CHAPTER

9

From agriculture to the global food chain/system

OUTLINE

Food waste occurs all along the supply chain; so, understanding the global food system and food supply chain (FSC) in particular as well as their intrinsic nuances is key to better comprehending the complexities of the wastage problem. In this endeavor, the following takes a snapshot of the agricultural, livestock, and fisheries primary farming landscapes to better set the backdrop of the supply chain characteristics of the proceeding sections. However, with regard to the food supply and the FSC, it must be noted at the outset that the two are two very different things; the food chain on the one hand is the chain that sees the bird eating the bug, the animal eating the bird, and humans eating the animal, and so on;

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the FSC on the other hand is just a supply chain—a sum of all the processes described in the next sections responsible for bringing food to the table.

9.1 Agriculture, forestry, and fisheries

Global food production in general (with some small caveats) has for a long time been a somewhat nationally protected sector. In fact, since the first General Agreement on Trade and Tariffs (GATT) back in 1947 (WTO, 2010), the industry was vociferously protected by producers and governments alike. However, after several decades and amid growing pressure from the World Trade Organization (WTO), as well as from a critical mass of capitalist momentum, all that changed in 1995 as agriculture was finally placed on GATT discussion table. Subsequent GATT rounds have further reduced trade barriers across nations resulting in a hefty increase in global agricultural trade (WTO, 2010).

As a result, for many if not most countries in the world now, agriculture has become an essential and inextricable component of economic growth. It comes as no surprise then that such developments have altered the traditional agricultural landscape. Incidentally, this is a situation that is also tied to the food security of many developing countries (more on this later). A closer look at the current structure of the global agricultural landscape and its impact on the global FSC helps to elucidate this point.

9.2 What is the food supply chain?

So, what about FSC themselves? In its simplest form, an FSC is the process that describes how food from the farm reaches our tables. Adding a layer of complexity, the FSC can further be described as the production, the processing, the distribution and consumption and to some extent the disposal of foods. With this in mind, FSC can be characterized by the flow of food in one direction and the flow of money in the opposite direction as shown in Fig. 9.1.

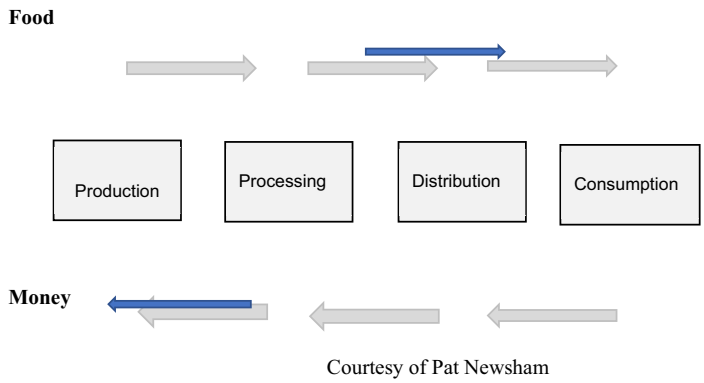

FIGURE 9.1 A simple food supply chain. *Courtesy of Pat Newsham*

From the perspective of food, producers, processors, and retailers push (supply) foods as consumers pull (demand) food. Conversely from the viewpoint of money, consumers push money as retailers, processors and producers pull money along the chain. In this way it can be seen that when one aspect of the FSC is affected, the whole chain is affected, thus representing two-sided causality or co-dependence. It has to be noted too that even in spite of this interdependence, the ability of the chain to function well is not a given. On the contrary, inefficiencies in early supply chains were noted among developing and developed countries alike and part of early developed countries strategic economic development policy gave high priority to the improvement of such systems (Gra, 1990). As a result, during the early part of the 20th century, technical and economic improvements facilitated by political goals, many countries were able to develop their FSC systems to meet the needs of the majority of their populations. Initially this meant increasing national production as well as building and improving storage and transportation facilities; later, however, it was also recognized that improvements along the whole of the chain were required if supply and demand were to be in equilibrium (Gra, 1990). For many this has ultimately resulted in systematic and continuous improvements in the production and distribution of food; for others—particularly in the developing economies, many barriers still remain.

9.2.1 Food supply chain characteristics

Food systems are predicated on the previously mentioned well-functioning primary farming models and as a whole the global food system can be thought of as a collection of FSC that make up the total supply and demand around the world. Over the recent past, the supply chain itself has witnessed many profound changes evolving through technological advances, globalization and politicization. More importantly, however, every aspect of the FSC is becoming increasingly accountable—particularly at the social level. Although thus far, this accountability has largely been confined to moral and ethical pressures and as is so often the case, such influences can be limited. That said this marks the culmination of pressure both at public and institutional levels. This trend is not seen in isolation either, accountability of the FSC is just one of many such social goals including inter alia: sustainability, natural resource allocation, an increased sense of fair trade and of course food wastage—and that's just the beginning; the pressures for change are mounting (SOFI, 2005; Ericksen, 2008; Gibson, 2016).

Social pressures aside, over the past few decades trends in global production have been characterized by Erickson and others as the intensification of agriculture accompanied by a corresponding trend for larger farm sizes and the increasing fragmentation of marginalized smallholders (Ericksen, 2008). On top of this, these last few decades have also seen increased "value-added" foods in the processing sectors and a concentration of corporate businesses up and down the supply chain (vertical integration) as opposed to the hitherto dominant traditional horizontal model. This can be seen in many levels of the food chain and it effectively allows increasing corporate control by large multinationals over large sections of the food system. Some of these changes were highlighted by Polly Ericksen in a recent paper contrasting food systems and their effects on societal outcomes (Ericksen, 2008) In a similar vein both Maxwell and Slater's work build on similar ideas and draws attention to some of the

TABLE 9.1 Features of "traditional" and "modern" food systems.

