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Food security and nutrition: Impure, complex and wicked?

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ABSTRACT

Food security and nutrition are receiving renewed attention in international and national policy agendas. This has been accompanied by a profusion of theoretical concepts borrowed from diverse disciplines and then employed to describe challenges to achieving food security and adequate nutrition. Complex eco-systems, wicked problems and public goods are among these. In order to make a constructive contribution to policy debate, the underlying political economy of food security is interrogated to understand why food security problems may be indeterminate. This reveals food to be an outcome from a complex problem-determined food eco-system. The problems are ill-defined, the solutions uncertain and food itself is a commodity, predominantly privately produced and purchased. As a result, governments are compelled to take account of competing interests of actors within the food system when considering any intervention. Further, food security includes non-exclusive components such as food safety, social protection and food price stability and the right to food is enshrined in Article 25 of the Universal Declaration of Human Rights. Albeit impure, food security is then a public good requiring public sector action to ensure that it is universal, indivisible and interdependent with other human rights. Achieving this requires that collective action problems be resolved in order to achieve food security and nutrition.

KEYWORDS:

Food system; impure public goods; social-ecological systems; collective action; human rights

HIGHLIGHTS:

- 2 billion people micronutrient deficient, 795 million undernourished, 2 billion overweight or obese
- Trans-disciplinary concepts may be welcome, but can result in policies that contain evocative metaphors but little substance
- Food security is an outcome of a complex problem-determined food eco-system characterised by antagonism and conflicts of interest
- As an impure public good, food security is the joint product of private and public action

Word count: 11,882 words

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1. INTRODUCTION

To adequately feed the increasing global population, the former chair of the UN Committee on World Food Security contended that, "…*in the next 40 years we need to produce more food than we have produced over the last 8000 years*" (Sheeran, 2012). While some foresight exercises suggest that this may be possible (cf. Paillard et al, 2014), others argue that without significant changes in consumption patterns and production processes, sufficient food cannot be produced on a sustainable basis (IAASTD, 2009).

Even if an increase in the availability of food is possible, a conundrum remains in which there is already hunger, under-nutrition and over-nutrition in a world in which sufficient food is being produced, and in which there is adequate scientific knowledge to produce, process and consume safe and healthy food.

It is within this context that food security and nutrition are receiving renewed attention in international and national policy agendas. This has been accompanied by a profusion of theoretical concepts borrowed from diverse disciplines and then applied to food security. These include 'complex systems' and describing food security as a 'wicked problem' and a 'public good'. There is a risk that conceptual confusion may follow, resulting in policies that contain evocative metaphors but little substance.

This paper will scrutinise this terminology. After reviewing trends, the food security *problematique* will be examined using a systems approach. *Problematique* is used narrowly as referring to the structural model of the relationships among members of a set of problems, rather than in its richer historical epistemological sense (Warfield and Perino, 1999; Maniglier, 2012). Food insecurity is proposed as possessing the attributes of a public good that is produced from a complex system.

These attributes result in problems that are ill-defined and solutions that are uncertain. A political economy lens is needed to identify possible policy responses to this *problematique*. The intention of the paper is to assist food policy processes that seek to take advantage of trans-disciplinarity without losing conceptual clarity.

2. FOOD SECURITY AND NUTRITION: A DEFINITION AND A CRITIQUE

The definition of food security adopted by the World Food Summit in 1996 and subsequently ratified by the Committee on World Food Security (CFS), states that:

> *Food security exists 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* (CFS, 2012).

Four dimensions are identified (availability, access, utilisation and stability). These are hierarchical in nature: food availability is necessary but not sufficient for access; access is necessary but not sufficient for utilisation; stability is necessary but not sufficient for utilisation (Webb et al, 2006:140).

Although widely quoted by the majority of international agencies concerned with food security, the nature of the food system itself is given scant attention by this definition. Instead, it is agnostic as to the type of food system that is desirable and the food environment that follows. It neglects the differences in the terms under which different actors are included into the system, and the impact that this might have on the four dimensions.

Further, resolving a problem conceptualised as 'food security' risks excessive focus on increasing food production and reducing its cost rather than on shifting the control of the system and improving diets. As a result, monetary, technical and medical solutions are proposed; continued globalisation of the food system is accepted as being inevitable and desirable; and further economic growth on the existing trajectory is offered the long-term response (Edelman, 2014; McMichael, 2014: 934).

Achieving food security and adequate nutrition is reduced to measurement and targeting, resolving production constraints; pricing policy; management problems concerning more efficient distribution; direct fortification or supplementation of diets; or poverty reduction through economic growth and social protection. This underplays the complexity and importance of nutrition security and diet by assigning these to an outcome of the utilisation of food. It also underplays drivers of food insecurity emanating outside the food system, and thus beyond the influence of conventional food policies. These include poverty, inequality and patriarchy that influence each of the dimensions of food security identified by the CFS.

For example, although access is usually thought of as being determined by the resources of those consuming food in relation to its cost, access is also shaped by the quality and safety of what is made available, by the relative power of those

making decisions about the food system including within households, and by the physical, cultural and political context of the food system.

Such positions are being challenged and alternative approaches have emerged, some of which take account of the practices and freedoms that follow from prevailing food systems (Sen, 1989; Akram-Lodhi, 2015; Rocha, 2007; Timmer, 2010; Wittman et al, 2010:3). From this perspective, food insecurity can be regarded as a form of deprivation and an outcome of vulnerability. The experience of food insecurity is then multi-dimensional with food itself being only one of these dimensions: its intensity and duration varies; it has an intra-household dimension; it has an absolute, subjective and relative nature; and there is culpability for its production, and duty in its reduction (Alkire and Foster, 2011; Hulme and Shepherd, 2003; Haddad and Kanbur, 1990; Sen 1983; Øyen, 2002).

