CHAPTER

10

Global food waste

OUTLINE

Most people would not deny that food wastage is a problem; it is also in direct conflict with the fundamentals of good housekeeping and compromises the integrity of the notion of sustainable living. Interestingly too, in large part from the perspective of societal or social responsibility, food issues till now have often been framed within contexts of food and human rights; of food security; food safety; health, and nutrition; and of animal welfare among others. Of course, on occasion, when these issues are broadened, they might further include employment matters, fair trade/fair wages, sustainability, and natural resource limitations.

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Coming late to the party, however, are issues of food waste; albeit part of the broader spectrums of natural resources and sustainability, till now the role of food waste has generally been that of an endnote—a side line. The good news though is this is changing. Thankfully, more and more people are beginning to get the message that all the world's people, without exception, have to be supported, clothed, housed, and fed solely from the earth's finite natural resources (EC, 2011a,b).

Broken down, the essence of the issue is the fact that a shamefully large part of food is wasted compared with what is being produced. Indeed, food waste, which also has other political, economic, environmental, and social implications, is of increasing public concern worldwide. In the *political* arena, issues of governance and responsibility are at the forefront of the problem; waste-less targets for instance have to be met and regulation, policy and change have all to be addressed. In *economic* terms, food waste is wasted money; money lost to the consumers, to the suppliers, lost in the upkeep and maintenance of landfill sites and other associated expenses of waste management such as transport and operational costs, etc (Monier et al., 2010). The *environmental* costs of wasted food too, produced at different stages of the food supply chain (production, transport, manufacturing, distribution and consumption) must also be well-thought-out. Considering the food sector represents a significant impact on Global Warming Potential (GWP) (a tool used to compare the global warming impacts of different gases.) (Pachauri and Meyer, 2014). So it can be seen that there are considerable environmental impacts from wasted food within the food sector itself (Monier et al., 2010). Wasting food also raises many uncomfortable *social* questions. Given the fact that there are approximately 815 million (a staggering 10.7% of the population) undernourished people around the world; add this to the fact that obesity is a fast growing global problem affecting 1.9 billion people (WHO, 2018), and furthermore, given the fact that every year approximately nine million people die of hunger and hunger-related diseases (MercyCorps, 2018) while current food production is sufficient to feed the world's entire population; in that context and taking into account periodic financial crisis and rising food prices - the fact that estimates put global wastage quantities at between 30% and 50% of production (depends on who one reads - see below). Consequently, some believe that food waste must be seen for the shameful scourge it surely is—simply criminal!

Of the total world food production, approximately four billion tons per year, food waste occurs at every level of the food supply chain from agricultural production through to the point of consumption. Whether from unavoidable losses of weather and pests through to avoidable waste from poor practices, food waste is composed of raw and cooked foods such as vegetable peelings, meat trimmings, bones, carcasses and organs as well as food which is simply out of date or spoiled or that which is simply left on our plate after we have eaten (Europa, 2012; IMechE, 2013b).

A few years ago, an important, albeit under-publicized report, was authored by Gustavsson, Cederberg and Sonesson of the Swedish Institute for Food and Biotechnology (SIK) on the problem of food wastage. It was written for the International Congress "SAVE FOOD!" in Düsseldorf, Germany in 2011 and highlighted the sheer volume of lost or wasted food that occurs every year on a global scale (Gustavsson et al., 2012). The report, compiled at the behest of both the Food and Agriculture Organization of the United Nations (FAO) and Interpack 2011, was a brief summary based on considerable evidence. While estimates of global losses vary considerably, in this report the major finding suggested that annually,

roughly one-third of all global food produced for human consumption was lost or wasted. The reports' estimates, amounted to a whopping 1.3 billion tons (approximately) of food per year. By contrast another report published by the Institution of Mechanical Engineers in January 2013 suggested a little more waste than this—in fact as much as between 30% and 50%, or between 1.2 and 2bn tons (IMechE, 2013a,b). Indeed, other estimates from reports around the world suggest food waste ranges from between one quarter to one third to 50 percent, depending on who one reads (Stuart, 2009; Parfitt et al., 2010; Parfitt and Barthel, 2010; Gustavsson et al., 2012; Kummu et al., 2012). Despite these wildly varying figures the one unavoidable truth is the fact that they are all excessively high. Another common finding too is that in low-income countries, much food is wasted mostly at the early to middle stages of the food supply chain; while among the medium- and high-income countries food was largely wasted at the consumption stage (Gustavsson et al., 2012).