Food system feature	Traditional food systems	Modern food systems
Main employment in food sector	Predominantly food production	In food preparation and processing, packaging production and retail
Supply chain	Short and local food-chains	Long-chains with increasing numbers of food miles
Food production system type	Diversified, varied productivity	Only a few crops dominate; which require intensive, high input requirements
Typical farm size	Smallish family owned business	Industrial, large scale
Typical food consumed in each chain	Basic local staples	Processed foods with brand names; more animal products
Purchased food bought often from	Small-scale, local shops or local market	Large supermarket chains
Nutritional worries	Undernutrition, malnutrition	Long-asting dietary diseases
Main areas of national food shocks	Production shocks, for poor practices, rain, and harvesting	Price and trade problems
Main areas of household food shocks	Production shocks, for poor practices, rain, and harvesting	Income shocks and food poverty
Important environmental concerns	Degradation of the Soil	Nutrient loading, agricultural and industrial chemical runoff, poor water usage, and greenhouse gas emissions
Characteristics of Food Chain	Local to national	National to global

Based on *Ericksen, P.J., 2008. Conceptualizing food systems for global environmental change research. Glob. Environ. Chang. 18 (1), 234–245.*

fundamental shifts occurring within the food system as a whole. Combine these trends with the more recent Foresight program's findings, the UK government's think-tank (Foresight, 2010) of traditional and urbanized systems and we get a clear indication of the way modern developed food systems are behaving (see Table 9.1).

Food, along with many other natural resources these days is increasingly being seen in a holistic fashion, both as an independent system as well as in its symbiotic relationship with the environment. Indeed by offering the notion that food systems as well as other social goals of sustainability etc. (Table 9.2) in turn are both affected by, and influenced by, outside considerations of policy, economics and the environment, this explicitly closes the circle that sees the global food system increasingly at the heart of political and economic as well as social considerations (Ericksen, 2008; Gibson, 2016). Furthermore, with on-going environmental concerns of water availability; pollution; energy use; land degradation and biodiversity among others, this ensures the continuation of a holistic concept that becomes increasingly difficult to separate from wider societal issues. In sum modern food chain systems are

TABLE 9.2 Food systems from traditional to industrialized.

Traditional systems	Intermediate systems	Industrialized systems
• Simple technological tools, customs and practices • Very labor-intensive • Traditional harvesting and basic storage techniques • Lack of proper integration with local markets • Growers do not particularly understand urban needs • Very limited access to international markets • Unstable prices • Poor market information	• Facilities co-exist alongside traditional systems such as refrigeration and storage • Produce quantity and quality varies • Local and export markets • Requires closer integration of the supply chain • Consumer demands, in distant markets not fully cohesive or understood	• Access to sophisticated technologies • Harvesting is highly mechanized • Food processing/manufacturing sector are more sophisticated • Medium- and large-scale farms are increasingly more prevalent • Quality and cosmetic produce increasingly demanded by consumers • Achieves many deadlines of quality, safety, and volume of retailers and consumers • High volume, low cost foods produce more wastage at both retailer and consumer levels

Based on observations from *Foresight, 2010. Expert Forum on Reduction of Food Waste, UK Embassies Science and Innovation Network and Foresight, London.*

unrecognizable from those of just 2 or 3 decades ago. Importantly too, while back then good governance was exercised evenly from one end the chain to the other, subsequent integration and concentration both vertically and horizontally is proving to be a meaty challenge. As a result, and as mentioned, this hitherto socially unregulated aspect of modern food culture is attracting increasing calls for public accountability in terms of fair play, good governance and open transparency.

9.2.2 Multi-disciplinary FSC's

While the above represents a typical FSC in its simplest form, in reality between the production and consumer stages there are many considerations of economics, politics, sociology, science and technology, health, agronomy entomology, pathology and others that must be deliberated (Gra, 1990). Consequently, within each of these stages there is a diverse and disparate collection of participants all with varying roles and motivations.

From this it can be seen the influences or the "pulls" and "pushes" along the food chain are numerous. Factors such as geography, population demographics, the structure and health of the financial sector, technology, the health of the economy, inward investment, the political environment, not to mention geographic benefits and limitations and climate change as well as consumers ever demanding requirements—all these factors collude to shape and determine the efficacy of all FSC's chains across countries and products (Minten et al., 2009).

As mentioned earlier, any changes along one part of the chain have a domino effect along the entire supply chain ultimately affecting both producers and consumers alike. Taking a small family farm producer for the moment, changes in trade policy might mean local wheat prices become too expensive compared to cheaper imports. If this situation continues for several seasons with no matching subsidies from the government or trade associations, then the producer will have to adapt either by dropping prices to compete (affecting income), or perhaps adapt by changing crops which would mean a complete new set of agricultural

inputs and associated costs. Moreover, increased or decreased labor, altered land management systems, extra investment in new technologies and a whole host of other considerations are dealt with for what may or may not turn out to be better or worse farmer incomes. This example reflects considerations at the individual level. In the wider picture, as has been mentioned another important driver of change in many developed economies is the trend of vertical integration that sees companies merging and buying up and down the chain. That is retailers buying processors, or farmers and manufacturers merging in alliances etc. This concentration of large parts of the chain has a profound effect on all other actors along the chain. The farming sector too, as has been mentioned earlier is also trending toward consolidation with increasingly larger farm sizes (Minten et al., 2009).

The trends and speed of change are different for different countries and regions.

9.2.2.1 Drivers of FSC change

As can be seen there are numerous components of a typical FSC from the wealth of individual's/countries; speed of growth; as well as the economic systems in operation (including transitional countries) among others. Add to these, however, social factors inter-alia the propensity toward globalization; urbanization; consumer preferences (i.e., more locally grown produce; changing dietary habits and more sustainable products etc. and the FSC ultimately becomes very complex with many competing and conflicting goals etc.

As for change, well it is not hard to see drivers of change in all supply chains are any one or combination of factors already described here and in the previous chapter. Yet, understanding such drivers in this context is paramount if policy and economic goals of food security, efficiency and wastage limitation are to stand any chance of success.

