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Sustainable Food Security Futures: Perspectives on Food Waste and Information across the food supply chain

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Purpose: This paper is seeking to signpost the genesis of food security and associated factors such that organisations, enterprises, policy makers and interested stakeholders can seek to explore and understand this important societal issue. The challenges that food security poses are eclectic in nature and cut through country, society, organisation and individual boundaries. Only through identifying these factors – hence identifying underlying factors of food waste and usage of information within food supply chains to untangle them - can we adopt enterprise interventions in order to initiate and mitigate food security risk.

Design/methodology/approach: As a viewpoint piece, there is no empirical work to report in this paper. An exploratory review of the literature has allowed for the extraction of food security concerns that need the attention of stakeholders across the enterprise to ensure robust food supply chains can be are created, maintained and sustained through a better understanding and usage of information, knowledge and data.

Findings: This paper articulates six constructs that underpin the challenges of establishing food security; *growing populations, aspirational changes, climate change, soil erosion / irrigation, water availability / consumption, and incremental levels of yield*. In doing so, it is suggested that information relating to factors may support decision-makers within communities, organisations and enterprises to better understand these factors that then contribute towards enhanced food security. Relevant strategies or policies can then emerge and be developed such that strategic as well as operational interventions can be prioritised across national, regional or industry level. Underpinning the above, the authors identify that waste within and across the food supply chain contributes to the six factors identified, also highlighting where additional focus may need to be applied in order to support / sustain food supply chains.

Research limitations/implications: This paper is a position paper that does not offer factual insight but rather highlights a direction of thought that others can consider exploring as part of wider research agendas in the topical area where enterprise, organisational, and information-based contributions may support the development of strategy-led food security policy.

Practical implications: This paper provides reassuring insights that will help decision and policy makers assemble their thoughts when it comes to prioritising their communications and interventions amongst organisational / enterprise-level stakeholder groups involved in food security and food supply chain contexts.

Social implications: This paper has highlighted the need for more research around the human and organisational factors that are identified as both underpinning the need for food security and, as drivers of waste throughout the food supply chain. Indeed, there is further work needed to highlight the inter-relationships that exist and, which then feed into resulting interventions.

Originality/value: To raise the importance of food security amongst differing stakeholder community groups at the organisational and enterprise level.

Introduction

Since the inception of the Declaration of Human Rights in 1948 (UN, 1948), the United Nations (UN) has recognized the individual's right to food going even as far as noting that this right is vital for the enjoyment of *all other* rights and therefore integral to our very existence (UN, 1999). Hence, political and social concerns about society's relationship with food are increasingly becoming important in an era of mass consumption, where the stable and secure supply of food is becoming a key topic of transnational debate. This debate encompasses not only nutritional and health aspects but also how food is produced, distributed and consumed.

Maintaining a stable and secure supply of food therefore will continue to be a perennial concern. Food security is commonly articulated to include both the physical and economic access to those food products that satisfy individual dietary and respective preferences (FAO, 1996). As such the FAO identifies the four pillars of food security as *Availability*, *Access*, *Utilization*, and *Stability* (FAO 2009). This is set in the context of feeding in excess of 9 billion people (Godfray et al., 2010). In modern times, this has manifested itself through intrinsic links between globalisation underpinned by the need for ever more manufactured products at increasingly sophisticated and higher levels of service quality. This is achieved via a workforce that has to service this developing need for what modern society wants. Of course, needs and wants are not the same, yet fundamental *access* to dietary needs is increasingly being confused and mixed with *excess* demand and consumption (leading to and promoting obesity other medical conditions that are harmful to health).

Global political and social concerns about society's relationship with food are hence increasingly feeding into debates about how to maintain a stable and secure supply of food. Whilst there is much need to rethink our relationship with food consumption and waste, this is only going to possible when all the constituent components that impact food security are better understood, modelled and analysed. Given human capital is more mobile, aspirational and in search for higher living standards, traditional norms of stability are now challenged and in search of scalable solutions.

Although there is a worldwide growth in population, much of this is around metropolitan and urban areas in developing countries – wherein food demand and supply is also increasing. This is as opposed to rural farming areas that have traditionally serviced community needs locally. Coupled with an ever increasing desire by consumers to have their food needs met within and outside of season, a range of consumer needs is therefore adding pressure to the previously cited factors, and the overall fulfilment of food supply.