10.1 Food waste: historical perspectives

Food waste was not always the side issue it has become over the last few decades. In the 18th century for example, Robert Heron writing for the Board of Agriculture in 1794 commented on the wasteful mill practices within the Isles of Great Britain and suggested change for the sake of progress (Heron 1794). In another example in a 19th article in the Popular Science magazine, Frederic Mather (1894) talks of the potential for waste to sustain mankind:

> It has been stated that if the waste products of the world had been saved they would sustain the present population for more than a hundred years. ***Mather (1894)***.

Furthermore, citing the benefits of converting waste products into tradable commodities Frederic Mather looks at the once wasted by-product from cotton seed oil production as an example of ingenuity and technology.

> What was garbage in 1860 was fertilizer in 1870, cattle food in 1880, and table food and many things else in 1890. ***Mather (1894)***.

Sometime later, and in a different setting the horrors of food waste were forefront in many people's minds when in 1917 it was estimated that food waste in Chicago alone amounted to around 1,250,000 pounds per day while total waste from the entire US amounted to $700 million per day/or year. A staggering amount which was enough, as experts at the time agreed, to sustain every man, woman and child in the 13 largest cities in the US (Windsor, 1917).

Meanwhile, in Britain during the war with up to two thirds of its food requirements eventually being imported, an odd situation arose where both food surpluses and food waste existed alongside each other. During the same period tackling the issues of food waste was one of the initial targets of the Women's Institute (WI). Set up in Britain in1915,[1] the WI initially set out to encourage women to get involved in food production during the war

[1]The WI initially began in Canada in 1897 in Ontario and soon spread to Belgium, Poland and the USA.

(WI, 2013). The government too realized that they needed to find ways of producing more food at home. This was tackled on many fronts but perhaps one of the most well-known ways in which the food situation was confronted involved giving the women's institute a grant whereby they would travel the country giving talks and demonstrations about methods of intensive cultivation, using subsidized fertilizers so farmers and countryfolk could grow plants more cheaply and quickly. However, the WI is better remembered for their workshops on preservation methods of surplus fruit and vegetables through jam making, bottling; pickling; and canning techniques, etc.

10.2 Attitudes to food: personal and cultural

Not surprisingly, within the cultural fabric of society, food takes in many roles from general sustenance, to celebrations, weddings, Christmas, and of course cultural references. Indeed, of the many faces of food, wastage is noticeable in many levels not least of which can be described as the individual level as well as within the community as a whole. This relationship, however, develops and changes over time and circumstance. As certain foods become cheaper, for example, perceptions of quality, desirability and ultimately value changes accordingly. Inadvertently adding to the problem, market signals can add to the problem too, with ever increasingly cheap—or the buy one get one free deals, the perception of food's value is being interpreted as an indicator of low-value, disposable food (WRAP, 2009). Furthermore in the cultural stakes, it is not uncommon for household guests to be offered more food than they can consume (WRAP, 2009).

An interesting but rarely considered problem of attitudinal behavior, concerns the idea that consumers might be overwhelmed by their ever-increasing environmental obligations (Monier et al., 2010). The difficulty here, suggests the EU Preparatory study, is that with so much food waste being generated on a personal/private level, the actual extent of the problem is difficult for the individual to see at the individual level and is therefore easier to avoid or ignore.

10.3 Terminology and typology

before you any further, there is some confusion over the terminology used in describing food waste. Indeed, the default position for describing any food that is thrown away, discarded for one reason or another, lost or otherwise inedible is simply referred to as "food waste". However, this does not reflect the true reality of the phenomena.