Most of those who are financially poor are food insecure since even fully self-sufficient subsistence farmers encounter seasonality, but not all of those are food insecure are financially poor. This is because components of diet (food choice, food preparation and food consumption) are derived from elements other than its cost including status, safety, convenience, roles, power, affiliations, religious beliefs, social norms, values and beliefs. Furthermore, nutrition security needs to be disentangled from food security. Good nutrition requires an adequate, appropriately nutritious and balanced diet: attributes not necessarily tied to poverty. Nutrition security exists when secure access to such a diet is combined with regular physical activity and coupled with a sanitary environment though which to avoid hazardous toxins, and to benefit from adequate health services, knowledge and care (FAO et al, 2015).

3. GLOBAL FOOD SECURITY AND NUTRITION

Trends in food security, nutrition and diet are well documented and need be only summarised. Of the global population, currently estimated at 7.2 billion, 2 billion are affected by micronutrient deficiencies of iron, zinc, vitamin A and iodine, and around 795 million people are undernourished (calorie deficient). At the same time, at 2 billion adults, the number of overweight people is more than double the number undernourished, and the age-standardised percentage of obese individuals doubled between 1980 and 2008. Worryingly, overweight is on the rise among children under five and among adolescents, especially girls (IFPRI, 2016: 2; FAO, IFAD & WFP, 2015; FAO et al, 2012: 23).

Driving the demand for food is the world's population, projected to increase by an average of 68 million people per year until 2050 to reach around 9.7 billion people

(UNDESA, 2017, Medium Variant Estimates). Despite this growth, foresight exercises propose that feeding this population is attainable.

As examples, both the 'high growth' and 'sustainable growth' scenarios produced by the Agrimonde study on feeding the global population in 2050 reach this conclusion, as do the projections of the International Institute for Advanced Systems Analysis (IIASA) (Agrimonde, 2009, IIASTD, 2009).

However, the challenge of achieving food security is likely to become more complex than it is already. While more optimistic scenarios suggest that severe under-nutrition could fall to 4 percent of the global population, over half could be overweight or obese. These will be concentrated in developing countries and will coexist with children who are under-nourished, potentially living in the same household (Agrimonde, 2009; FAO, IFAP & UNDP, 2012; Dobbs and Manyika, 2015).

In addition, developing countries that were previously mostly rural are experiencing rapid urbanisation. By 2050, over six billion people are expected to be living in the world's urban areas, with the rural population declining from 3.36 billion in 2014 to around 3.21 billion (UNDESA, 2014: 20). Sub-Saharan Africa is the exception with a rural population that will continue to grow by 400 million until 2050. Since urban dwellers must buy their food, as must landless rural dwellers, diets and the foodways that produce them shape, and are shaped by what is provided in the shelves and baskets of distributors in the formal and informal economy.

Their incomes are likely to be higher than those still living in rural areas, and as incomes rise, consumers demonstrate greater selectivity in the products that they consume. Less preferred parts of animals (such as the offal and hooves) and plants (such as the stalks and leaves) will be discarded and convenience foods that require less time and energy to prepare will be preferred.

The urban population is also likely to increase their consumption of animal protein and fats as well as 'empty calories' such as caloric sweeteners, especially from aerated beverages (Popkin, 2006).

This intensifies the transition of the global food system, moving from food that is mostly produced on family farms, consumed locally or sold through fresh produce markets and small business, to industrialized commodity production, mass distribution, long value chains and globalized trade. Rural diets are following, sponsored by remittances received from migrants who have moved into urban areas.

This can produce an obesogenic environment in which diets are characterized simultaneously by over-consumption and under-nutrition, increasing the risk of non-communicable diseases (NCD). In this way, demographic and nutrition transitions drive an epidemiological transition. This encompasses a shift from a backlog of common infections, under-nutrition, and maternal mortality, towards NCDs such as cancer, diabetes, heart disease, and mental illness, and health challenges directly related to globalization, such as pandemics and the health consequences of climate change such as respiratory and foodborne diseases (Egger and Swinburn, 1997; Ng et al, 2014; Frenk & Gómez-Dantés, 2011; Portier et al, 2010).

While feeding more people is possible, and as argued by Tudge (2005) perhaps even easy, scenarios tend to agree that achieving this in a sustainable fashion is only possible if existing production and consumption patterns change. However, the trends described are taking place in the face of increasing variability in weather due to climate change, increasing demand for water and energy for purposes other than the production of food, and decreasing availability of arable land. Further influences hindering the possibility of change include the production and provisioning of food becoming less diversified; disregarding of the full cost of agricultural inputs, especially energy and water; greenhouse emissions contributed by the agri-food value chain; widespread loss and waste of food; the pursuit of cheap food at the expense of livelihoods and health; the failure of food governance to connect the state, the private sector and citizens; and poor coordination between institutions responsible for the different aspects of food security and nutrition (FAO, 2010).

People, and perhaps governments endowed with adequate resources might be able navigate these hindrances: those that are poor face enduring food and nutrition insecurity in which under-nutrition and over-consumption are perversely coupled. Unpacking the implications of this requires clarity as to the properties of food, the food system and food security.

4. IMPURE

To begin this analysis, we need first to recall the nature of food and its place in the food system:

> *"Food is any substance, whether processed, semi-processed or raw, which is intended for human consumption … and any substance which has been used in the manufacture, preparation or treatment of "food"* (FAO/WHO, 1963).

In terms of this definition, flavourings, flavour enhancers, preservatives, emulsifiers, antioxidants, stabilizers, colourants, anti-caking/firming/curing agents and acidity regulators all constitute food. The implication is that the modern food system

includes the agri-food value chains of these products in addition to the inputs, services and products conventionally included in the analysis of agriculture, aquaculture, agri-processing and food distribution.

Importantly, most of these foods and food components are private goods that must be produced or purchased. This means that most food adheres to the primary scarcity problem of economics, and any government intervention will face a ‘‘food price dilemma” in which the competing interests of different actors in the food system are affected (Timmer, Falcon and Pearson, 1983). Furthermore, it means that food is rivalrous and exclusive: the consumption of food by one actor reduces its availability for others; and it is possible for some to be excluded from access to food by others.