Placing all of this in context is incumbent on the big picture, so taking the global FSC as a whole the following chapter looks at the current food production capacity, usage and future needs.

9.3 Size of the global food sector

The food market is a difficult sector to pin down in terms of breadth and size. The reason being is that food is a confusing sector; it is many things—it traverses many industries, it is both a commodity and an ingredient, and of course a meal. As such quantifying the food industry is beset with difficulties as its value can be measured at every stage along the food chain (Murray, 2007). Take the output from the farm sector as an example, it is sold and processed and sold again—and potentially processed and sold again—each time adding value. Then there is the different categorization of foods—primary, processed, animal-human-biofuel uses, and these are just a few examples. On top of this there are also the huge amounts of food being bought and sold informally, on the gray and black markets, in fact, all in all the potential for miscalculation, double counting and omission is great. Yet despite these challenges for this book we have used the raw production values of 2009 to serve as an example because the full spectrum of figures are readily available. Using this data, it can be seen that the global industry was valued or estimated to be worth in the region of USD 4.8 trillion annually (UNEP, 2012). While, with growth rates of about 4.4% annually between 2009 and 14, the food industry result in a global market worth in excess of USD5.3 trillion annually (Murray, 2007; Alpen Capital, 2011). This growth was

largely underpinned by continued rises in per capita income (next section), especially in emerging markets, which was expanding faster than the developed world (Murray, 2007; Alpen Capital, 2011).

9.3.1 Global food production

Of the 8.9 billion tons produced in 2009, stripping out food grown for alcoholic beverages this left 8.6 billion tons, from which when we factor in imports, exports and stock holding variations we arrive at 8.5 billion tons. Now set aside food produced for seed, for animal feed and industrial uses such as biofuels or the pharma industries and the like, we are left with approximately 4.2 billion tons (excluding alcoholic beverages)—less than half of what we originally started with. This is the average food produced annually for human consumption. Table 9.3 shows these figures in a little more detail.

TABLE 9.3 Global food production commodities by Volume (2009) (million tons).

Item	M. Tons
Cereals, excluding beer	2251
Sugar crops	1890
Vegetables	1008
Starchy roots	720
Milk, excluding butter	697
Fruits, excluding wine	593
Oil crops	490
Alcoholic beverages	310
Meat	285
Sugar and sweeteners	189
Vegetable oils	144
Fish, seafood	143
Eggs	68
Pulses	63
Animal fats	35
Offal's	17
Stimulants	17
Treenuts	14
Spices	7.5
Total	8945

Based on FAO's database - FAOSTAT, 2013. Food and Agriculture Statistics, Food and Agriculture Organisation.

A little more detail helps with perspective here. By re-arranging the above table, we can better visualize the main components we produce in order of volume as classified by similar commodity groups.

It can be seen too from that by far the biggest food commodity produced was cereal grains at between 2.2 and fast approaching 2.4 billion tons annually. This growth was pretty much universal although perhaps Africa and Latin America trailed the rest of the world in actual volumes.

When it comes to meat and, as mentioned previously, of the global total production in 2009 of about 285 million tons. We consume about 210 million cattle, 418 million sheep or goats, 1.1 billion pigs and 55 billion chickens annually—or about 40 kg per person per year (approx. 10, 2, 15 and 13 kg of beef, lamb, pork and poultry respectively). Production wise, breaking this figure down regionally we learn from FAOSTAT that predominant livestock in South and Southeast Asia mainly comprises pig (7 million ton) and chicken (9 million ton). In Europe pig production was dominant at approx. 27 million tons while in North America and Oceania it was more diversified with chicken (18 million ton), cattle (16 million ton) and pig (12 million ton). In Latin America, meat production was largely dominated by cattle (around 15 million ton) and chicken (around 17 million tons) while lastly, in both sub-Saharan Africa and the North African, Western and Central Asian regions it was mostly chicken (around four million tons each).

The fish and seafood production industry as a whole cannot be underestimated—indeed it reportedly supports the livelihoods and incomes of an estimated 540 million people—or about 8% of the world's population (FAO, 2012; UNEP, 2012). We can also see from the FAO statistics of 2011 there was an estimated 154 million tons available (a little increase on the 142 million tons of 2009) of which 80%–85% or 131 million tons was available for human consumption[1] (FAO, 2010b; FAO, 2012; FAO, 2013a; FAO, 2013b). Total production comprise about 90 million tons of captured seafood and 64 million tons of aquaculture giving a total per capita food fish supply of about 18.8 kg. On top of this there is also the aquatic plants component made up of 89 1000 tons of capture and 19 million tons of aquaculture for a total of about 20 million tons (FAO, 2013b).

China remains by far the largest fish-producing country with production of 52 million tons in 2010 (37 and 16 million tons from aquaculture and capture fisheries, respectively) with India being the next largest producer at just over nine million tons (FAO, 2012).

This means, looking at the figure almost as much fish, seafood and aquatic plants were supplied through farming (aquaculture) as was captured from the sea. Yet this is not the whole picture for while aquaculture or aqua-farming is indeed a growth industry it is not the overarching panacea to the problem of a declining fisheries industry that many had hoped for. The reason is simple—aquaculture, although it implies the farming of fish independent of the marine and freshwater ecosystems the truth is that for every 1 kg of farmed fish we produce we still require a significant amount of caught fish to feed them. In this regard therefore, in order to maintain current per capita fish consumption levels to 2050 it will require approximately 56% growth in the aquaculture industry. In turn this would require

[1]Based on extrapolated trends from FAO yearly statistics in the "Disposition of world fishery production" report 2009 FAO (2013b). "Yearbook of Fishery Statistics Summary tables." Retrieved 5 Jan 2019, 2019, from http://www.fao.org//fishery/publications/yearbooks/en.

about 23% increased fish landings as feed to support this production and any further collapse in marine ecosystems would consequently have a major detrimental effect on future production sustainability not to mention prices (Gustavsson et al., 2012).