In European legislation, in particular Resolution 2011/2175(INI), this very confusion is recognized, and by way of example it is suggested that people believe that "food waste" is generally used to describe all discarded foodstuffs from along the food supply chain owing to several reasons including economic, aesthetic or simply owing to the nearness of the products "use by" date, but which may still be fit for human consumption. Furthermore, in the absence of any alternative useful application of food passed its "use by" date (as opposed to its "sell by" date) is, in the end disposed of (Caronna, 2011). So back to the definition of

food waste, in the absence of any harmonized definition the European Commission was called upon to legislate specific definitions for food waste, food loss, biofuels and biowaste among others.

Understanding the differences between losses and wastage is an important exercise. Not surprisingly, the notion of food loss and wastage means different things to different people. In the Swedish Institute for Food and Biotechnology report for example, the report distinguished food waste and loss in the following ways:

> *Food loss* refers to the decrease in edible food mass at the production, postharvest and processing stages of the food supply chain.
> *Food waste* on the other hand referred wastage the profligacy of retailers' and consumers' behavior, i.e., at the retail and final consumption stages of the chain.

In both cases, losses and wastage referred only to that part of the chain that was originally primarily planned for use by human consumption. All else, i.e., food that was intended for use as animal feed and production such as biofuels, etc., were not included (Pachauri and Meyer, 2014).

While this is a good place to start, and indeed proved very useful in the report, it is this author's view that such treatment of food loss and waste in this way might be somewhat limiting. Semantically, the idea of loss and waste intrinsically contain within both words, different measures of culpability and as such are suggestive of varying degrees of blame. In light of this a better definition might separate loss to mean that part of the equation that we have little or no control over (i.e., adverse weather conditions such as flood or drought or perhaps conflict or pest infestation), while waste is more suggestive of culpability through such things as lack of knowledge, poor management or simple profligacy.

It is in this author's opinion, and solely for the purpose of this book, the terms "food waste" and "food losses" will be used sparingly, concentrating more on the term "food waste." While strictly speaking, this is incorrect, for the sake of clarity this chapter will not dig deeply into the full terminology of food waste. Instead, this author aims to get the message across irrespective of the correct terminology.

10.4 Why now?

While large figures of food waste are currently being bandied around which, in and of themselves are staggering, what is perhaps not so obvious are the many associated wasted resources that are used to produce the food in the first place. These include things such as soil inputs, manpower and land usage, etc., or indeed the many incurred costs such as emitted greenhouse gases, soil degradation, fertility, or pollution, etc. From this it can be seen that by reigning in our wasteful habits, by promoting more efficiency, through technological innovation, and through a sea-change of habit, humanity has the ability to make considerable inroads, not only on the headline wastage figures but also on the many ancillary costs too. Ultimately then, if we are to reduce this burden of waste while achieving the goals of food for all, sustainable living, and generally reduce the size of our environmental footprint, then it is incumbent on us to understand the issues involved.

To supplement the fragmentary picture and to flesh out the big picture of wasted food this chapter aims to highlight the many considerations, arguments and areas of acrimony that fall between what we as a species produce in terms of sustenance and what we consume, waste and lose through both fault and non-fault. A tall order without a doubt and one in which the chapter tackles in a very specific way. Where much of the data is empirical in nature and where supporting data cannot be found, alternative acceptable estimates, guestimates and considered opinions will be sought where suitable. On the note of quantification of the problem, this chapter importantly, does not seek to add to the guestimates of global waste but rather, to bring together the varying figures for consideration as a whole. Inevitably, this means that there will be gaps, and but by highlighting such gaps it is hoped that future research will ultimately close these with hard evidence.

By highlighting the significance of the problem; identifying the worst culprits; by investigating the scope for improvement within the food supply change; looking at system efficiencies and the challenges of affecting behavioral change to reduce postconsumer waste; as well as other initiatives for waste reduction, this work looks to bring together, to assimilate if you like, into one chapter as much of the debate as possible.

10.5 Key causes of food waste

There are many causes of waste along all aspects of the food chain. That said, food waste can also be described in various ways, not just according to which part of the food chain it falls on. The following takes a liberal approach using many different ways of describing the key causes of waste. It does so too not in any particular order but rather as the narrative flows.