Most food is thus possessed through market transactions that depend upon ability to pay the price, whether in monetary terms or as direct labour. Food is also a commodity, or as Appadurai (1986:82) proposes, passes through a “*situation in which its exchangeability … for some other thing is its socially relevant feature*.” As a commodity, food is part of a system of capitalist production that some argue runs “…*counter to a rational agriculture*” (Marx, 1981: 216). This leads to one response to the causes of food insecurity as being due to: “…*the irrationalities and contradictions in the capitalistic management of agriculture and food provision*” (Albritton, 2009: ix).

Consumers are actors in this arrangement. Foods that are cheap, convenient and labour saving, store well and towards which demand is actively managed as being tasty, desirable or safe are perceived to be moving away from “…*the taste of necessity, which favours the most ‘filling’ and most economical foods, (to) the taste of liberty – or luxury*” (Bourdieu, 1984: 2). Consequently the diets desired are those based on foods such as bread, rice, maize-based fast-foods, sugar and salt-laced foods and beverages, and those that are reconstituted, extruded, hydrogenated and nano-packaged.

It must be acknowledged that the capitalist food system has succeeded in bringing about innovation throughout the agri-food value chain, reducing drudgery, risk and uncertainty, improving punitive conditions of labour and generating sufficient financially inexpensive calories to feed the world’s population. But it has not been successful in making this food accessible to all, the stewardship of the natural resources required for the sustainable production of food, the generation of jobs and livelihoods, the stability of prices, nor the provision of diets that are balanced, affordable and healthy for all. Instead markets concerned with maximising profits direct the availability of food, in which some consumers encounter extensive

demand management through advertising and other strategies, while others subsist on the waste that is produced.

Nevertheless, some variant of capitalist production, along with its contradictions and inequalities is likely to remain the dominant mode for food provisioning for the foreseeable future. Under such a system, food security problems may be indeterminate because important aspects of the food system are public goods while food itself is a private good. That is, unlike food, the benefits (or costs) of food security are non-rivalrous (consumption by one does not reduce availability for others) or non-exclusive (market transactions do not exclude some from the benefits (or costs) of consumption), or both.

Food knowledge is an example of a component that is non-rivalrous while food safety is an example that is non-rivalrous and non-exclusive. Achieving food security thus relies upon processes that are subject to market imperfections and which contain significant positive and negative externalities. As an illustration, a critical determinant of food security, food prices, are highly politicised and thus of intense interest both to those who are poor and to those who are in power. Taxes, subsidies, regulation and publicly funded infrastructure have a direct and immediate impact upon the cost of food, the profits to be made, and the response of those affected (Allan et al, 2015:301). As a result, policies that may affect food prices are subject to lobbying, advocacy, collusion and other forms of influence (Nestle, 2013).

Another determinant, food value chains, are characterised by significant power asymmetries, and increasingly the processors and distributors of food hold power rather than the producers or consumers. Inequalities of resources, access to food and power are to be found within each of these groups. Finally, some of the natural resources required for food production are public goods under the stewardship of food producers. Examples are the water necessary for plant and animal survival, or the biodiversity of local ecologies necessary for pollination, pest control and soil health.

However processors and distributors "*have as yet little incentive to engage outside the fence of their warehouses, silos, factories and wineries*" (Allan et al, 2015: 302). As a result, price signals that could bring about market efficiencies operate poorly in the context of un-priced natural resource and public health costs including both direct costs and the opportunity costs of mismanagement. To achieve universal food security, public sector regulation is required and food security can be regarded as a public good.

This has been recognised, and although a link to food security is not always explicitly made, an extensive public goods literature has identified environment,

health, knowledge, safety and governance as falling into different categories of public good necessary for food security (Stiglitz, 1999; Kanbur et al, 1999; Morrissey et al, 2002). A more sparse literature on food security argues that food security not only requires the list of public goods just mentioned; it produces these goods and its absence can erode them. In this literature, food security is explicitly proposed as a public good (Rocha, 2007; Ver Eecke, 1999).

Kaul and Mendoza (2003) make a valuable contribution for such a proposition. They argue that the roles assigned by society to goods must be taken into account when determining what is private and what is public. That is to say, society may deem some private goods as being "*de facto public in their consumption",* and thus takes steps to modify the *"(non)rivalry and (non)excludability" of their costs and benefits through public policy"* (Kaul and Mendoza (2003: 80). As an example, land, a critical resource for food security, is usually a rivalrous good. In many parts of Africa however, land is managed in a non-exclusive manner as a common pool resource. Another critical resource for food security, genetic stock, is non-rivalrous, but is increasingly managed in a manner that is exclusive by the granting of property rights in the form of patents.

Since the right to food is enshrined in Article 25 of the Universal Declaration of Human Rights (United Nations, 1948) and the Article 11 of the International Covenant on Economic, Social and Cultural Rights (United Nations, 1966), from the perspective of Kaul and Mendoza (2003), the signatories of the Covenant have deemed food security to be universal, indivisible and interdependent, and thus non-rivalrous and non-exclusive. This makes food security a national and a global public good in the eyes of society even if not from the perspective of mainstream economics.

Practically, what does this mean for the countries that have committed to these international agreements? Denoting food security as a public good assigns governments as duty-bearers to for its provision, and thus makes public entities responsible (and preferably accountable) for delivering food security to rights-holders: the citizens and potentially the immigrants and refugees living within their borders.

The manner and extent to which this is done varies across the food system. For example, the responsibility for ensuring food safety is frequently undertaken by national departments of health in cooperation with sub-national structures such as municipal authorities, and with oversight by international agencies such as the WHO and FAO through agreements such as the International Health Regulations 2005 (van der Meulen, 2014). The accountability for food safety more often lies with the private sector, who may also self-regulate.

Intervening in the input and output markets for food production is another example of public sector policy ostensibly motivated by the need to ensure food security for all. These have extended from direct state control over food production and marketing employed by various Communist states, through to the use of parastatal agencies to intervene in the food system used by governments in many African countries. A recent example is the Malawian government's Agricultural Input Subsidy Programme, described as a 'new generation of large-scale smart subsidies' (IFAD, 2011:96).

