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Editorial

Food security and global environmental change: emerging challenges

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ABSTRACT

Most research linking global environmental change and food security focuses solely on agriculture: either the impact of climate change on agricultural production, or the impact of agriculture on the environment, e.g. on land use, greenhouse gas emissions, pollution and/or biodiversity. Important though food production is, many other factors also need to be considered to understand food security. A recent international conference on ''Environmental Change and Food Security: Bridging Science, Policy and Development for Adaptation'' included a range of papers that embraced the multiple dimensions of the food systems that underpin food security. The major conclusion from the conference was that technical fixes alone will not solve the food security challenge. Adapting to the additional threats to food security arising from major environmental changes requires an integrated food system approach, not just a focus on agricultural practices. Six key issues emerged for future research: (i) adapting food systems to global environmental change requires more than just technological solutions to increase agricultural yields; (ii) tradeoffs across multiple scales among food system outcomes are a pervasive feature of globalized food systems; (iii) within food systems, there are some key underexplored areas that are both sensitive to environmental change but also crucial to understanding its implications for food security and adaptation strategies; (iv) scenarios specifically designed to investigate the wider issues that underpin food security and the environmental consequences of different adaptation options are lacking; (v) price variability and volatility often threaten food security; and (vi) more attention needs to be paid to the governance of food systems.

Global environmental change (GEC), including land degradation, loss of biodiversity, changes in hydrology, and changes in climate patterns resulting from enhanced anthropogenic emission of greenhouse gas emissions, will have serious consequences for food security, particularly for more vulnerable groups. Growing demands for food in turn affect the global environment because the food system is a source of greenhouse gas emissions and nutrient loading, and it dominates the human use of land and water. The speed, scale and consequences of human-induced environmental change are beyond previous human experience, and thus science has a renewed responsibility to support policy formation with regard to food systems (Carpenter et al., 2009; Steffen et al., 2003).

Most research linking global change and food systems focuses solely on the impact of climate change on agricultural production, or the impact of agriculture on land use, pollution and biodiversity. Interactions with other aspects of the food system – such as food processing, packaging, transporting and consumption, and employment derived from these activities – are often overlooked. There are also important new questions about the interactions between the governance of climate and food such as those associated with carbon trading and labelling, and the role of the private sector in carbon mitigation and in the management of food systems. Addressing food systems holistically, rather than separate components such as agriculture, markets or nutrition, demands the engagement of multiple disciplines and researchers to understand the causes and drivers of vulnerability. The challenges of adapting food systems to unprecedented GEC constitute a broad agenda that requires input from an integrated community of researchers. Ensuring food security while avoiding negative feedbacks to key ecosystem services places stiff demands upon the design and implementation of adaptation strategies and options.

A series of recent events have stimulated broader interest in food security and food systems, most notably the 2008 news coverage of high food prices which were variously blamed on biofuels, growing demand for meat and dairy products, commodity speculation and climate (Gregory and Ingram, 2008). Other debates have arisen about the potential impacts of climate change on food availability and water as the projections of climate change become even more serious, around US/EU subsidies disadvantaging farmers in developing countries, and about the role of integrated policy in shaping food security in Europe and in other countries (Barling et al., 2002; Schmidhuber and Tubiello, 2007; Stiglitz, 2006). The price increases highlighted the connections between food systems in different places, e.g. drought in Australia and demand for meat in Asia, biofuel policy in the US and Latin America, and between the local food movement in Europe and export farmers in Africa. The challenges facing food systems will accelerate in the coming decades, as the demand for food will double within the next 25–50 years, primarily in developing countries, and with the WTO agriculture talks in disarray, options for reforming trade policy are still highly contentious (Von Braun, 2008). Food security and agricultural growth remain high on the science, policy and development agendas.

1. One framework for research

It is clear that, important though food production is, many other factors also need to be considered in food security debates. Food security is defined as when *all people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life* (FAO, 1996). The food chain approach (''farm to fork'') is now well established to identify the nature of the actors involved, and the roles they all play in the different food system activities. Other literatures discuss the food security issues of food availability, access, utilization and stability (Stamoulis and Zezza, 2003). Both the activities and the consequences of these activities for food security (i.e. their outcomes), are influenced by GEC; and the activities have environmental feedbacks as well as food security implications.

