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The First International Conference on Global Food Security – A Synthesis

1. Global food security and the conference in context

Food security exists when all people at all times have physical, social and economic access to sufficient, safe and nutritious food preferences for an active and healthy life (FAO, 1996). In the order of 800 million people suffer from hunger (FAO, IFAD and WFP (2014)) – both in absolute and relative terms the number has decreased significantly over the past decades, yet still one in nine people go to bed hungry. Next to these hungry people, 2 billion people suffer from micronutrient deficiencies (FAO, 2013), while 1.4 billion are obese (WHO, 2014). This lack of global food and nutrition security is in the spotlight and demands urgent attention.

Since 2008, food and agriculture is back on the agenda. The link between agricultural development and poverty reduction is acknowledged (DFID, 2003) and significantly more donor money is available, particularly with a focus on smallholder farming. The sustainable development goals (SDGs) are being formulated for the post-2015 development agenda. In recognition of the many contributions the global food system makes to sustainable development, *sustainable agriculture and food systems* is one of the central themes for which goals, targets and indicators are being proposed (SDSN, 2013). The moment is ripe to tip the balance decisively from prevailing food insecurity to security.

Four dimensions of food security portray the multi-faceted nature of food security – availability, access, utilisation and stability (Fig. 1). These four dimensions provide the structure of this article.

Improving food security is difficult. There are many reasons why hunger and malnutrition persist, not least because deep social inequities and conflicts often dominate. Equally many approaches are needed to deal with this global problem. In the case of global food security, improvements can depend on actions taken in farmers' fields, at local markets, on global markets, in company boardrooms, national parliaments, conference rooms, laboratories and kitchens. The many strategies pursued to improve food security are coloured by a diversity of worldviews and it is not surprising that food security is an emotive and political issue.

The First International Conference on Global Food Security (September 29–October 2, 2013 in Noordwijkerhout, The Netherlands) was a unique scientific event aiming to build stronger bridges between different disciplines working on improving food security. The conference brought together a critical mass of scientists (600 participants from over 65 countries) from a wide variety of disciplines; scientists with shared goals but different research strategies. Here we report the outcomes of various interactive sessions of the conference, as presented and discussed during the concluding, synthesis session of the conference. The chairpersons of the 10 parallel sessions and 14 “Workshop Cafes” of the conference were asked to summarise their main conclusions and questions. This introductory paper of the special issue highlights the main issues that emerged and culminates in a number of messages for the broad scientific community on how to continue moving the global food security research agenda forward. We cite papers from this special issue, but also mention contributions which to our knowledge are as yet unpublished, by referring to “this conference”.

2. Summary of the conference synthesis session

2.1. Some general issues

Our food – what *we* eat – is a very personal and emotive issue. A survey that appeared just before the conference of 500–1000 respondents across a wide range of 13 developed and less-developed countries[1] indicated a strong preference for locally-produced, organic food for their own families. Yet when asked how the world would meet the future demand for food, large-scale intensive agriculture and governments were thought to have the strongest potential roles. Whilst consumers throughout the world want technology in their pockets – such as the latest smart-phone – why do we seem uniformly to reject technology in our food? This emphasises how emotive the whole issue of food is and raises the question as to what makes agriculture and food unique in relation to ethics, values and perceptions?

Some points of consensus emerged from the discussions across the breadth of the conference. The need to understand and adopt a global food systems approach was generally held – such as the approach used by the Global Environmental Change and Food Systems (http://www.gecafs.org/) initiative (Ingram, 2011). Studying the global food system as a (complex adaptive) system demands a systematic approach to data and models. van Dijk and Meijerink (2014) reviewed major global food security scenario

[1] The online survey (conducted as a telephone survey in Kenya) specifically targeted an “informed public” (college educated, high income, media-engaged) in Argentina, Brazil, China, France, Germany, India, Indonesia, Kenya, Russia, South Africa, Switzerland, UK and the USA. See ⟨http://www.syngenta.com/global/corporate/en/goodgrowthplan/⟩.