Enforcing the obligations of duty holders also varies. In some food safety cases such as the 2011 listeria outbreak from tainted cantaloupe in the USA that resulted in the death of 33 people, culpability is obfuscated. Following litigation in 66 different cases, 6 months of home detention for the farmers involved and out-of-court settlements, 24 of the 26 wrongful death and personal injury lawsuits were dismissed (Field, 2015). In others such as the melamine contamination of milk and wheat gluten in China during 2006-08, culpability has been more directly enforced. Following this incident that resulted in 300 000 illnesses and 6 infant deaths from kidney complications, two business leaders were executed, six imprisoned and eight government officials were dismissed (Gossner et al, 2009).

A further implication of food security being a public good is that there may be negative externalities associated with its production that arise from a poorly functioning food system. These include increased pressure on the public health system, political insecurity, international migration, greenhouse emissions and environmental degradation. Some of these are due to moral hazard whereby actors in the food system accept higher risks because someone else will bear the cost of those risks.

Notwithstanding these arguments, food security remains a particular type of public good: one that is partially non-rival or non-excludable and hence impure. To be impure means that food security possesses the characteristics of both a private and a public good (Cornes and Sandler, 1994). Partly this is because one component, (the food itself) is usually produced, accessed and consumed as a private good, but the benefits and externalities of doing so (for example environmental and public health, food safety, and food knowledge) are publicly enjoyed, or publicly endured.

Food security can thus be argued to be impure because it delivers two, or probably more outcomes. It is a 'joint product' that has the private characteristic of satisfying the energy, nutritional, socio-cultural and emotional needs of the consumer, joined to public characteristics: the food security of others, the benefits of a healthy society, and the sustainability of the food system in the future. Its provision thus uses, creates and needs both private and public goods.

As with any other public good, the provision of food security confronts a number of economic problems. Free-rider problems are one example: some will benefit from its presence without contributing towards the full costs of its production. Furthermore as an impure public good that is limited and thus partly rivalrous, further problems arise. For example, different groups (households, communities, classes, nations) may lay competing claims to food security though collective action. This means that like 'development', food security can be depicted as a 'multilevel' collective action challenge (Booth, 2012). In other words, groups of actors, faced with a common collective concern, will need to find ways of acting together with their different interests in mind.

Additionally, some actors may not share this collective concern even though their actions directly impinge upon its resolution. The food system provides the context and systems of rules within which this collective action takes place.

5. COMPLEX

An established literature proposes a system to be a set of interacting or interdependent elements that function together as collective units, thereby forming a larger whole that has properties greater than the sum of its component parts (Von Bertalanffy, 1950; 1968).

A system may include organisational sub-systems; have geographical boundaries; and multiple levels and actors. Some are described as 'complex adaptive systems' that possess many mutually interacting parts, complex in their arrangement, characterised by interdependence and multi-causality (Ingram, 2011). Further, a system has the capacity to change or transform in response to internal or external stimulus (Baser and Morgan, 2004).

Activities in the system are arranged in sub-systems, each with their own networks, dynamics and feedback loops, both positive and negative (Saaty and Kearns, 1985). The carrying, regeneration, assimilation and adaptive capacity of the different sub-systems circumscribe these interactions. As change is non-linear and non-simple (Simon, 1962), the system is vulnerable to internal and exogenous forces that transform, disrupt or destroy its parts, its sub-systems, or the system itself (Prigogine and Stengers, 1984).

Food provision and consumption bring together biophysical and social elements to form the food system. This comprises multiple sub-systems that are chains of "…*human-organized activities concerned with the production, processing, transport, selling, cooking and eating of food and the disposal of the wastes of such*

activities" (Green and Foster, 2005: 664). Production/processing, retail/distribution and consumption/nutrition are the usual contenders for the sub-systems identified although waste disposal, distribution and even the Habermasian life-world and Bourdieusian habitus have been proposed (Sobal et al, 1998; Ericksen et al, 2010: Fairtlough, 1981; Warde, 1997).

As the components of what is eventually consumed as food move along these chains, they experience "*operations and processes involved in transforming raw materials into foods and transforming nutrients into health outcomes*" (Sobal et al, 1998: 853). As such, the food system encompasses the outcomes of these transformations also embedded in systems other than the economic, social and political. As examples, these include microbial, ecological, hydrological and knowledge systems (Erickson, 2007).

Finally, the operation of the food system results in 'cross-scale' interactions, between processes and actors in different arenas and at different levels such as the plot, farm, factory, street, supermarket chain or transnational corporation (Cash et al, 2006).

Although appropriate to many contexts, such functionalist definitions are inadequate when applied to social systems. As Hjorth and Ali (2006) recognise, being open, social systems bring further complexity. Five properties are identified: bounded rationality, limited certainty, limited predictability, indeterminate causality, and evolutionary change. In the case of food security, bounded rationality is of particular importance. This refers to the inability of the actors in the system to anticipate correctly the complex sequence of contingencies that might follow from repeated exchanges along the breadth and complexity of a system problem.

Due to these five properties, the costs of obtaining full information necessary for a rational decision may become excessive. As a result, decision-makers make use of past experience to assess alternatives, and to settle for adaptive behaviour, satisficing rather than optimising (Simon, 1996). The result is poorly coordinated policies that address symptoms, repeat failures and do not deal with systemic causes (Little, 2012).

One systems-based response to improving food security is that of the food eco-system. This requires taking the agronomic, ecological, economic, and social dimensions into account simultaneously, at different scales, and through inter- or trans-disciplinary enquiry (Francis et al, 2003). The 'food eco-system' approach contends that humans are part of an eco-system, both as producers and consumers, and as actors participating in the chains that make up the food system (Drimie et al, 2010; Pollan, 2009).