Food systems can be described as comprising four sets of *activities*: (i) producing food; (ii) processing food; (iii) packaging and distributing food; and (iv) retailing and consuming food. These activities lead to a number of *outcomes*, many of which contribute to food security, and others which relate to environmental and other social welfare concerns (Fig. 1 from Ericksen, 2008a). Including the outcomes as part of the food system concept provides an explicit analytical lens for understanding food security, the principal objective of the food system. Adopting the ''food systems'' concept has proven valuable in framing GEC/food security research questions, especially at regional level (e.g. GECAFS, 2006, 2007, 2008) and structuring the debate more broadly (e.g. Aggarwal et al., 2004; ESF, 2009). In particular, it helps identify the specific interactions between and within biogeophysical and human environments which determine the set of food systems activities; it helps define the activities themselves; and it highlights the full range of outcomes of the activities (e.g. FAO, 2008) (Fig. 1).

2. Importance of considering multiple scales and levels

The food systems approach has also helped to identify the importance of considering multiple scales and levels in food security discussions. Many studies related to food production and food security have been conducted at experimental plot and household levels, respectively. The focus of enquiry for other studies has been the national level, e.g. for Sri Lanka

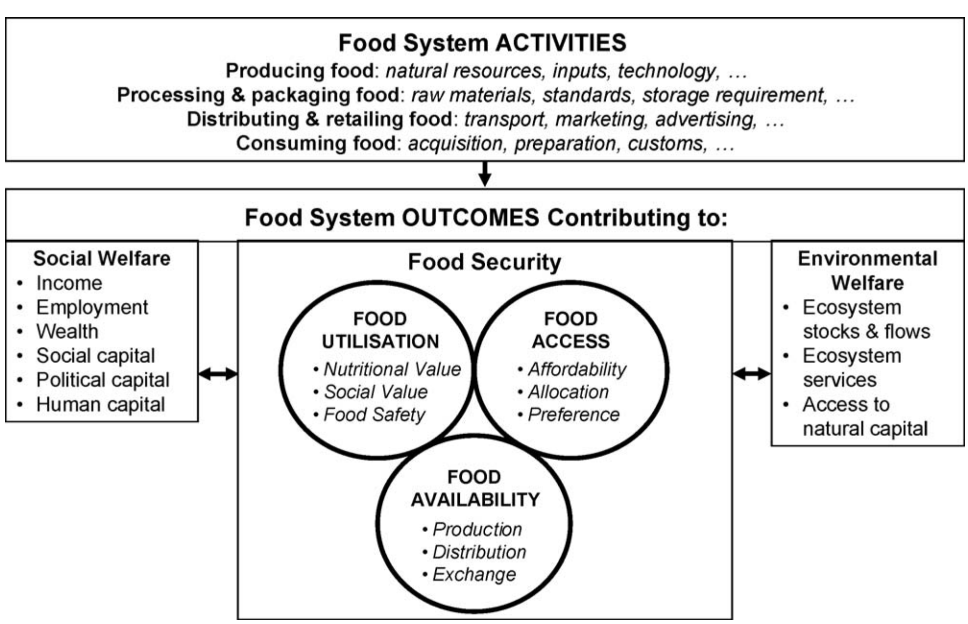

Fig. 1 – The GECAFS food system concept.

(WFP, 2007) or global level (e.g. Fischer et al., 2001). It is important to bridge the national-to-global gap along this spatial scale and hence to consider projects designed at the sub-continental (meso) level. In addition to helping to integrate studies at lower level, and being able to contextualise these within the "big picture", the meso spatial level is important for food security, food system research and GEC considerations in its own right.

First, climate and weather-related perturbations are often experienced at the sub-continental level and adaptation strategies may be applicable across more than one district or nation. Second, some adaptation strategies may prove most effective if managed at the regional level, e.g. in terms of improved intra-regional trade, food storage and transport facilities. Third, some environmental management issues only manifest at this spatial level (e.g. water resource depletion) and solutions to such problems may often require supranational considerations. Regionally based research also provides an opportunity for capacity building by linking researchers addressing regional issues with others worldwide.