http://dx.doi.org/10.1016/j.gfs.2014.10.008

Fig. 1. Food security and its four dimensions (figure from Harrie Lövenstein, Wageningen UR).

studies and point at the progress made, but also at the gaps in studies to date. During the conference, a huge concern was expressed on the lack of reliable data on all aspects of food systems from production to consumption across the globe. The available data tends to be highly fragmented, lacking the consistency that is needed to allow integrated and comparative analyses. Further, few data sets are widely accessible at present. Initiatives such as the Global Open Data for Agriculture and Nutrition (GODAN) initiative (http://www.godan.info) that was launched around the time of the conference, and the new data journal, the Open Data Journal for Agricultural Research (www.odjar.org) are important initiatives that can support future availability of data.

To date there are no global analyses of food security in which different levels are addressed consistently to explore the continental, regional, national and local contexts and solutions. This is a challenge that needs urgently to be addressed so that we can understand how things play out on the ground given that the need to tailor approaches to local needs and/or conditions was a conclusion that resonated across the different conference sessions. This was one of the few points on which there was a clear consensus – that there are no "one-size-fits-all" solutions. The huge diversity in global food systems across all levels demands that we develop tools to help us understand and grapple with this diversity – not in an attempt to simplify diversity as this would be to ignore one of the most important attributes of food systems. How to generate "baskets of options" of food systems, technologies, institutions and policies that can support local innovation and adaptation is an area that needs much more emphasis. From a science and data perspective, this implies that global studies need local validation and downscaling and on the other hand local studies need to be placed in a global context.

2.2. *Food availability – the discrepancy between supply and demand*

A much-quoted figure is the need to increase global food production by 60% to meet the demand of 9.2 billion people in 2050 (Alexandratos and Bruinsma, 2012). But how was this estimate derived? Alexandratos and Bruinsma (2012) discuss the uncertainties behind their estimate, which are generally ignored in the quotations which tend to round off the number to 70–100% or more. When aggregating the needed increases in global production, it matters a lot what units are used and how different commodities are included – whether as mass, calorific content or monetary value. Alexandratos and Bruinsma (2012) arrived at an estimate of 60% increase in food requirements using monetary value as the weighting factor. But with anticipated shifts in consumption away from staples towards meat and higher value commodities, a 60% increase in requirements does not imply a 60% in production volume for each of the crops or livestock types. Thus more disaggregated figures are required when considering future food and feed needs and availability.

Similarly a spatial disaggregation is needed to understand implications of the increased food demand. Population already peaked in Europe and is levelling off in the Americas and Asia, whereas population in Africa will continue to rise rapidly – at least to 2050 and likely beyond (UN, 2013; Gerland et al., 2014). Thus, these spatial differences in population growth plus the anticipated differences in economic growth shed light on where increases in availability are particularly urgent.

There are basically three options to increase production to meet future food requirements: (i) expanding agricultural area; (ii) increasing yields – including associated animal production systems – on current agricultural area through a narrowing of yield gaps (i.e. the difference between farmers' yields and theoretical, potential yields); and (iii) increasing potential yields through breeding and/or genetic modification. All three options provide opportunities. There is scope for area expansion (Eitelberg, this conference), and this is something going on presently (Grassini et al., 2013), but at the same time this is with clear trade-offs as to other functions of land use and greenhouse gas emissions. Narrowing yield gaps, sometimes also labelled as sustainable intensification, is often advocated and has massive opportunities, at least theoretically, to increase food production (Lobell et al., 2009; van Ittersum et al., 2013; www.yieldgap.org; Schierhorn et al., 2014). This requires a local quantification of such yield gaps and identification of biophyscial and socio-economic factors explaining yield gaps. Clearly, increasing production per unit land requires in many locations an increase in the use of external inputs. Although this can be achieved often at similar or higher levels of resource use efficiency (i.e. kg output per kg of input – see e.g. Capper et al. (2009), De Wit (1992)) or kg of output per unit of greenhouse gas emission, local accumulation of nutrients and pesticides are an evident environmental risk (Zhang and Shen, this conference). The third option is the domain of breeding and genetic modification. Crop improvement through "classical" plant breeding still provides incremental increases in yield (Fischer et al., 2014). Though genetic modification did not receive much attention during the conference, it clearly receives a lot of attention, for instance through initiatives such as "C4 rice" and engineering the ability to fix nitrogen from the atmosphere into cereals.