10.5.1 Economic development

One way of looking at food waste is through the lens of developing and developed nations. Characteristically, in the developing world, wastage usually occurs through a lack of infrastructure, managerial skills in food production as well as postharvest processing and other technical difficulties. Thus, it can be said that much of the developing nations waste is preconsumer oriented. As suggested too, perhaps one of the biggest barriers is that of knowledge transfer, especially from developed nations (Parfitt et al., 2010) (http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2935112/WRAP, 2009). This is in stark contrast with that in the developed countries where the majority of food waste continues to occur at the consumer and postconsumer stages. One of the key findings of many reports point out cost of food, being low compared to disposable incomes. Furthermore, consumers have high expectations when it comes to the cosmetics of food (more on this later). All in all, it is suggested there is an almost tangible disconnect with how food is grown as well as the true value of food in terms of production, employment and the general reality of the back end of the food chain (Parfitt et al., 2010). In a similar vein, many transitioning countries follow the same economic development path, this involves a general shift away from raw ruralism to urbanization; and as above, this will likely generate the same kind of ignorance

or disconnect from the way food is being grown. Of course, this will take a generation or two, but the danger is still there. Lastly, as food begins to reach its peak output levels, and while climate change alters the traditional growing patterns of food, irrespective of the arresting variable, food values will begin to rise and perhaps potentially reflect the true worth of the product in question. This would encourage less wastage and a more sensible relationship with the food we eat (Parfitt et al., 2010).

10.5.2 Personal preferences

As has been mentioned, as food becomes relatively cheaper compared with personal or household incomes so food choices take on more and more influence (WRAP, 2009). Dichotomously, this means more food choice decisions are based on whim rather than on need. So prevalent is personal preference approximately 1.5 million tons per year in the UK alone. Demographic trends, also play a part in the wastage profile of people. Take for instance single occupant households who, because of their lack of sharing food, will tend to generate more waste than two or more people would (Monier et al., 2010). On top of this personal preference, increased disposable income and changing cultural values are all colluding to increase wastage at all levels. This brings us nicely to wholesale retail sector in general.

10.5.3 Wholesale/retail sector

Within the wholesale and retail sector wastage occurs at many levels and for many different reasons. These are summarized as: management issues; technical problems; and consumer demands. In management issues the problem lies in the communication inefficiencies that commonly exist between retailers, distributors, wholesalers as well as manufacturers; poor stock management especially in the difficult areas of forecasting demand and the like. When it comes to technical issues that generate waste within these sectors is often related to the sensitivity of food produced that require certain temperatures for operation and storage. Poor conditions within the areas of storage, distribution and transportation can all lead to premature spoiling. Perhaps the most disturbing or at least most worrying trend over recent decades, and one that is increasingly recognized these days for the frivolity that it is, is the trend of aesthetics' (Monier et al., 2010). This has been mentioned before and concerns the perceived quality improvements of having all the same shape and same sized carrots, straighter cucumbers or oranges all of the same hue for example. There are many areas of food waste common to both the wholesale/retail sector and the manufacturing/processing sectors too. In particular food waste can be found in the management of stock and forecasting issues as well as packaging problems. Areas of interest here include the carrying of too much stock and relying on such schemes including the generous "take-back" schemes; the often-contractual obligations of suppliers to accept the return of unsold goods with up to 75% residual shelf life from retailers. While it is great for retailers it is not good for the suppliers who then have to quickly offload deteriorating food before it spoils. In this way stock holding is a managerial problem in which inaccurate ordering and demand forecasting is prevalent.

10.6 Undervaluation of food

In circumstances where food is not considered of value the potential for waste is ever-present. We mentioned previously that as food becomes increasingly cheaper in relation to incomes so consumers relative spending power increases. This leads to a situation where perhaps the proper value of food is undermined; that is to say the intrinsic value of food in this situation is clearly not just to be found in the cost of purchase but rather in the aggregate of its economic plus associative costs of environmental, political and social tags too. In such situations, such as those of free school lunches for instance, the perception among children is one of plenty; ergo children are potentially open to the temptation of taking more than is needed (Monier et al., 2010).