This notion of a food eco-system may be helpful, since an ecosystem approach suggests the presence of 'keystone species' that play a disproportionately large role in the system, and on which the functioning of other parts of the system depend (Paine, 1995). Keystones may be bacteria species, insects, plants or animals such as bacteroidetes (Foster et al, 2008), lactobacillus (Ze et al, 2012), bees (Kuhlmann, 2009), maize or beef (Cristancho and Vining et al, 2004). A broader view of keystones may also be individuals, institutions and entities including women (Brown et al, 1995), financiers (Mars et al, 2012) and transnational companies (Österblom et al, 2015). In order to be healthy a food system would need to be "…*self-reliant, controlled, accessible, safe, sustainable, resilient and food-secure*" (Burchi et al, 2011: 366), with its keystones aligned to maximise food security.

Mainstream economics anticipates that efficient markets will eventually result in optimality and alignment. Unfortunately in a system characterised by "inequality … compounded by local exploitation, rent seeking and corruption, appropriation of resources of the poor" (IAASTD, 2009: 25) that is "fragmented and dysfunctional" (Morris et al. 2008, 608) with "no-one in charge" (Seabright, 2010:11), but where the most powerful actors control the "networked internationalization of the core of the production process" (Castells, 2010:116), an outcome that benefits the food insecure is unlikely without public policy. Decision-making in such a system is likely to be increasingly based on the bounded rationality of the actors who are involved.

The possible consequences are that no one contributes towards actions that would be to the common good; the minority able to influence the food system pursue individual choices to the potential detriment of all; the majority have little influence over the food system beyond that of choices constrained by what is available, their resources and the difficulty of obtaining it (Olson, 1965; Brown, 1965). Regulation, social norms and the pursuit of social capital might ameliorate these tendencies.

However in a crisis, whether natural (a drought) or human (price speculation), there is a risk that some actors will stampede rather than cooperate, while others pursue opportunistic goals even if these jeopardise the functioning of the system. New regulations, alliances and compromises will also emerge in response to crisis, which may change the operation of the system and the nature of the problems to be addressed.

If this is the consequence of a complex food system, might both the barriers to achieving food security, and their solutions, be indeterminate and thus classifiable as being 'wicked'?

6. WICKED

To elaborate, the food system has been described as a 'problem-determined system' rather than a 'system-determined problem' (Ison et al, 1997). Following the argument of this paper, the problem determining the system is to sustainably realise food security and nutrition for the poor. However a problem of this nature is socially constructed and the nature of the problem may vary according to the perspectives of the actor who defines it. Consequently, the food security problem is not objectively understood by those attempting to provide solutions, and solutions may reflect the preferences of those who are proposing them, rather than being evidence-based.

Further, problems such as this are part of a network of problems in which "…*every problem interacts with other problems and is therefore part of a set of interrelated problems, a system of problems…. a (social) mess*" (Ackoff, 1997: 427).

Such problems are unlike the tame problems usually faced by scientists, physicists and engineers that, however complex, can typically be defined precisely, and which possess a finite set of solutions that can be reached through the application of an established and linear set of processes.

Termed 'wicked', such problems are not easily solved: often they are only momentarily solved only to re-emerge, altered, and needing to be re-solved. Interventions intended to solve such problems may have substantial, but nevertheless, impermanent effects (Horn and Weber, 2007).

Rittel and Webber (1973: 160-167) provide ten characteristics of wicked problems:

1. There is no definitive formulation of the problem but every formulation of a wicked problem corresponds to the formulation of a solution;
2. There is no stopping rule, a 'solution' is reached when money or time runs out;
3. There is a continuum of good to bad solutions;
4. There is no test as to the quality or durability of the solution;
5. Attempts to solve problems count;
6. There is no enumerable set of solutions and no set of permissible options;
7. Problems are potentially unique;
8. Problems may be symptoms of other problems;
9. Multiple explanations of problems are possible;
10. Aspirant solvers of problems are culpable for their solutions.

Others have built on this list, and Levin et al's (2012) additional attributes of 'Super Wicked Problems' are pertinent for food security:

11. Time is running out, which is certainly true for the children who are experiencing malnutrition, and arguably true for the sustainability of the food system;
12. Those who are causing the problem are also seeking to provide a solution, which is arguably true for the agri-food value chain that provides inputs, grows, processes and sells food, and certainly true for consumers and of course, food policy-makers and analysts;
13. A central authority to resolve the problem is weak or non-existent: recall no one is in charge of the food system.

Conklin (2005: 11) outlines a strategy to dealing with wicked problems that may be attractive in the short term. Termed 'taming', this involves imposing structure on the wicked problem using tools of management science and development planning. Other tactics include redefining the problem as a different problem that can be more easily addressed and then declaring both problems solved.

Alternatively, the success parameters by which a solution to the problem is to be measured can be identified in such a way that the problem appears to be already solved. Decision-makers can also pronounce the problem to be to be similar to prior problems that have already been solved, and then apply the same solutions.

Declaring that 'there is no alternative' and narrowing the solution choices to those for which there is already sufficient support is then employed. Finally, a response might be doing nothing or 'making do'. Although these may suffice for the term of office of the decision-maker, ultimately such solutions will fail in the long term. Dangerously, they produce perceptions that problems have been solved, when they still exist and are likely to return.

Indeterminate problems are attractive to both researchers and those making policy decisions. This is both because wickedness implies complexity, and is thus interesting and fertile ground for the production of research publications, and because wickedness can be presented as having being solved despite being difficult.

Wickedness can also be offered as an excuse for doing nothing or for doing too little. However, although complexity and wickedness recognise the dynamics and *problematique* of food system transitions noted earlier, the underlying political economy of food security is generally not directly considered.

The question as to *why* food security problems are indeterminate and consequently wicked is not confronted, and thus solutions remain generic and partial.

7. DISCUSSION

To summarise the *problematique* so far: food security is an outcome of a complex problem-determined food eco-system characterised by antagonism and conflicts of interest in which the problems are ill-defined and the solutions uncertain. The ability of this system to deliver food security relies upon keystones in its sub-systems, which extend from the microbial to the institutional. Food itself is a commodity, predominantly privately produced and purchased, and is one component of food security, along with other components such as food safety, social protection and food price stability. Public sector action is needed to ensure that food security is a public good, and is a human right: universal, indivisible and interdependent with other human rights. However, food security is also the joint product of private and public action, and thus an impure public good. It is therefore subject to collective action problems that must be resolved.