9.3.2 Current food usage

As we have already highlighted, we utilize less than half of the food we grow, catch or rear for human consumption. The following highlights some of the key food usage statistics:

- Total food supply, approximately 8.9 billion tons
- Feed 1.133 billion tons
- Seed 142 million tons
- Processing 2.426 billion tons
- Other Utilization 743 million tons
- Food 4.2 billion tons (excluding alcoholic beverages)

Factoring in these deductions we can calculate that which is left for human consumption equates to about 1.8 kg of food or approximately 2828 kcal for every person on the planet every day. One of the important concerns relates to the way we utilize our food especially when we are dealing with the efficient and equitable allocation of this precious resource. One of the key considerations relates to the competition our food resources face from other uses such as animal feed or those used as industrial substrates (inputs) such as in the biofuel and pharma industries (UNEP, 2012). Indeed, many argue that such competition only adds to food insecurity around the world and suggest alternative uses other than food inputs in such industries bringing about a more equitable sharing of the food supply. The argument, however, is never that simple.

So, going back to the equitable use of the food supply, we can examine just how the levels of global food production are translated into nutritional status of individuals around the world. This can be seen in the prevalence of over and undernutrition, or more overarchingly malnutrition.

9.4 Employment in agriculture

According to the International Labor Organization (ILO) in 2011 about 1billion people around the world were employed in the agricultural sector. This represents about 35% (36.2% women, 32.8% men) of the total employed global workforce and the second greatest source of employment after services (43.8%)—with the industrial sector trailing at about 22.1%. In many countries too, the agricultural sector is also the most important sector for female employment especially in Africa and Asia (ILO, 2012). illustrates the global workforce by region in terms of gender and industry (ILO, 2012).

Taken together these figures while representative of total employment and considering global working population in 2008 was in the region of three billion (male 1.8 billion, women 1.2 billion), seen in isolation these figures can be somewhat confusing. The following graph combines this data and presents the figures as a proportion of the three billion globally employed.

Furthermore, the trend for employment in agriculture is a downwards one and one set to continue. As the literature highlights, of interest is that over the 10 years to 2008 in every

region in the world without exception agricultural employment numbers have been on this marked downward trend. The 10-year trend also shows the rapid rises in the industrial and service sectors in almost all regions.

In the past the role of women in agriculture has not generally received broad-based recognition. However, trends in globalization and more acknowledgment of the valuable contribution that women play in both industry and the service sectors are redefining the relationships of women in economic and rural development paradigms (Hall, 1998). Sadly though, while progress is being made it has been a little slow and women continue to be plagued by low incomes and limited access to things like education, health care and equitable access to land and natural resources.

When it comes to food and improvements vis-à-vis employment in agriculture, the food sector and general food security—a strong case has been made regarding the combined importance of education and employment. Education it seems is at the heart of many attempts to improve human development although an important barrier to adult education remains the relatively high illiteracy rate (Mukudi, 2003).

9.4.1 Education and employment

Over the last few decades there have been great improvements in global literacy. However, in 2016 although high on the development agenda, literacy shows that 750 million adults (of which two-thirds are women) still lack basic skills in reading and writing. Accordingly, the latest data for 2016 tells us that 102 million of the illiterate population were between the ages of 15- and 24-year olds. Conversely, the global adult (25+) literacy rate was in the region of 86% in 2016, while the youth literacy rate was 91%. Once again gender disparity is an important consideration within these figures and it could be seen that in Southern Asia 73% of men compared to just 51% of women could adequately read and write resulting in a gender parity index of just 0.70. As a consequence, general low levels of education combined with high levels of illiteracy can drastically hinder the economic development of individual's and their countries (Gibson, 2016). It also has an important bearing too on the nutritional status of children as parental education has been found to be an influential factor in theirs and their children's nutritional status, so much so in-fact that children of illiterate parents are consistently seen to score more poorly on nutritional status indices (Mukudi, 2003).

The rationale for this is widely agreed, the better educated a person is, the more empowered they are with improved social skill sets which might also help in which more reasoned choices can be made regarding nutrition and health and of course in other social ancillary costs of food such as wastage and the environment (Dollahite et al., 2003; Rosegrant and Cline, 2003; CFS, 2007).

9.5 Commercial control over the supply chain

Everyone is involved in food; from production to processing to retail to consumption, everyone is affected. Yet increasingly of concern within the Food Supply Chain (FSC) dynamic are the fundamental relationships along the chain from farmer to consumer. This becomes especially important as the trend toward a more integrated global food chain

increasingly sees fewer and fewer Small to Medium Enterprises (SMEs) in favor of a small band of large multi- or transnational corporations concentrating the lion's share of the market. A lot has been written about corporate power, even the United Nations Food and Agriculture Organization acknowledges that large transnational corporations have come to increasingly dominate world agricultural commodity markets (FAO, 2004; Mousseau, 2005). This allows such enterprises to wield direct and increasing influence on what is produced and distributed. Put in perspective, the top 500 businesses by market value in 2010 included in their ranks—23 food producers or retailers; 20 biotechnology companies; and 13 oil and gas giants. The top four food companies were: Wal-Mart-US, Nestle-Switzerland, Unilever-Netherlands/UK and Tesco-UK with a combined market value of $533.2 billion and a turnover in 2010 $637.1 billion with Wal-Mart alone accounting for $405 billion of this. Interestingly while Wal-Mart was only seventh in the rankings by market value it had by far the biggest turnover during that year, beating its nearest rival, the oil giant Exxon Mobil by over $100 billion. In-fact, so great are the food giants' economic power that in turnover alone the big four: Wal-Mart, Nestle, Unilever and Tesco's individual 2010 turnovers each out-earned the 2009 Gross Domestic Product (GDP) earnings of 171, 137, 127 and 133 countries respectively (Table 9.4). In-fact the combined turnover of the 23 top food companies of that year almost equaled that of the Russian Federation earnings of 2009 (Financial Times, 2010; World Bank, 2010).