Beyond simply increasing food production there is much attention currently to the re-design of agricultural systems at crop, farm and regional levels. A focus on enhanced resource use efficiency appears justified everywhere. In some parts of the globe – North America, parts of Europe and Asia – there is a need to reduce inputs and spare resources. In others – much of Africa – there is a need to increase inputs in order to raise productivity. This contrast is exemplified by the study of Sattari et al. (2014), presented at the conference, which suggests that efficiency gains in China due to proper accounting for soil residual phosphorus could provide half of the phosphorus needed for agriculture across the whole of Africa up to 2050. Issues associated to yield gap closure as a way forward and that were raised during the conference included the lack and/or the presence of incentives to close yield gaps, the need for locally-adapted approaches allowing for diversity of crops, of farming methods and types of farms and the interference of climate change with the size of yield gaps and yield gap closure.

2.2.1. *Alternative food sources*

Attention at the conference was also devoted to food systems beyond terrestrial agriculture i.e., farming either in or on water (aquaculture and sea farming) and harvesting through fisheries (Youn et al., 2014). Perhaps further into the future algae, which are already cultured for food, oils and energy at a small scale, may play a more important role in food production. Using food waste as a substrate to culture insects for feed is a rare potential win–win (Pieterse and Pretorius, 2013) – while consumer acceptance of

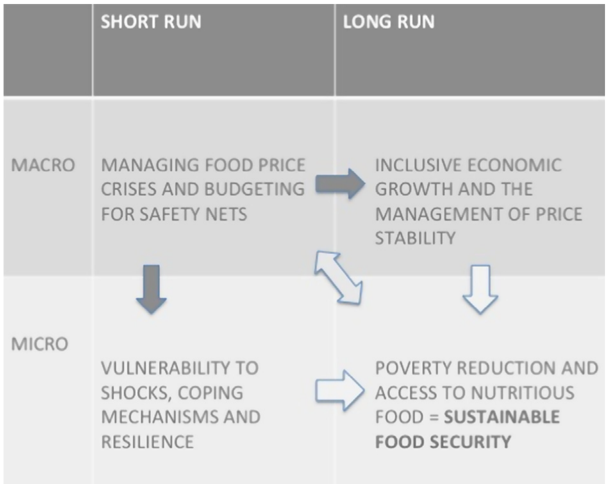

Fig. 2. Framework for understanding access to food (after Timmer (2014)).

insects is likely to be an issue in many countries. The same applies to artificial meat – the first hamburger made from laboratory-cultured meat was consumed in London in August 2013, just ahead of the conference.[2]

2.2.2. *Lost harvest and wasted food*

Despite recent syntheses (e.g. HLPE, 2014), there remains great uncertainty as to the importance of post-harvest food losses and food waste. As further research appears it is clear that the dichotomy between post-harvest losses being the major problem in developing countries and food waste being important only in higher-income countries is false.

National surveys in three sub-Saharan countries indicate that food losses at farm level based on estimates of the households are much less than generally assumed and are concentrated in only a fifth of the households (Kaminski and Christiaensen, 2014). This study highlights the need for more robust methods and analyses to quantify food waste. Discussions at the conference concluded that policy makers require fairly low-resolution data that identifies the major losses in food systems, whereas high-resolution data is needed to understand why food is wasted and to help prevent waste. Above all, proposed solutions to the problems of food waste need to be economically viable. An important point that is often ignored is that food waste not only incurs a direct loss of food. Waste also plays a strong overall role in the efficiency of resource use of land, water, energy and nutrients for food availability and in the spillover impacts of nutrients and agrochemicals in the environment (e.g. Grizzetti et al., 2013).