Conventional collective action problems are those of coordination, co-operation, and finding and keeping agreements. Food security brings additional complications: problems of wealth and power inequalities and entrenched privilege; problems of unstable solutions; problems of fundamental uncertainty about causes and consequences; and problems of conflicting interests and high stakes. Moreover, in the context of bounded rationality, both private and public actors in the food system are unable to anticipate correctly the sequence of contingencies that might follow from decisions, fuelling motivation to not cooperate.

Finally, even when negative consequences can be anticipated, free riders can benefit without incurring costs.

Despite its complexity, the operation of the food system need not daunt the trans-disciplinary analyst. Systems theory is well developed and has transcended the functionalism of its origins to provide an opportunity for an integrative approach. Scientific computing power continues to grow exponentially and there are rich global, national and local level data available, including high volume, highly variable and high velocity ‘big data’.

Qualitative, action research and post-positivist approaches, and their triangulation with quantitative approaches have advanced and gained epistemological credibility, while reductionist approaches have largely been rejected. There has been an upsurge of trans-disciplinary research defined by the problems being investigated

rather than the disciplines of the investigators (Brandt et al, 2013). This has advanced approaches to achieve more nuanced problem framing as well as methods for integration across disciplinary boundaries. Finally developments such as quantum computing and artificial intelligence offer new opportunities for the investigation of complexity. The question is where to start.

It is thus unnecessary to evoke the spectre of wickedness and abandon attempts for lasting solutions. After all, Rittel and Webber (1973) did not claim that wicked problems are inherently unsolvable. They argued that wicked problems are hard, their causal pathways are difficult to follow, and they are not likely to be resolved using conventional analytical and linear approaches. They did caution that once solutions are attempted, they are not easily reversed: *"One cannot build a freeway to see how it works, and then easily correct it after unsatisfactory performance"* (Rittel and Webber, 1973: 140).

Much the same applies to many food security interventions such as social protection, land reform or agricultural subsidies. Ultimately such decisions rely upon political judgement and once made, will be caught up in political processes. In the language of computational complexity theory, such problems are undecidable when approached as linear. There is consequently no algorithm that will provide a correct answer for every instance of the problem even if there is massive improvement in the quantity or quality of data provided. To push this analogy further, such problems are NP-hard: they take a long time to solve, and, importantly, it takes longer to check whether the solution is correct.

The difficulty of these problems, the tensions of problem solving, and the inability to quickly check for correctness, is not unique. Indeed, these are the foundation of political economy that questions who wins and who loses, where are benefits and losses concentrated, and under what contexts are different decisions reached for whose benefit. Experience shows that there are opportunities for interventions to resolve problems of this nature for other impure public goods that require collective action to resolve distributional problems.

Although this may take time, human judgement and repeated effort to change societal perceptions of the different components of food security, collective action has been possible and successful (Booth and Cammack, 2013; Levy, 2014; IFAD, 2016). Universal basic education and primary health care are notable instances of rivalrous goods that are now enjoyed as a non-exclusive right in many countries.

In most cases, these rights were achieved through drawn out, uneven and messy processes rather than through systematic evidence based planning. Political protest, violence, iniquitous outcomes and conservative backlash have

characterised such struggles. Historic examples include the United Kingdom's welfare state and the United States' New Deal.

Recent examples include the Right to Food Campaign in India that lead to the Mahatma Gandhi National Rural Employment Guarantee Act (MGNREGA) and the *Juntos* and *Haku Wiñay* programmes in Peru that bring together a conditional cash transfer and a programme to promote rural livelihoods in areas most affected by the conflict of the 1980's and 1990's (IFAD, 2016: 100).

Also from this perspective, some interventions, such as the liberalisation measures imposed on African governments by the Washington Consensus could be seen as ideological efforts to pull food security out of the public good sphere, deny its status as a human right, and to re-commodify it.

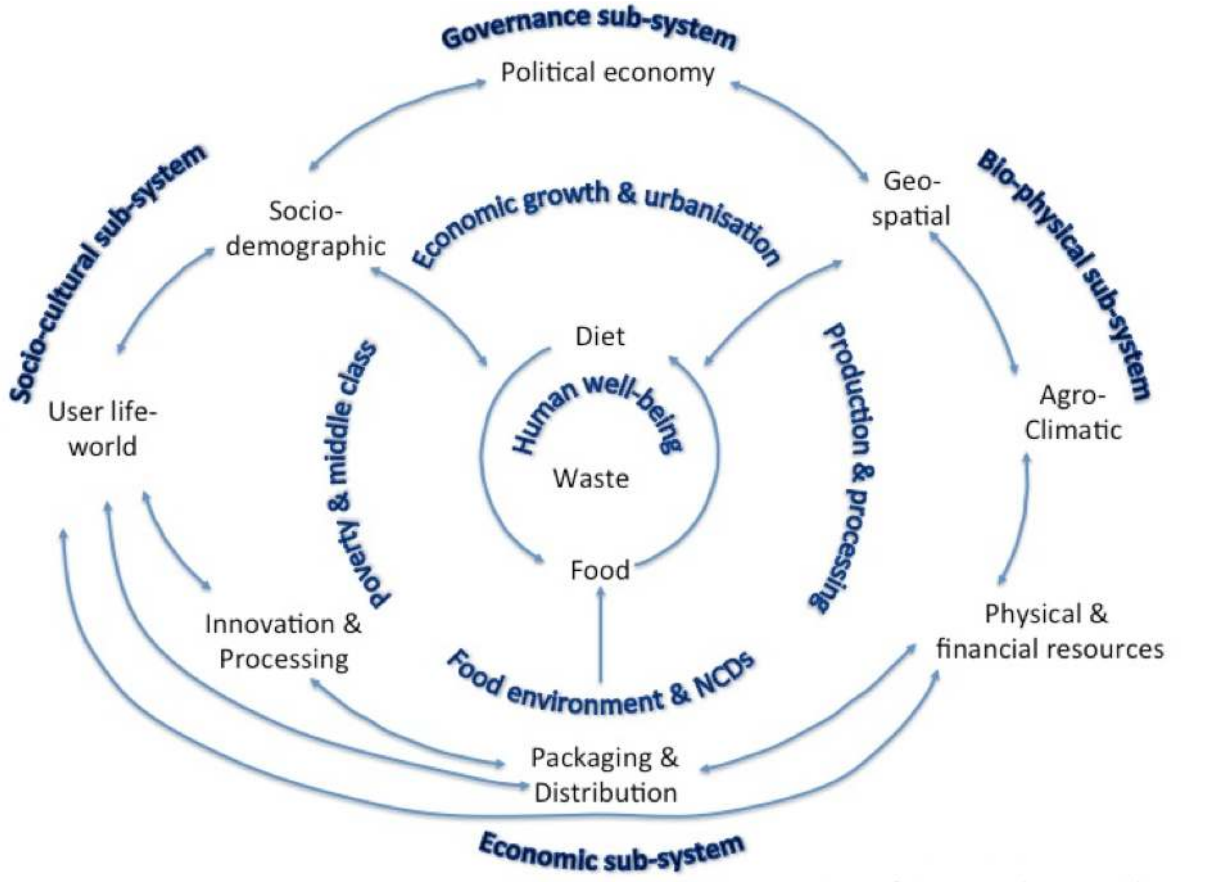
From the perspective of the analyst, these might be motivated by the search for economic growth and hunger reduction as claimed by the official discourse, or for private corporate profit as argued by some food sovereignty analysts, political economists and food activists (cf. Akram-Lodi, 2015; Albritton, 2009; Patel, 2009).