Scales other than spatial are also relevant to food security/ GEC interactions, especially when discussing adaptation options. Cash et al. (2006) identify a number of other scales (temporal, jurisdictional, institutional, management, etc.) each of which spans different levels. As food systems are inherently multi-scale and multi-level, adaptation options must recognize both cross-scale and cross-level interactions. This is because food system vulnerabilities are linked across scales and levels; vulnerabilities in different aspects of the same food system may be synergistic; and adaptation actions relating to one level on one scale may be enhanced or frustrated by factors at another scale or level (Ericksen, 2008b). Globalization and global environmental change have changed the nature of many of these linkages, further increasing the prospects of unexpected outcomes and feedbacks (Leichenko and O'Brien, 2008; Nepstad et al., 2006; Young et al., 2006).

3. An international conference on "Food Security and Environmental Change"

The 2008 food price increases coincided with the timing of a conference on "Food Security and Environmental Change: Linking Science, Policy and Development for Adaptation" held at the University of Oxford in April 2008. The mission of the conference was to bridge disciplinary and well as policy-science boundaries and issues. This was the second such conference to be held at Oxford University; in 1993 Thomas Downing and colleagues held a conference on "Climate Change and World Food Security" (Downing, 1995).

The 2008 conference covered a range of topics pertaining to environmental change and food systems; it brought together over 230 scientists from more than 50 countries around the world. The conference programme, addressed in plenary presentations and about 20 parallel sessions, focused on three key organizing themes, all pertaining to approaches to research on the interactions between GEC and food security: (a) integrating across the natural and social sciences, (b) the importance of the regional level, and (c) linking scientific research to development policy. Specific topics included:

- impacts of climate change on agriculture and food security;
- managing carbon embodied in food;
- governance of food systems in the face of global change;
- policy processes for ensuring food security in Southern Africa and South Asia;
- potential impact of biofuels on rural livelihoods and food security;
- food industry responses to climate change;
- tradeoffs between ecosystem services and food security;
- adaptation to climate change to enhance food security, including trade reform;
- resilience across scales in globalized food systems.

The major conclusion from the conference was that technical fixes alone will not solve the food security challenge, and the major environmental changes bringing additional threats to food security need a food system approach, not just a focus on agricultural practices. The conference also noted the importance of global food trade in reducing vulnerability to environmental change, while also highlighting that non-production aspects of the food system (e.g. road and rail networks) can also be vulnerable to environmental change, on top of the obvious environmental stresses now facing agriculture in many parts of the world.

4. An emerging agenda for food security in an environmentally constrained world

The conference posed many questions and identified where further research is needed; solutions to managing environmental change and ensuring food security require a new integrated, multi-disciplinary research agenda. The papers included in this special issue are a selection from the many sessions and plenary presentations. Rather than summarize or comment on these papers, we use the rest of this introductory paper to discuss important emerging issues for research in the next few years. Although not an exhaustive list, we suggest six key areas of research challenges as particularly important to making progress on food system adaptation to global environmental change.

First, adapting food systems to global environmental change requires more than just technological solutions to increase agricultural yields. Unfortunately, the climate change research agenda is largely failing to adhere to lessons from several decades of research and practice on enhancing food security and agricultural development, and the bulk of the research is still focusing on agriculture not food systems. However, research on food security and rural livelihoods offer critical insights into both vulnerability and adaptive capacity (Devereux and Edwards, 2004; Ellis, 2000). Drawing upon these approaches, several studies have shown that often people adapt to stressors other than climatic or environmental (Eakin, 2005; Reid and Vogel, 2006). What does this portend for designing strategies to adapt to increased environmental change in the future? Furthermore, adaptive capacity and adaptation strategies depend upon distribution, retail and governance arrangements, and they need policies and institutional capacity to support them.

Second, tradeoffs across multiple scales among food system outcomes are a pervasive feature of globalized food systems. Failure to recognize these tradeoffs often results in food insecurity, ecological degradation and loss of livelihoods (DeFries et al., 2005; Sundkvist et al., 2005). Resolving these tradeoffs, particularly across multiple levels of organization and decision making, is crucial to reducing the vulnerability of food systems to GEC (Ericksen, 2008b). The concerns about the land use requirements of biofuels at the potential expense of food security should remind us that we must always consider the tradeoffs among food system outcomes when choosing mitigation and adaptation strategies, or else we risk introducing new vulnerabilities.