2.3. *Food access*

The access dimension of food security requires that food is affordable for everyone. Further, the infrastructure in terms of roads, railways and ports must be sufficient that markets and food are within physical reach. The question of affordability is directly related to food prices but equity, social protection and poverty reduction are at the core of ensuring food access in the long term. Fig. 2 presents a framework for understanding the intersection of issues related to securing access to food. The micro to macro scale from individual to the globe on the vertical axis is juxtaposed against the temporal dimension from the short to long term on the horizontal axis. This allows, for example, the disentangling of consequences and responses to price spikes at the household or national level. It further emphasises that stimulating systemic changes to food systems to support inclusive development and poverty reduction requires a long run perspective and with different actions and consequences at the micro and macro levels.

2.3.1. *Managing and coping with high and volatile food prices*

High and volatile food prices are increasingly understood to be the "new norm" (World Bank, 2012). Koning and van Ittersum (2009) argued that this is typical for long-term trend changes in prices of agricultural commodities and that price volatility will be the norm, if we are indeed experiencing a trend change (which we will only know in another 5–10 years from now). Both low and high food prices pose a risk. Low prices may be a disincentive to R&D in agriculture, stimulate rather than halt food waste and lower farmers' income. High prices impact the food purchasing power of consumers and price volatility negatively impacts both rural- and urban-poor households. Food comprises a large share of most poor household's expenditure and many food producers also purchase food. The distribution of impacts is confounded by different production and consumption patterns resulting in a heterogeneous mix of food insecure groups. For example, in rural areas in developing countries many smallholder farmers are net consumers and such households are particularly vulnerable (McCullough and Barrett, this conference). Empirical evidence shows that female-headed households can be disproportionally affected by price shocks (Kumar and Quisumbing, 2013). There is scope for research to further elucidate the impacts of food prices on food security. Meanwhile, measures to cope with and minimise food price fluctuations are required. First, in the short run there is a need to manage price crises and to provide safety nets that protect vulnerable groups such as rural landless, smallholder farmers and the urban poor (top left corner of Fig. 2). Strategic food reserves are able to play a price-easing role in the short run to support nations and regions facing food emergencies. For example, Belesky (2014) assessed the ASEAN Plus Three Emergency Rice Reserve within the broader debate of food reserves serving as public goods. While food reserves are able to ensure food availability during emergencies and perform additional roles such as supporting regional cooperation, appropriate management is paramount to avoid perverse or unintended consequences. Similarly, measures must be taken to stabilise food prices in the long run and food reserves have a role to play here (top right corner of Fig. 2).

Long-term price volatility is linked to the uncertainties surrounding a range of social, political, environmental and economic phenomena. These include global food markets and trade, global environmental change (compromising agricultural productivity), competition for resources (energy, land and water), environmental degradation and changing consumption patterns (Ingram, 2011; Tilman et al., 2011; Kearney, 2010; Woods et al., 2010). Importantly, price volatility is aggravated by untimely investments in agricultural research and development (Koning et al., 2008). R&D in agriculture has a relatively long delay before benefits become apparent. Too low investments today, will become evident in 10–15 years from now, which links us to the next topic.

2.3.2. *Inclusive development and poverty reduction*

Ultimately, inclusive development and poverty reduction are needed to secure access to food (right hand side of Fig. 2). Inclusive development and poverty reduction mean that the most marginalised groups of society also experience rights and benefits, whether from economic growth and/or from government support schemes. Smallholder farmers play an important role in inclusive economic growth, development and poverty reduction. From a

[2] ⟨http://www.bbc.com/news/science-environment-23576143⟩.

