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Agricultural systems research and global food security in the 21st century: An overview and roadmap for future opportunities

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ABSTRACT

This article presents a brief history and overview of some key intersections between agricultural systems research and the literature on global food security. It also serves to contextualize the submissions for this special issue, which comprise selected relevant research presented at the 2nd International Conference on Global Food Security, held at Cornell University in October 2015.

1. Introduction

With the release of the Sustainable Development Goals in late 2015, the United Nations has continued to put food security front and center in its vocalization of the great challenges facing humankind. Replacing Millennium Development Goal Target 1C ('Halve, between 1990 and 2015, the proportion of people who suffer from hunger'), the latest iteration emphasizes not just hunger, but also sustainability and nutrition: (Sustainable Development Goal 2: end hunger, achieve food security and improved nutrition and promote sustainable agriculture).

The explicit inclusion of the agricultural sector in the goal's design represents a growing recognition and concern that stresses on the world's agricultural systems from climate change, environmental degradation and population growth will increasingly threaten our collective fundamental right to food security (Jones and Ejeta, 2016). This comes despite dramatic increases in global food production during the 20th century and concurrent impressive declines in worldwide undernourishment and hunger over the last quarter century, with near-universal global attainment of Millennium Development Goal 1C (FAO Statistical Pocketbook 2015).

Despite hundreds of variations and contextualizations, a frequently used definition of food security emanated from the 1996 FAO World Food Summit: "Food security exists when all people, at all times, have physical, [social] and economic access to sufficient, safe and nutritious food which meets their dietary needs and food preferences for an active and healthy life" (FAO, 1996). Implicit in this definition are four key dimensions of food security that have driven the research agenda in recent decades (WFP, 2009; Simon, 2012):

1) Food availability, defined by the World Food Program (WFP) as "The amount of food that is present in a country or area through all forms of domestic production, imports, food stocks and food aid."
2) Food access, defined as "A household's ability to acquire an adequate amount of food regularly through a combination of purchases, barter, borrowings, food assistance or gifts." This differs from the availability dimension in that food stocks in a village, region or country may be sufficient, but there may be physical, economic or socio-cultural barriers to obtaining food.
3) Food utilization, which WFP defines as "Safe and nutritious food which meets dietary needs," introducing into the food security discussion considerations of concerns about food quality and complementary investments in human health that contribute to maximizing the benefits of food intake.
4) Stability of dimensions 1, 2 and 3: a recognition that food security rests on consistent availability, access and utilization over time. The identification of the importance of sustainable agriculture in the new global goals is a specific vocalization of this potential threat to stability.

The role of agricultural systems in ensuring these critical dimensions of food security varies widely across economic, geographic and socio-cultural contexts and is also evolving over time. For example, in the rare case of a wholly subsistence agricultural context (Fig. 1a), one might consider the 'Agricultural System', the 'Food System' and the 'Food Security System' of a small-scale farming household to overlap to a great extent, with the bulk of the household's food needs being

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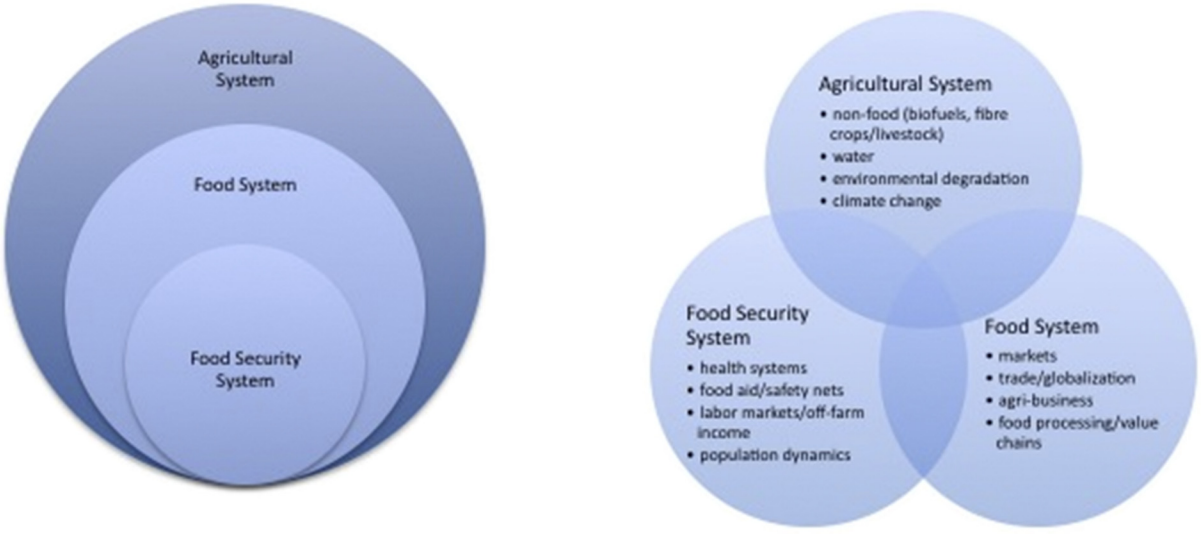