Seeking an understanding of these key factors, and how the usage of information can expand the perspective on this topic so that organisations and enterprises involved in the supply of food can manage and maintain food demand in a sustainable fashion.

The Intractability of Food Security

Our basic human needs are driven by a desire to eat, which is polarised by two extremes: pure survival through to greed. Even in the 21st Century, there are millions of people starving and going hungry who rightly observe and require food as a basic human need, whilst at the other extreme first-world inhabitant see food as a resource which can be consumed and

enjoyed extravagantly without fear of understanding the basis for its ongoing supply. This raises fundamental questions around where the real challenge about food security (as defined previously) lies: is this with agriculture (farming), manufacturing (operational management of food processing), or distribution (supply chain and logistics) or is it simply related to demand fulfilment (economics)? Perhaps that is simplifying or even trivialising the challenge – however the inherent complexity involved in teasing apart all of the various elements of food production through to consumption (and importantly also, waste) this topic has evolved over recent generations from being a puzzle to be solved into being a type of "mess", that is a set of interrelated and hence system of problems (Ackoff, 1974).

As such successive governments and policy-makers around the world have continued to dedicate resources to improve their infrastructures and thinking around the creation of equal and sustained access to food. Yet, there are many challenges that continue to thwart this aspiration, preserving the complexity of its solution within. These challenges are now outlined below.

- **Growing Populations:** There are enormous concerns about the consequences of population growth for the environment and for social and economic development. However, these challenges are not restricted to the growth in numbers alone, although Lutz *et al.* (2001) produce scientific models to predict that there is an 85 per cent chance that the world's population will stop growing before the end of this current century. There also remains the challenge around the distribution and mass movement of people across geographical regions (depopulation of farming communities and the like), in search of prosperity in cities and conurbation areas. This has lead to the very real problem of dwindling populations in the rural countryside in first-world as well as third-world countries.

- **Aspirational Changes:** The search for employment and a regular stable income has developed a generation of wealthier people, who want to demonstrate and enjoy their success through improved standards of living. Clearly this extends to the expansion and variety of diets whereby increases in meat consumption predicts that poultry consumption is projected to grow at 1.5% per annum through 2020, with other meats growing at 0.5% (Delgado, 2003). Magdelaine *et al.*, (2008) go onto to identify quasi-structural factors linked to this growth in consumption although Delgado (2003) does highlight the public health issues associated with such growth in meat consumption. There is a clear correlation between rising aspirational standards, dietary intake, consumption of food groups and the impact on health and wellbeing (principally leading to increasingly negative health outcomes such as obesity, diabetes and heart disease).

- **Climate Change (Adaptation and Mitigation)**: Much has been written about the effects of climate change both from the perspective of those who accept or do not accept the impact of industrialised society on the biosphere (including those who believe that increases in global warming are part of a cyclical climatic trend and are not related to pollution and other harmful emissions). What is unquestionable is that the world is experiencing climatic change which is also leading to extreme weather events. Such events may then also have a profound impact on our food security (Khandekar, 2013).

- **Soil Erosion and Irrigation**: Soil is the basis of crop production so there is an intrinsic link between soil (and its productivity) and food security. Therefore, soil erosion is seen as a key contributing factor to a loss in soil productivity that will have a potentially significant detrimental impact on crop production. Indeed, nearly a third of the world's cropland is losing topsoil faster than new soil is forming, reducing the land's inherent fertility (Brown, 2012). Brown (2013a) explains that during the last half of the 20th century, the world's irrigated area expanded from some 250 million acres in 1950 to roughly 700 million in 2000. Therefore, there remains much concern around the relationship between irrigation-induced soil erosion and the impact this has on crop harvests and thus, food availability.