macro-economic perspective, this assertion is supported by numerous linkages between small farms and the economy (seeds, fertilizer, transport, milling, employment and consumption) (Atwood, this conference). It is such linkages (often formulated within logical frameworks of causal pathways) that justify investments that enhance smallholder sustainability and profitability. At the same time, the necessary smallholder transitions and developments cannot be achieved without supportive social, institutional, economic and ecological environments. Next to the fact that many rural communities lack basic infrastructure and services such as roads, clean water, electricity, hospitals and schools, additional questions resonate. For example: What roles could land policies play where land holdings are unequally distributed and the majority are poor (Muyanga and Jayne, this conference)? To what extent are the rural poor excluded from markets and value chains (Giller et al., this conference)? What impacts do migration and remittances have on rural livelihoods (Amare et al., this conference)? and What are the implications for governance of the global food system if food is considered as a common good (Vivero Pol, this conference)? Such questions highlight the need to understand situational factors affecting food insecurity at the household level and to embrace the complexity and sometimes conflicting goals of micro and macro policies (Vel, this conference).

2.4. Food utilisation

Food security is a question of both adequate nourishment (caloric intake) and adequate nutrition (quality of diet and utilisation) (Fanzo, 2014). Much of the critical work on nutrition falls within the utilisation dimension of food security. Broadly, utilisation refers to care, feeding practices, dietary diversity, food preparation and intra-household distribution for determining sufficiency of energy and nutrients within food that is consumed (FAO, 2008). The challenge of even greater integration to address the root causes of food insecurity remains an important objective (Fanzo, 2014). For example, the utilisation dimension of food security is also related to poverty reduction, access to adequate resources such as clean water, health care and education. This is relevant for developing and developed nations alike, yet the context and systemic causes of under-nutrition and poor quality diets differ (Remans et al., 2014). The extent to which the causes and impacts of under-nutrition can be captured realistically is addressed by Stein (2014).

2.4.1. Breaking the intergenerational cycle of under-nutrition

The crucial role of nutrition for growth, cognitive development and health is evident and proven beyond doubt (Burchi et al., 2011). The dramatic consequences for adults who experience under-nutrition in the first 1000 days of their lives (Burchi et al., 2011) and the fact that 200 million children under five years of age suffer from under-nutrition highlight the cyclical and intergenerational nature of under-nutrition, with impacts on economic and social development. A key strategy to break this cycle involves targeting women's health and nutrition in babies.

2.4.2. Integrating agriculture, nutrition and health

Biofortification is an example of an established type of agricultural intervention targeting under-nutrition (Nestel et al., 2006). More recently focus on the agriculture–nutrition linkage has been extended beyond such a nutrient-centric focus to question how agriculture impacts human health and nutrition (Webb, 2013). This has triggered a search for analytical frameworks that capture the multiple causal pathways linking agriculture with nutrition and a search for empirical evidence supporting the hypothesis that agricultural interventions improve nutrition.

Agriculture as a source of food (directly and via income); food prices; non-food spending; women's control over resources; women's nutrition and health, and women's time and caring practice are seven pathways often included within agriculture–nutrition analytical frameworks (Gillespie et al., 2012). Several recent reviews of this literature highlight that the evidence of impacts from agricultural based interventions is weak and mixed (Hawkes et al., 2012; Masset et al., 2011). This is an important research gap.

Elaboration of pathways reveal confounding mechanisms which Webb (2013) suggests could be considered pathways in their own right. For example, the link between food expenditure and the quality of food intake is substantially mediated by changing consumption patterns such as a shift towards more processed foods. The rise of obesity amongst the urban poor is a cause of increasing concern: Will supermarkets in developing countries result in over-consumption and less nutritious diets?

2.5. Food stability and sustainability

As highlighted in Section 2.3, avoiding price volatility is key to guaranteeing access to food, particularly for the (both urban and rural) poor. In turn, price volatility is caused by fluctuations in supply that arise from yield variability due to climate variability and climate change and (lack of) political stability. The resistance and resilience of food systems to shocks depends on food reserves (Belesky, 2014), on the availability of resources and infrastructure to produce food, and on the balance between importing food and self-sufficiency. In the same way that energy has geo-political implications, so do food systems. Will greater integration and interdependencies among countries through global food systems lead to greater political stability?