Fig. 1. a) Overlapping systems for agriculture and food security in subsistence agriculture. b) Potential divergence between food security and the agricultural system in regions with more spatial and economic dispersion between production and consumption of food.

met through consumption of staples and other food crops produced by the household. Availability, access, and stability are all fundamentally determined by the state of the agricultural system on the farm, with tight feedback loops between the farmers, the land, the environment, physical, natural and financial capital resources, and the chosen agricultural enterprises.

Yet even in these contexts, many factors that may be linked to, but not entirely determined by the agricultural system, are sure to influence the food security status of households and individuals. For example, intra-household food allocation, food preparation practices and hygiene, and the health of individuals will all function to shape the utilization component of food security. Some researchers might argue that these factors and other factors are sufficiently complex forces that their role in an individual's 'nutrition security' should be considered almost separately from 'food security'. These and other nutrition and food security drivers will determine in part the bioavailability of macro- and micronutrients within consumed foods, as well as which household members will even be able to consume available nutrient-dense foods. Other external factors such as volatility in temperature and precipitation patterns may affect the temporal stability of food security, as well as other shocks to important agricultural inputs that can impact farm productivity and therefore food availability or access.

In other contexts, the influence of such external factors and internal decision-making and agency may be even more conspicuous. For example, many agricultural households depend on multiple income sources for their livelihood. Local or regional agricultural systems may be only one factor in the system of elements that determine food security. These households may depend minimally or not at all on their own production for food. Rather, they may purchase food from local markets or vendors, the existence and availability of which is itself representative of yet another collection of institutions and elements governing a region's overall and distinct 'Food System'. Further, such a food system may or may not completely overlap with or encompass food (or nutrition) security issues and concerns. Indeed, current statistics on the global growth of food production, trade and industry belie the fact that globally, almost 800 million individuals are still undernourished. There may thus be important divergences in these contexts between food security and food and agricultural systems (Fig. 1b).

Despite long historical acknowledgement within both the agricultural and food security stakeholder communities of the importance of these many interlinkages, particularly for the world's most food insecure populations, the research agendas in both fields have not typically reflected these relationships or attempted to bridge the interfaces. Starting with the identification in the 1970s of widespread food insecurity and food shortages, the main response and contribution of the agricultural research community to these food security issues was to focus on improving yields and food productivity to reduce shortages and increase the supply of total food calories (World Bank, 2014). The most obvious manifestations of this 'food shortage paradigm' era of agricultural research were the Green Revolution innovations in high yield varieties of staple grains (Herforth et al., 2015) with accompanying fertilizer and pesticide programs. After the great success of these initiatives, despite the multifaceted conceptualizations of food security being developed at the same time, further attempts to use agricultural research to improve food quality and food security, as a follow on to increased food quantity and aggregate supply, did not emerge. (World Bank, 2014).

However the experience of the global food price crisis in 2007–2008 refocused and reenergized the conversation between agriculture and food security, with renewed calls in many quarters to examine the future of our food systems in the context of shifting trends in commodity price volatility, climate change and population growth. Within this, reassessment of many aspects of food security relating to quality, such as malnutrition, micronutrient deficiencies and obesity, are being incorporated into more systems approaches to understanding food security to improve analysis and make headway in solving critical issues within these complex systems (Ingram, 2011). The 'food environment' concept, for example, is an attempt in the food security research community to reconcile some of the complex and counterintuitive lessons learned about food consumption patterns and their connections to food markets, providing a new way to bridge traditional agricultural research focus on supply with downstream impacts on relative food prices, consumption, nutritional outcomes and food security overall (Herforth and Ahmed, 2015).

2. Agricultural systems vs. food systems and food security

Writing for the FAO to classify smallholder farming systems in Asia in 1997, Douglas McConnell and John Dillon's important work mapping systems theory to agriculture succinctly (if broadly) defined the agricultural system as "an assemblage of components which are united by some form of interaction and interdependence and which operate within a prescribed boundary to achieve a specified agricultural objective on behalf of the beneficiaries of the system." The focus of the agricultural systems literature has since traditionally been on capturing and analysing those factors impacting agricultural production (of food/

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