From another perspective we can see that the top five corporations' share of the global food processing sector represents 18% of the entire global market. Adding in the next five companies and this figure rises to 28% (Mulle and Ruppanner, 2010).

Bringing these figures up to date (2017), according to Forbes one can see the top five food and beverage companies by market value are many of the same as in previous years:

1. Nestle—headquarters: Switzerland, market value $229.5 billion
2. PepsiCo—headquarters: US, market value: $159.4 billion
3. Coca-Cola—headquarters: US, market value: $182.9 billion

TABLE 9.4 Top corporations' share of the global food processing market 2009.

Share of the global market	%
Nestlé (Switzerland)	26
PepsiCo Inc. (USA)	12
Kraft foods (USA)	12
The Coca-Cola company (USA)	9
Tyson foods (USA)	8
Mars (USA)	7
Archer Daniels Midland company (USA)	7
Cargill (USA)	7
Danone (France)	6
Unilever (The Netherlands)	6

Inspired by Mulle, E.D., Ruppanner, V., 2010. Exploring the Global Food Supply Chain Markets, Companies, Systems. THREAD Backgrounder No 2, May 2010. V. Ruppanner. Online, 3D: 35.

4. Kraft Heinz Company—headquarters: US, market value: $110.4 billion
5. Anheuser-Busch InBev—headquarters: Belgium, market value: $213.1 billion

Such concentrations in the food retail sector can have negative consequences on the supply chain too. It has been noted that with the likes of Wal-Mart for instance, the sheer size of the company threatens market competition. Indeed, with over $400 billion in annual sales, the company is able to impose strict rules on quality control and enforce its own price targets on suppliers. Such is the bargaining position of these corporations that consumers can continue to pay relatively higher prices for goods on the shelf as retailers force price reductions on farmers and suppliers simultaneously threatening revenues of smaller individuals and companies further along the supply chain (Mulle and Ruppanner, 2010). Moreover, it has also been said that in pursuit of profit, larger corporation's practices also tend to reduce wages and working standards—although to be fair this is not confined to multinational agri-food retail businesses either. Such practices do not significantly differ by sector; however, one thing that is different is that other sectors by comparison rarely share the same inelastic captive markets. Furthermore, while globalization of trade opens up opportunities for agricultural exports it represents a clear potential threat in the development of internal markets through displaced competition—the cheap imports of commodities of a higher quality than can be found locally (Parfitt J, Barthel M et al., 2010).

Further elaborating on the charge that corporate profits are made all too often at the expense of the primary producers is the example of the genetics industry and the growing proclivity of biologically based intellectual property rights (IPR) ownership. Combined, genetic engineering and IPR's are charged with promoting monopolistic privilege over material that many believe should be common property. Effectively what is happening is the growing trend for proprietary ownership of seed and livestock at the genetic level thus ensuring farmers' continuing servitude. Interestingly in this point Windfuhr and Jonsén observe that:

> Whereas more than 90% of genetic resources for food and agriculture are from biotopes in the South, corporations in developed countries claim 98% of the patents on genes and living organisms. ***Windfuhr and Jonsén (2005)***.

Furthermore, IPR's are also said to be an obstacle of technological transfer too—a barrier of common social development. This is especially so if you factor in the reality that many developing countries often lack the sophisticated patenting infrastructure enjoyed by many industrialized countries.

This is just one example and there are many more along the full length of the food chain. In fact, as more of our food is being innovated, transacted, processed and retailed by an ever-decreasing number of transnational or multinational companies, so many are beginning to question the sustainability of continuing trends. In this sense, one observer, Olivier De Schutter, the UN's special rapporteur on the right to food, at the 17th Session of the UN Commission on Sustainable Development commented:

> Trade is mostly done not between States but between transnational corporations … The expansion of global supply chains only shall work in favor of human development if this does not pressure States to lower their social and environment standards in order to become 'competitive States', attractive to foreign investors and buyers." ***CSD (2009)***.

As a result, there has been an increasingly vocal backlash against what is seen as the commodification of the food chain. At the heart of the argument is the fundamental dichotomy inherent in both food-as-profit and food-as-a-right ideologies (Actionaid, 2010; La Via Campesina, 2011). The argument unfolds like this, while corporations are small to medium-sized, the many and varied stakeholders enable a more equitable division of power between producers, processors, retailers and finally consumers—and consequently, any benefits received are more evenly shared. By contrast, as the concentration of the agri-business sector (both in traditional horizontal[2] and vertical[3] integration strategies) sees the democratic free market being replaced by a de facto oligopoly.[4] From this point it does not take an economic mastermind to understand that a market concentrated with fewer companies effectively increases a company's economic power base. This argument incidentally, also underpins many anti-globalization and anti-capitalist movements; moreover, the juxtaposition of the two arguments is increasingly being polarized. That is to say, on the one side, as relentless capitalist economies demand ever growing profits, so companies respond with increasing innovation, ingenuity and novelty—further consolidating and concentrating their competitive advantage. On the other hand, traditionalists and anti-capitalist movements dismiss what some see as "progress" out-of-hand descending instead on G8 Summits and the like.

9.6 Food price volatility

One disturbing trend over the past few years has been the increased frequency of wild fluctuations in basic food commodity prices. As a result, in 2007/8 alone, it had been estimated that increased prices pushed a whopping 200 million people (or 133 or 115 million) depending on who you read into food poverty (SOFI, 2008; World Vision, 2019; GFMG, 2010).

This escalation in volatility has been attributed to many causes, not least of which is a direct consequence of globalization—or more precisely, a flawed global development model based on competition, self-interest and speculation. Others speculate that the rapid expansion of the developing economies, especially BRIC countries (Brazil, Russia, India and China) coupled with a growing change in dietary habits as being one important root cause. Others still cite increased general demand owing to increased wealth coupled with higher fuel costs (Shah, 2007; Watts, 2007; FAO, 2008; Smith and Edwards, 2008).