- **Water Scarcity / Consumption:** There is a clear relationship between water scarcity (availability) and consumption, and indeed logic suggests that one should drive the other but in reality there is little evidence that this is the case in developed countries, at least. Water is a natural and fundamental constituent of our environment and is literally a key element of food. Therefore any aspect that relates to either the scarcity or increased consumption (even wastage) of water should be of concern to us. The scarcity of water varies considerably across geographical territories, with some having sufficient levels of usable water yet, elsewhere, the water table is falling, leaving Governments with a careful balancing act when it comes to managing complex ecosystems and natural resources necessary for life. While there might well be an immediate need, it does raise questions about the sustainability of currently available water resources as both a means (to drink) and an end (to produce crops). There is a growing dependency on grain and other produce grown with over pumping groundwater to feed dependent populations thus, resulting in aquifer depletion that represents a real and present danger to levels of water stock. Similarly, levels of water consumption continue to rise throughout the food supply chain, whether in farming (during the production of crops) or feeding of cattle - or at the other end of the chain when it comes to personal levels of consumption. Essentially, getting enough water to drink is not considered as an imperative but finding enough to produce the ever-growing quantities of crops the world consumes is (Grey and Sadoff, 2007).

- **Incremental Levels of Yield:** Innovations in what is produced and how it is produced (food and water) have revolutionised the way consumers' value food. Yet, this has been offset in part, but growing levels of consumption fuelled by population growth and corresponding levels of waste (physical waste produced and nutritional loss in waste produced). Notwithstanding genetic advances and innovations in crop production like hydroponics, a glass ceiling appears to have been reached when it comes to plant yields. In some respect, it is now a volume game, dictated through levels of produce that can physically be grown given increasingly scares resources. Nevertheless, understanding the intricate interplay between production, consumption and waste is a key element of the yield equation (Ray *et al.*, 2012)

The two-sided coin: Understanding Food Waste and Integrating Information

Noting the key drivers behind food security, we therefore posit that there should be better ways to understand and therefore identify drivers for ensuring the safe supply of food. In doing so, we draw together two seemingly disparate but intrinsically connected underlying drivers that are seeing rapid traction in this wider debate.

Food waste is a perennial and ongoing issue within society. Apart from the loss of nutritional value, damage to the environment and concerns about increasing levels of consumer demand, in the UK alone food waste accounts for well over £5 a week (and rising) of food which is thrown away (WRAP, 2007). Within the household, packaging, lack of education / appreciation of sell-by dates, over-consumption (in some cases, sheer carelessness) and reliance upon an abundant supply contribute to food that is wasted. This accounts for several million tonnes of waste in the UK per year – however there are many other sources of wastage along the chain, comprising of 1.6 million tonnes from grocery retail outlets and 4.9 million tonnes from food manufacturers alone (WRAP, 2013).

Whilst this viewpoint has sought to highlight contributory factors of food *insecurity* at a macro-level, the levels of waste produced throughout the food supply chain continues to grow, as volumes rise and consumption increases. Traditional views of food waste are changing, no longer seeing it as being evidenced at the two extremes (production or consumption).

At the same time, we need to keep in mind that all elements of the food supply chain essentially form part of the "mess" of food security: i.e. food manufacturers, distributors, retailers, safety organisations, regulators and other key stakeholders, form part of a series of networked enterprises. The flow of information across and between these tiers is therefore of key importance in ensuring that the supply chain operates effectively and efficiently (Lambert and Cooper, 2000). As such there is limited understanding and research carried out in terms of information and flows within the food supply chain, where the main focus has been on either the development of IS frameworks to support the wide-scale enterprises organisations (Sharma and Patil, 2011); or in terms of alignment of IT and retail food distribution strategies (Bourlakis and Bourlakis, 2006).

Could a part of the food security and food waste challenge lie in understanding and capturing the information which relates to this? In terms of Ackoff's "misinformation systems", there may not be a lack of relevant information that we know or don't know relating to food security / food waste; but rather a *paucity of integration of that information* that leads to meaningful analysis and resulting decisions (Ackoff , 1967). Thankfully, both the UN's FAO and WFP programmes are clear about the need to include relevant and timely information captured from the field (literary) in relation to how food is produced, distributed, consumed and where the need to provide it is most necessary (UN WFP, 2009). Efforts are clearly underway to now include localised as well as geographic sensor-based systems for data capture relating to a wide variety of food chain datapoints (FAO, 2015). For example, soil conditions, weather reports and patterns, on-farm production levels, off-farm food processing production cycles, transportation, distribution and logistics monitoring, and geographic information – such as displaced peoples and identification of regions of drought / famine.