There are potentially more efficient solution options to be derived from political economy and the Social-Ecological Systems (SES) framework developed by Elinor Ostrom and others offers a potentially rewarding point for departure. Using such systematic approaches, collective action models have been used to analyse time, context and perspective specific problems within the food system.

An example is foodborne disease in lettuce in California between 2002 and 2007 viewed from the perspective of industry members investing in food safety (Richards et al, 2009).

The discussion on systems presented earlier is offered as motivation that the food system has the characteristics of a SES, albeit a large one that encompasses multiple second-level sub-systems within multiple first-level sub-systems. Applying Ostrom's (2009: 420) multilevel nested framework to such an extended system requires the introduction of additional levels while retaining the underlying logic of her approach. The integrated conceptual model of the food system discussed earlier is helpful in this regard and is adapted in the onion diagram presented in Figure 1.

Figure 1: **Sub-systems in the food SES**



Source: Sobal et al (1998); Ostrom (2009)

There are differences between this figure and those of Sobal et al (1998) and Ostrom (2009). The first is perspective: Although a two dimensional figure is readily presented, the food system is better thought of as a three-dimensional landscape in which the 'importance' of a specific sub-system and its attendant set of problems form the surface. The importance attributed to a sub-system will depend on the position of each actor in the system.

As such some sub-systems may be unseen from the viewpoint of an actor, others may be given greater status, and the connections between systems may be missed. Since importance is relative, disputable, political and thus subject to stress, it will change over time and by context, and these changes may be reversible or permanent. The result is a surface that is simultaneously elastic, viscous and plastic. The metaphor is perhaps more a landscape of sea-ice than a more permanent geological one.

Secondly, the extended set of sub-systems described earlier is presented as being the first-level. This elevates socio-cultural and governance contexts described by Sobal et al (1998) to sub-systems in their own right, a decision that is supported by

the literature on food politics and food sovereignty which emerged since the publication of their review (cf. Nestle, 2013; Patel, 2009; Pollan, 2008). Second-level sub-systems encompass the actors, resource units, resources systems and governance systems put forward by Ostrom. These bring together physical, including land and water, financial, human and other capitals to grow, process, package, distribute and prepare food. Once food has been converted to physiological well-being, as well to other forms of human well-being, the waste sub-system disposes of the detritus of production and consumption.

Thirdly, three key socio-economic dynamics form the third layer of Figure 1: 1) economic growth and urbanization used in food security forecasting models; 2) inequalities and a growing middle class used in consumption forecasting; and, 3) the changing food environment and the prevalence of diet-related non-communicable disease (DR-NCD) used in epidemiological forecasting (Briggs, Wolstenholme, Blakely & Scarborough 2016).

Finally, in keeping with the heuristic framework of this paper, 'users' have been replaced with 'actors'. The implication is that these are both individuals *and* institutions that possess and exercise social agency in the food system. Actors also provide the bridge from the food system to other systems. The interactions linking the sub-systems include information sharing and conflicts between actors, lobbying and negotiation activities, and self-organising and networking arrangements.

This depiction reveals the operation of a system in which food is a source of nutrition, a commodity and also "*a highly condensed social fact*" (Appadurai, 1981: 494). Although Sobal et al (1998) place physiological nourishment as the ultimate purpose of the food system, this reductionism seems unhelpful in a context in which food serves many purposes, and in which the choice of actors involves balancing these goals.

As Belasco (2008) notes, food choices are the result of a complex negotiation among competing considerations. These are the identity of consumers both in terms of individual attributes and preferences as well as in terms of adherence to social norms (the life-world); matters of convenience such as prices, the availability of different foods, and the skills required to prepare these (consumption); and finally a sense of responsibility, which Belasco describes as having an awareness of the consequences of what we eat and how it is produced.

Although Belasco's focus is on consumers, these considerations apply to choices made by actors throughout the food system, including the producers, distributors, financiers, administrators and regulators of food and nutrition.

At the hub of Figure 1, human actors exercise choice over their diet: that is the food that they intend consuming and the manner in which this consumption will take place. Having absorbed the nutrition provided by this choice, the final outcomes are changes to human well-being (positive or negative), and also the human, plant and animal effluent that must be disposed of through the waste management sub-system. Thus depicted, the system depicts the transfer of food from 'farm to fork', 'land to mouth', and 'seedling to supermarket' (Kneen, 1995; Burch et al, 2013).