Indeed, regarding this last point, it serves to highlight the fact that there is an apparent strong correlation between cereal grains and oil prices. It is not the first time this has been suggested either with some even suggesting that were this convergence to continue in the same vein then the possibility of oil prices acting as a de-facto agricultural price index is certainly conceivable (von Braun, 1995; Schmidhuber, 2003; Brown, 2008; SOFI, 2008).

[2]Horizontal integration - is a microeconomic principle that sees expansion of the firms at the same level in the value chain as in retailers buying up other retailers.

[3]Vertical integration - is a microeconomic principle that sees expansion of the firms into other areas of the supply chain as in retailers buying up or merging with food processing industries or investing in primary producing activities.

[4]It takes approximately 6.5–7 kg of wheat grain to produce 1 kg of beef.

Notes: indices set at 2005 = 100.

In reality, however, price fluctuations that were seen over recent years was the result of a combination of factors beginning with a drought in Australian—the worst for a century, which halved farmer's wheat production volumes in 2007. Then there was the weight of increased demand from such growth markets as mentioned earlier (BRIC countries etc.) in which individuals are trending toward more meat-based diets.[4] Couple this with the fact that biofuel[5] production was seen at that time as something of a benevolent industry[6] and as oil prices spiked reaching $60 a barrel, so biofuels become much more competitive, further incentivizing the diversion of crops away from food. Moreover, consideration too needs to be made of a relatively new phenomenon of food commodity speculation. A phenomenon cited to be just as responsible for artificially inflating food commodity prices as these other drivers and one which, according to Frederick Kaufman (of Harper's Magazine) is unconscionable (Phillips, 2008; Vallely, 2009; Kaufman, 2010).

Ultimately the confluence of these four factors: shortages, increased demand, speculation, and competition from nonfood industries provided almost unprecedented volatility within the commodity markets (OECD-FAO, 2007; Shah, 2007; FAO, 2008; UNEP, 2012).

There are many widely accepted consequences too of these erratic movements in price. On a very basic level the demand for food is price inelastic, that is to say—overall, the quantity of food people require or consume varies little with changes in prices (Lee, 1993; UOVS, 2008). That said, people still exercise food choices; in poorer low-income countries for instance, people are very responsive to price and as prices rise so they may end up reducing demand for meat, dairy and vegetable products and increasing staples like bread and cereals. More affluent countries are not immune either and equally, rising prices too might force some to substitute cheaper food in place of expensive items rather than reducing the quantity consumed. However, while both communities suffer, it is generally agreed that it will the poorer sections of the community that will suffer the most in such situations. A worrying statistic in developing countries which places this notion in perspective was made by Regmi in 2001 when he suggested that for every 1% increase in food prices, food consumption expenditure decreased by about 0.75% and caloric intake reduced by 0.5% (Regmi, Deepak et al., 2001; Brown, 2008).

Not surprisingly then, frustration at rising food prices over the last two decades and more recently also translated into social unrest. For example, there were tortilla demonstrations in Mexico, pasta protests in Italy, maize disputes in Kenya, and even food riots in some areas, these were just a few of the many issues around the world which eventually led some governments to intervene (Lee, 1993; von Braun, 1995; King and Elliott, 1996; Regmi, Deepak et al., 2001; Eifert et al., 2002; Watts, 2007; BBC, 2008; Brown, 2008; Delva, 2008; UOVS, 2008; Clapp, 2009; FAO, 2009b, SOFI, 2018). Some of these interventions included the removal

[5]Biofuels are made from corn, sugar-cane/beet and/or cassava among others, crops are converted into ethanol as a greener alternative to fossil fuels. The industry is vast, led in spirit by Brazil. In 2007/8 the Committee for Food Security (CFS) estimated that the biofuel industry utilized a whopping 4.7% of annual cereal production in the production of alternative fuels sources CFS (2008). Agenda Item II: Assessment of the World Food Security and Nutrition Situation. Committee On World Food Security: 34th Session, Rome, Food and Agriculture Organization.

[6]*The US, in a bid to reduce reliability on oil exporting countries increased the use of corn and other crops in the production of ethanol and bio-diesel, however, rather than importing these crops the US attempted to be self-sufficient and diverted approximately a third of its corn crop for biofuel production.*

of quotas and tariffs on imports; the banning or introduction of export duties; buying food at preferential rates; increasing grain stockpiling and the increasing of food subsidy interventions—all in an effort to control the prices of certain basic food staples. However, it was recognized that this was largely a short-term fix and one which was not sustainable in the longer term (Vidal, 2007; SOFI, 2008; Dupont and Thirlwell, 2009).

However, while such inflationary pressures are on course to increase it must be noted that high food commodity prices in and of itself, is not necessarily a bad thing. There are inherent winners and losers in food price increases—higher prices, for instance, are good for sellers or farmers who are net sellers of food. This can have a trickle-down effect too, translating into increased agricultural employment, better wages and potentially increased agricultural investment (SOFI, 2008).

9.7 Current global food situation: production, usage and needs: food balance sheets

The food balance sheets (FBS) illustrate the structure of a country's food supply during a specified reference period. They were first introduced during the First World War, used extensively after the war and were improved by the Second World War. By the inception of the United Nation's Food and Agriculture Organization great emphasis was placed on both the preparation and utilization of the FBS. Since then the food balance sheets have been prepared and published by FAO on a regular basis. The use of this data allows governments, organizations and individuals to analyses trends over time in the overall national food supply and to determine whether supply, as a whole, is sufficient in relation to its nutritional requirements. Moreover, this data can also be used to determine changes in production and consumption patterns of its population, better enabling good stewardship and governance in matters of food policy (FAO, 2002).