Third, within food systems, there are some key under-explored areas that are both sensitive to environmental change but also crucial to understanding its implications for food security and adaptation strategies. These include the social and cultural values of food, which shape both consumer preferences but also the role and importance of agricultural production in many places. Equally important are the nutritional implications of environmental change which are little understood but pertain both to changes in the content of food grown on degraded lands and the impacts of changing disease distribution on human health (Biggs et al., 2004; Confalonieri et al., 2007). Finally, the ongoing changes in consumption patterns that are reshaping the structure of food demand at local, national and global levels require close analysis.

Fourth, scenarios specifically designed to investigate the wider issues that underpin food security and the environmental consequences of different adaptation options are lacking—none of the existing scenarios developed at the global scale address all the environmental and other issues related to food security (Zurek, 2006). Creating regional scenarios is not just a matter of ‘‘downscaling’’ the information available in global scenarios (e.g. climate change projections) for regional use. Much relevant information will need to come directly from the region in question (Zurek and Henrichs, 2007), including regional climate models as well as stakeholder identification of key drivers of socio-economic change. An additional under-explored area is the use of scientific (or research-derived) scenarios to guide actual decision making over the 10- to 30-year time-lines that are relevant. Most science-based scenario exercises have stopped once the storylines themselves are developed. Scenarios hold the most promise if they are used interactively with groups of engaged stakeholders to test policy options and discuss the tradeoffs among critical outcomes. This process builds shared understanding among diverse perspectives but also creates a space in which risky management options can be explored. Ultimately, the process builds adaptive capacity among the diverse range of actors whose decisions affect food security and environmental outcomes in food systems.

Fifth, price variability and volatility often threaten food security. Analyses of global food systems to date have concentrated on food availability and access: the methods used do not account for variability in prices nor climate. However, the IPCC 4th Assessment (IPCC, 2007) report stated that climate variability and climate extremes were likely to increase, and changes in variability in climate are likely to have greater impacts on agricultural production than changes in mean climate alone. Furthermore, historical and current experience informs us that variability is critical to food prices, availability and access. Food stability needs explicit incorporation into future food security scenarios, including the effects of changes in climate variability and extremes, economic and trade policies which promote responses such as lower food stocks and speculative investment. New assessment methods are needed (e.g. partial equilibrium economic models instead of general equilibrium models) (M. Howden, pers. comm.).

Finally, more attention needs to be paid to the governance of food systems, in order to understand their vulnerability to environmental change and to identify solutions for both adaptation and mitigation. The emerging ideas around ‘‘earth systems governance’’ (Biermann, 2007) pose a number of challenges for 21st century food systems. For instance, to what extent are concerns about food security manifest in the discourse around global environmental governance? How does governance of food systems shape feedbacks to the earth system, in the form of greenhouse gas emissions, land cover change, and changes to hydrology? How can we ensure equity in food security as well as other ecosystem services? Which actors (e.g. private or public) are best suited to make decisions about this, and at which levels of governance (local, national, international)? How can governance across temporal and spatial levels be managed—is a polycentric approach possible in practice? Related to these governance questions are concerns about knowledge, as knowledge and governance are closely related and both are important for building adaptive capacity.

To conclude, the ‘‘mainstreaming’’ of climate change into development is widely recognized as critical to the design and implementation of adaptation and mitigation strategies that will succeed. Given the importance of food security as a development priority, we urge the research community to take up the issues presented here and to pursue such research in an integrated fashion.

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Polly J. Ericksen[1,*]
John S.I. Ingram[2]
Diana M. Liverman[3]
Global Environmental Change and Food Systems (GECAFS) International Project Office Environmental Change Institute, Oxford University Centre for the Environment, Dyson Perrins Building, South Parks Road, Oxford OX1 3QY, UK

**Corresponding author*
E-mail address: polly.ericksen@eci.ox.ac.uk (P.J. Ericksen)
[1]GECAFS Science Officer.[2]GECAFS Executive Officer.
[3]Chair of the GECAFS Scientific Advisory Committee and Director, Environmental Change Institute, Oxford University.

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