their potentials and restrictions to contribute to the future food supply can not be discussed in this special issue and have to be assessed in comparison to alternative options (see Sauter 2008).

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