Specifically, the FBS disseminates data on both supply and utilization of each food item.[7] In detail the FBS comprises data on: production; imports and exports; that used for feed and seed; some wastage figures; and other utilization data to arrive at total food supply figures for human consumption (FAO, 2002).

Production and Trade: Production and trade data are usually part of regular national official statistical analysis within most countries and are either based on direct survey's and enquiries or in its absence, estimated by Government bodies or agencies. Any changes in stock holdings are derived from information from any combination of marketing authorities, factories or farmer stock surveys. With regard to trade statistics, these data usually obtained from industrial and manufacturing censuses or surveys and these figures can be used for instance, as an indication of a country's dependency on its imports (import dependency ratio) to feed itself among other things.

Feed and Seed: The FBS collects data on that part of total food production that is used for animal feed and for future seeding. These figures are generally obtained from cost of production surveys or can be estimated by the relevant government bodies and agencies concerned.

[7]Food items consist of a basket of primary and a number of processed commodities which are potentially available for human consumption.

Once again both indices can be used to garnish a picture of the degree to which primary food resources are used in the production of both seed and animal feed.

Processing and other utilization: As we shall see in later sections not all food that is grown is used for food. Other industries such as the biofuel, pharma industries vie for the same finite resources and as such valuable data on nonfood uses are collected from industrial or manufacturing censuses and surveys.

Stock changes and waste: Stock changes are calculations which aim to reflect actual changes in what is produced, what has been imported/exported as well as that part of a country's stock holdings which has been utilized or added to. Wastage covers are estimates, themselves are often based on assumptions are based on expert opinion obtained in a country:

Supply: What is left after the above is taken into consideration is total proportion of food remaining for human consumption. This is an important data stream for analyzing trends in food demand and consumption expenditure as well as things like income elasticity coefficients etc (FAO, 2002). This data is often represented in several forms either as total volumetric production figures in tons or in terms of per capita supply as in kg, grams or calorie equivalents per capita per.

The proceeding sections look at what and how all the food that is produced year on year is utilized. Yet before any of this can be discussed it is incumbent to understand something of the difficulties inherent in statistics such as these and those described above.

9.8 Nutritional status: over- and undernutrition

According to both the UN Standing Committee on Nutrition (SCN) and the World Health Organization (WHO) and others, malnutrition today is one of the most striking public health problems and a major contributor to the total annual global disease burden (DFID, 2009; WHO/EMRO, 2010; WFP, 2019).

Malnutrition by itself refers to the overarching problems of "mal" or bad-nutrition; in other words, it describes all deviations from adequate or optimal nutritional status. This is an all-encompassing definition which includes not only deficiencies as is common but also inappropriate nutritional combinations too. Moreover, this view of malnutrition also incorporates poor nutrient absorption and/or the poor biological uptake of nutrients (bioavailability[8]) and lastly, as is becoming increasingly common, the excessive intake of nutrients too (Thomas, 2007; DFID, 2009).

Undernourishment/undernutrition results from the insufficient intake or the inadequate utilization of ingested nutrients (Shetty, 2006; Thomas, 2007; DFID, 2009). Historically, this was associated with overall caloric or energy intake, but strictly speaking it can and does include insufficient micronutrient intake too. This is because when calories are deficient,

[8]Bioavailability is the availability, irrespective of the quantity consumed, of useable nutrients to the body. That is, not all ingested nutrients are necessarily available or properly metabolized owing to perhaps such barriers as infection and disease Shetty (2002). Measurement and Assessment of Food Deprivation and Undernutrition: Keynote Paper: Measures of nutritional status from anthropometric survey data. International Scientific Symposium, Rome.

the likelihood is that micronutrients (vitamins and minerals) are also likely to be deficient too (Thomas, 2007).

Overnutrition—whether overweight or obesity on the other hand, are far from being the once labeled "diseases of affluence." Instead both are becoming increasingly prevalent in developing countries (Cleaver et al., 2006; WHO, 2010). Sweeping dietary changes at the global level see largely hitherto plant-based diets being quickly replaced by energy-dense, high-fat, high-sugar processed diets (Muller and Jahn, 2009; WHO, 2010). The health implications of over eating are also in turn being further compounded by physical inactivity as the propensity for more sedentary lifestyle is becoming the norm in both developing and developed regions alike. In fact, so prevalent is the problem that the World Health fully expect to see chronic disease such as Cardiovascular Diseases (CVD) (heart disease, hypertension, stroke) and its attendant comorbidities such as diabetes to be the leading cause of death in all developing countries in the very near future (WHO, 2010).

However, for the full picture, irrespective of whether under- or overnutrition malnutrition can be thought of, broadly speaking, as taking two forms—chronic and acute (Cleaver et al., 2006).

9.8.1 Chronic

In cases of chronic malnutrition usually occurs in prolonged or protracted crisis where people continually fall short of adequate and/or appropriate nutritional intake. Without regular or sufficient key vitamins such as iron, zinc, vitamin A, and iodine individuals, especially children, development is severely hindered. For this reason, chronic malnutrition is often seen to result in stunting (short stature for age), and it is this form of malnutrition that is ultimately responsible for most of the hunger-related deaths every year (USAID, 2007; World Vision, 2019). In addition, as chronic undernutrition occurs in children early in life (between 6 and 24 months) this particularly affects their mental development as well as their physical ability to cope with similar circumstances when adults, making them more vulnerable to chronic illnesses throughout the course of their lives (Checchi et al., 2007; USAID, 2007).

9.8.2 Acute

Acute malnutrition by contrast is often brought on quickly and not always with sufficient warning. Sudden food shortages whether from poor harvests or conflict mean that food, perhaps once freely available is no longer obtainable in significant amounts. This can manifest in rapid weight loss and is often associated with wasting (thin stature for height). Because of the sudden nature of acute malnutrition, as opposed to chronic or slow-onset malnutrition, acute malnutrition generally has a more immediate and profound effect on an individual's immune system. This is particularly so in children under-5. As a result, there is a strong correlation between acute malnutrition and mortality and in such emergencies, it is the acutely malnourished therefore who are to mostly dealt with first (Checchi et al., 2007; USAID, 2007; World Vision, 2019).