Identifying keystones can help identify which problems should be prioritised, and the sequencing of solutions. Although this list would vary by context, over time and by the actors' perspective, some options include:

- Individual actors such as mothers and children due to their vulnerability to nutrition shocks, and social actors such as consumer groups, unions, farmer co-operatives and social movements;
- Organisations such as the distributors who stock and price the shelves and provision the baskets and plates of consumers, and thus shape the choices that can be made, or financiers who decide where to invest and thus shape what is profitable to produce;
- Institutions such as the agricultural innovation system and the principal food value chains that facilitate the adaptation of the food system to new technologies, products and processes while determining its form and functioning;
- Dynamics such as changes in population structure, consumption patterns and disease prevalence;
- Policies such as import and export tariffs, taxation, social protection, public health and food safety that ensure access to food, as well as its healthy and safe utilisation; and
- Contestations such as food politics, knowledges and symbols that reflect power relations, culture and values.

The alignment of these keystones determines whether and how the food system will deliver affordable, sustainable and healthy diets in a manner that 'no-one is left behind'.

8. POLICY IMPLICATIONS: WHAT TO DO?

As noted in the introduction, food security is receiving renewed interest in public policy, globally as the Sustainable Development Goals, nationally as food security policies and locally as food sensitive urban planning. As argued in this paper, those seeking solutions may be part of the problem. They will include different spheres and sections of government, producer and consumer groups, academics and

perhaps celebrity chefs. The policies that result, and the manner of their implementation will depend upon the actions, negotiations and relative powers of those engaging in the process: but also of those that are not.

In such processes decision-makers in the public and the private sectors can be engaged as duty bearers for the provision of food security as a public good. Actors would then be called upon to acknowledge (and be acknowledged for) their role, duties and culpabilities in securing the sustainability of the food system and the future health of the natural resources required to produce food, the keystones, and of those that consume food. Engaging these as rights-holders is also important. After all, these are the current and future consumers, labour force, taxpayers, shareholders and fellow citizens in the food system.

Lastly, a changing food system is likely to produce individual costs, some of which will be borne by actors who are not duty holders nor hold rights that can be realised. A changing food system will also produce new beneficiaries, some of whom will be free riders: able to benefit without any contribution. The distribution of costs/benefits and how/whether these are to be managed will influence the nature of the engagement and likelihood that agreements will be reached and kept.

The collective action challenges that arise from food security's *problematique* as described here will also be an influence. To problematize the characteristics of a wicked problem, these include:

1. Identifying the actors involved, including the duty-bearers, rights-holders and marginalised; convening these actors in some cases having first constituted them as agents; seeking a shared understanding of the problems and solutions being proposed, recognising when a solution may result in non-cooperation or contestation.
2. Selecting solutions from the continuum of good to bad; identifying who will benefit, including free riders, and who may bear costs without garnering any benefits.
3. Establishing which problems are symptoms of which other problems, or are problems arising from previous attempts to find solutions. Dealing with any unresolved culpabilities that remain from these attempts;
4. Listing multiple narratives and explanations of problems, identifying for whom the explanation holds, and the implications of this;
5. Partnering to establish processes, procedures and actions, and assigning responsibilities, including that of a regulator who will provide oversight and enforce stopping rules;
6. Agreeing on ways to check and report on the anticipated and unanticipated outcomes of the solution (including those affecting

common property resources), and how these checks will evolve over time;
7. Identifying strategies to respond to these monitoring and evaluation activities in order to adjust the interventions established under 3);
8. Finding reflexive processes to regularly revisit the problem, the solution, the actors and the outcomes. Establishing a credible ombudsman to address contestations;
9. Identifying strategies to facilitate the transferability of solutions to new problems that while unique, are familiar;
10. Accepting and assigning duties and culpabilities for the provision of food, food security and nutrition, including the positive and negative externalities that follow, and include mechanisms for recourse, oversight and insurance.

Meeting these challenges might require new forms of innovative governance. It will require a dialogue between multiple agents and bodies of knowledge, as well as between multiple rationalities and multiple levels. Such dialogue will not necessarily be initiated by the public sector, and may require more assertive action on the part of consumers and civil society with the realisation that they indeed hold rights for which others bear duties to fulfil. Finally, to avoid remaining a 'super wicked problem', it will require replacing the current system in which no one is in control, to a polycentric system "*organized in multiple layers of nested enterprises*" (Ostrom, 2000: 152).

The horizontal interactions between diverse actors should result in better-coordinated delivery and regulation of food security, and the enforcement of rights and duties.

9. CONCLUSION

Despite the complexity of food security and nutrition this paper argues that solutions are possible using existing tools for the analysis of complex systems and existing approaches for the resolution of collective action problems. The contention is that even the most complex systems can be analysed and even indeterminate problems can problematized. The impure public good characteristic of food security is a cause of both complexity and wickedness. It nevertheless offers opportunities that have been applied to other collective action challenges. Some of these have been identified by turning the attributes of wicked problems into actions for polycentric governance.

Returning to Figure 1, such analysis rests upon a rheology of "…flows of capital, flows of information, flows of technology, flows of organizational interactions, flows

of images, sounds and symbols" (Castells, 2010:442). Actors will hold different and often conflicting positions with different priorities at different times, including the system's analysts such as the author. In such a conjunction, the type of food security that results will rely upon the relative strengths and positions of those trying to create collective purpose.

Churchman (1967: B142) warns, merely taming the "…*growl of a wicked problem while leaving the beast unchanged*" will not suffice. The short-term benefits of such strategy will be outweighed by the long-term costs of expediency, and both climatic and political events suggest that time is indeed running out. A task for food policy analysts is demonstrating this to the actors in the food system with the hope that they will self-organise to ensure universal food security while minimising the negative externalities that might follow from this accomplishment. A conundrum though is that some actors may be part of the beast.

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