Indeed, the digitisation of the agricultural landscape is rapidly occurring such that even more intensified and up-to-the-minute data, information and knowledge can be gathered relating to the entire food supply chain. This is most prevalent in the emergence of so-called “smart / precision farming systems”. This is where a whole array of sensing technologies (such as enabled through the now ubiquitous Internet of Things, IoT), across crops, fields, livestock, food production and farming machinery is possible (Kaloxylos *et al.*, 2012). Hence on-farm information systems will allow agribusinesses themselves to be able to interrogate and share their own enterprise information as part of a wider agri-tech ecosystem.

Table 1: Positioning Points of Waste and Information in the Food Supply Chain

Waste Phase	Waste Driver	Enterprise / Organisation Level	Information / Technological Level
Economic	Mergers and Acquisitions	Economic	Financial data and metrics
	Poor demand management		Consumption trends and KPIs
	Immature markets		Market pricing
	Supply reduces price		
Farming	Poor practice	Agriculture	Crop and soil sensing
	Appearance – quality		Farm machinery efficiency
	Unfit for human consumption		Inventory and Production levels and controls
Processing	Inefficient operations management	Manufacturing	
Storage	Ineffective operations management	Logistics	
	Lack of infrastructure		Asset identification / warehousing
Transportation	Poor logistics infrastructure	Haulage, shipping or flight	Transportation tracking and monitoring
	Weak levels of investment	Government	Traffic and flow management
	Bad packaging	Suppliers	Packaging technologies
Consumption	Purchasing habits	Retail	Consumer trends
	Purchasing incentives		Sales and marketing targets
Premature harvesting due to bad weather	Bad weather	N/A	Climate / weather monitoring and remote sensing (GIS)
Lack of disposal options	Disposal is cheaper than recycle	Environmental	Reverse Logistics metrics (recovery and recycling)
Embedded energy	Total energy consumption	Cyclical	Energy indices

As such, Table 1 seeks to offer the notion of food waste contributing to the food security debate as part of a staged outcome, phased at different parts along the food supply chain. In progressing this viewpoint, it then becomes possible to identify what those waste drivers might be and thus, aligning these to source of information, where interventions might occur. We therefore suggest that by taking a combined supply chain (waste-focussed) as well as information-focussed approach, food security can be better understood and managed.

Conclusions

Food security is set to become one of the dominating factors that defines our future existence, as the supply of food and water starts to struggle in satisfying our growing consumer needs. Yet, countries around the world will tackle different aspects of food security in varying degrees of order. Some will seek to use science to navigate through these challenges, advantaged through their developed nation status, while others may use same financial resources to secure their food supply chains by buying or leasing the natural resources often existing in abundance in less developed countries. Indeed, the challenges around developing robust food supply chains are contemporary and do range from production through to consumption.

However, there is also much need for research and management enquiry into two other underlying factors which impinge upon our understanding and how we can tackle the subject of food security. This paper has highlighted these as being food waste (including assessment of how such waste is monitored, measured and reduced); and how information relating to this and food security in general can be utilised to make and inform food security-conscious strategic decisions. On the latter topic of information within food supply chains, there is a desperate need to quantify, integrate and inter-relate a disparate range of data and knowledge so that food production, consumption, waste and more importantly specific food *needs* can be identified and balanced with nutritional and health vectors. As indicated a range of existing information-based systems (including geographical information systems, GIS, but also increasingly interconnected technologies such as the Internet of Things, IoT) may help to accelerate our understanding of where and how food is being used.

On the former, food waste is not simply driven by consumers but occurs at each stage of food manufacture and distribution. Reducing such waste will directly improve efficiency levels and contribute towards enhanced levels of effectiveness when it comes to securing food supply chains. Currently, there is little research exploring food waste, perhaps because as consumers there is an in-build sense of regret or even heightened levels of shame. But as the divide between consumer types expand and the need to leaner food chains gains prominence, a growing desire to explore both supplier and consumer driven food waste factors will gain momentum.

Understanding all these inter-relationships that are often wrapped around human and organisational factors represents the most appropriate way to manage our naturally gifted resources so that we can all continue to enjoy our existence.

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