However, in terms of equitable food distribution there is more focus on undernutrition than there is with overnutrition. This is simply because the focal point of the social lens

over the last few years has been firmly focused on issues of food security, and while there are no extant measures of food insecurity—undernourishment or measures of underweight serves as effective proxies.

One of the most widely used measures of undernourishment is the FAO's "Prevalence of Undernourishment" figures. It is calculated on the basis of three parameters: average food consumption (availability); inequality of access; and the minimum calorie requirement for a "typical" average person weighted by the population demographic (MDG, 2010) highlights the regional prevalence of undernourishment as of 2010/12. In this year there were an estimated 868 million undernourished people in the world—or about 12.5% of the population. It must be said too that although these figures were way down on 2009 figures of 1.02 billion, the downturn has been attributed more to improved economic conditions than any great progress in hunger alleviation policies (FAO, 2010a). Despite this caveat this figure of 868 million people is still large by any standards (CIA Factbook, 2010; FAO, 2010a; SOFI, 2012).

As for trends over time, it would seem that little progress has been made over the last 40 years or so suggestive, even by FAO's understanding:

> … that present solutions are insufficient … ***SOFI (2009)***.

On the face of it, it can be seen that in the 3 decades to the late 1990's there was a slow but definite decline in both absolute numbers as well as in the prevalence or percentage of globally undernourished people in the world. Over the last 10 years or so, however, this trend seems to be reversing with prevalence of undernourishment figures over the last 5 years or so hovering at a low double digit percentage of the total world population (CFS, 2008; SOFI, 2008; FAO, 2009a; SOFI, 2009; WFP, 2019).

While this gives an overall trend, such figures do little to pinpoint regional trends. Much literature attests to the fact that food insecurity is predominantly a phenomenon of lesser developed countries. And so it is that while these developing countries account for approximately 70% of global population—19% of their numbers are considered to be suffering from undernutrition (SOFI, 2009). Furthermore, year on year the developing world continue to collectively represent in excess of 95% of the global prevalence of undernutrition numbers.

On a positive note and for the sake of the big picture if we look at the figures from another perspective, we can see that today's 19% is actually way down on the near 35% figures of 1969. In-fact the intervening period has witnessed some great gains. Take for instance, the near 35% figure of the developing world during the 1969−71 period and project that figure on 2010's population figures—this would, (based on a population of 5.67 for the region) represent undernourished figures of nearly 1.99 billion (DESA/POP, 2010). Compare these to actual figures of 852 million for the region (2010/12 figure's) and the reduction of well over one billion undernourished and progress can definitely be seen (SOFI, 2012).

Yet even this does not adequately portray the full picture of regional trends. For that we can combine the previous two figures into a picture that represents both the numbers and prevalence (or percentage of populations) of undernourishment of individual regions. In doing so the following uses the fully disaggregated regional figures from the rolling period 2010−−12 (FAO, 2011).

As can be noted from the literature one can see the full grim reality of regional inequalities. Of the total 815 million undernourished, the vast majority were seen to come from the

developing countries. Notably, most of these numbers comprised Asia and sub-Saharan Africa, representing the bulk of undernourished people in the region. Further, from these figures it can be seen that within the sub-Saharan African region, Ethiopia is the worst affected followed by Kenya Sudan, Nigeria and Tanzania. In Asia too, widespread undernourishment was found in Southern Asia India followed by Pakistan and Bangladesh while in East Asia, China. In South-eastern Asia the story continues with Indonesia and Philippines respectively. In the America's, particularly in Latin America the worst affected are Brazil and Columbia; while in Haiti in the Caribbean people were also underfed.

Note: The FAO are not the sole publishers of undernourishment metrics—both the United States Department of Agriculture's Economic Research Service (USDA/ERS) as well as the World Health Organization (WHO) also collect and collate indices of nourishment. In the case of the ERS their indices differ from the FAO in two main areas; firstly, the ERS use a different methodology relying on a universal cut-off point of 2100 kcals per person to determine undernourishment; and secondly the data is restricted to 70 developing countries. The WHO by contrast concentrate on anthropometric indices of both adults using a measure of body mass index (BMI) and in children under five using three measures namely: a low height-for-age—**stunting** metric; a low weight-for-height—**wasting** metric; and a low weight-for-age—**underweight** metric. Moreover, unlike the measures of other institutions which are subject to complex statistical manipulation, the WHO's figures are largely unadulterated.

9.9 Sufficient food

It can be seen clearly from the above statistics that the vast majority of malnutrition fall in the regions of Africa, Asia the Caribbean and parts of South America. This inequality is not a recent phenomenon and marks a longtime trend spanning decades if not centuries. This regional inequality in availability and food consumption patterns is further reflected in the food security status of these regions. Indeed with many underdeveloped countries receiving a less than equal share of world food availability it is perhaps not surprising that perceived worldwide food shortages continue to persist (Charles, 2008; Sachs, 2008).

The reality, however is very different and there is not, nor have there been for many years now, global food shortages; in fact, the opposite is true. This is evidenced in which shows clearly that the global food supply continues to provide an adequate diet consisting of over 2800 kcals for every single man, woman and child on the planet (SOFI, 2012).

Put simply, thanks in no small part to the green revolution, global food production continues to produce enough food for the entire world population. From this it can be seen that while food shortages, hunger and starvation are still prevalent in many regions of the world, insufficient food production is not the cause (DeRose et al., 1998; Freedom 21, 2008). This state of affairs serves to highlight a fundamental and underlying truth that while there is no global food shortage as such, there does in-fact exist vast regional disparities in availability, access, and ultimately consumption patterns.

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