In both the short- and long-terms, global food security and planetary health are inextricably interlinked. There is much debate concerning the “safe operating space” for mankind (Rockström et al., 2009; http://www.icsu.org/future-earth/). This is also clearly exemplified by an emerging governance mechanism for sustainable sourcing through certification schemes. Oosterveer et al. (2014) make clear that in the case of the oil palm certification scheme there are important effects on local and global food security that have been largely ignored to date. At a global scale, current food production and trade have very different impacts on the fluxes of nutrients through food and feed, and thus on the major causes of spill-over effects (Billen et al., 2014).

Considerable discussion at the conference focused on intensification and the debates “land sparing” or “land sharing” for nature and ecosystem services apart from provision of food. This is a clear example where a highly contextualised, “place-based” approach is needed. van Noordwijk et al. (2014) highlight that agriculture and forestry are interfaced in different ways across the stages of tree-cover transition that shift the balance among food and other ecosystem services. Both land sparing and land sharing can be valuable approaches depending on the local environmental and socio-economic contexts.

2.6. Some overarching issues: governance and education

We can learn from historical divergence in governance of food security in different parts of the world, for instance from the distinct pathways that India and Bangladesh opted for, one of foodgrain policies versus liberalisation and market-orientation (Banerjee et al., 2014). In relation to global governance of issues relating to global food security, the lack of a rational process to engage in an effective policy debate was noted during the plenary discussions. Whereas a large community of scientists is engaged in the International Panel on Climate Change (IPCC) to weigh up the evidence surrounding climate change and to link directly to policy, there is no equivalent science-policy process for food security. The Committee on World Food Security (www.fao.org/cfs/cfs-home/en/) has nowhere near the visibility and political influence of the IPCC. As climate change debates have become highly politicised, so have the debates on food security become dominated by specific interest groups. Galvanising a truly global approach to the issue of food security necessitates integration of national and international policies, or at bare minimum their coordination.

Perhaps the need for equivalent attention to food security as to climate change will emerge through the building of awareness and understanding in society. The multidimensional challenges of global food security highlight the need of building new scientific capacity that can bridge disciplines and scales of analysis. As major contributions to global food supply and food security will come from developing countries, there is a specific need to build local expertise to develop sustainable and equitable food systems.

3. Outline of special issue

This special issue contains a selection of 13 papers based on presentations in the various plenary and parallel sessions of the conference. They address issues within the four dimensions of food security but also interactions between the various dimensions. The first four papers provide an integrated (Keating et al., 2014) or partial (Schierhorn et al., 2014; Youn et al., 2014; Kaminski and Christiaensen, 2014) view on Availability of food. Two papers address different aspects of access, i.e., market and food policies and food reserves (Banerjee et al., 2014; Belesky, 2014). A subsequent set of three papers deals with utilisation, focusing on measuring nutritional diversity (Remans et al., 2014) and on the nutrition and health nexus (Fanzo, 2014; Stein, 2014). Finally, four manuscripts address issues of stability and sustainability but also interactions between the various dimensions of food security. van Noordwijk et al. (2014) present how production systems in the world and their interactions with ecosystems evolve in time and how agricultural and ecosystems show different degrees of integration with implications for ecosystem services. Billen et al. (2014) take a biogeochemical view of the global food system with respect to nitrogen flows, while Oosterveer et al. (2014) consider the interaction between the governance of sustainable sourcing of food and food security. The final paper reviews various global food security studies and identifies gaps and some research priorities in global, integrative studies (van Dijk and Meijerink, 2014).

Although this issue does not cover the richness of all presentations and discussions of the conference, we hope it does provide a flavour of the first version of a unique event that brought together all scientific disciplines relevant for what is probably the largest challenge that humanity is facing, achieving food security for all its citizens in the decades to come.

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