10.6.1 Poor food planning

In an era of low cost of food in relation to increasing household incomes, throughout much of the developed world, poor food planning ranks high within the household food wastage profile. Simply popping down the local supermarket and buying a week's supply of groceries, especially within the EU, without too much thought or consideration of what is going to be eaten on a day-to-day basis sees too much food being discarded (Monier et al., 2010). Whether from the mismatching of food items (in terms of balanced meals); or from over production for dinner guests; food that is not wanted by other household members; or simply having too much food in the trolley which could not be eaten before being spoiled are all too common excuses (Monier et al., 2010).

10.6.2 Portion sizes

When it comes to portion sizes, both at retail but more importantly within the foodservice sector there has rarely been anything other than a one-size-fits-all approach; and one that is, according to the 2010 EU preparatory report on food wastage, a major cause of concern (Monier et al., 2010). This is particularly prevalent in canteen style operations, particularly in schools, army messes' and the like, where people are given a fixed-cost, standard portion size irrespective of the individual's needs or wants. Not surprising then, that some people will eat all of the food on their plate while others might waste a considerable proportion. However, the story is different in situations where customers serve themselves. The report tells us that in self-serve style operations, whether buffet, vending machine or similar as much as 92% of the food chosen is actually consumed. While this is good news for the wastage figures, there is a major trade-off in such situations. This trade-off relates to the success or otherwise of the self-serve operation in question; i.e., whether or not it is well attended and all the food has been sold or is in a position to be reused (Monier et al., 2010).

Another interesting study along these lines was conducted in 2006 by Wansink et al. whose experiments showed that given larger bowls, people actually eat on average 31% more food and while given larger spoons the increase was about 14.5% (Wansink and Cheney, 2005; Wansink et al., 2006).

This occurred even for nutrition experts who took part in the study. This taps into study by Monier et al. in that as people generally eat most of what they serve themselves so the extra

portion sizes of people serving themselves with larger utensils results in overeating. This is what Wansink and colleagues alluded to as the Ice Cream Illusion and one important counter measure of this would be to consider carefully the many contextual cues which are commonly used in foodservice operations. This, according to the study can also apply to the home situation or simply anywhere where food is being served (Wansink and Cheney, 2005).

These considerations also tap into single serving items like those served in hotels and many catering facilities such as jams, cereals, juice and milk cartons for example where waste could be avoided simply by allowing customers to serve themselves from central containers. Once again there is an important caveat in this scenario and that concerns the trade-off between longevity and shelf life versus holding bulk food items in large storage containers. Take bulk containerized cornflakes in a hotel in Macau or Hong Kong for example; during the spring and summer month's humidity can reach as high as 100%, not the best conditions for serving the hydrophilic breakfast cereal, especially if lax procedures see the containers being improperly sealed and stored. This is just one example; another might include the cross-contamination of foodstuffs through careless or plain thoughtless customers (or poorly trained staff) who might use the wet prune spoon in the rice crispies bowl. In both cases the whole stock might have to be discarded and waste arising out of such practices will offset any savings of the centralized serving operation. Such practices, and potential gains and losses need to be carefully considered (Wansink and Cheney, 2005; Wansink et al., 2006).

In sum serving styles, preportioned and canteen/buffet style foodservice operations carry with them, inherent pluses and minuses when it comes to potential food waste. Both service styles need to be looked at for innovative preventative measures. In restaurants or non-buffet style operations where set portion sizes are served for instance, one solution already introduced by the TGI Friday's chain in the United States is the offering of smaller portion sizes of existing dishes. In canteen or buffet style service operations on the other hand, due diligence, training and measures to increase public awareness will only benefit the cause in the long run. In both cases though, consideration of contextual cues such as bowls, plates and serving spoon sizes could act as powerful subconscious messages of moderation (Wansink and Cheney, 2005; Monier et al., 2010).

10.6.3 Consumer demands

An increasingly worrying trend over recent decades is the trend that the "customer is always right." This oft quoted mantra pampers the customer to the tune that what the customer wants the customer gets. I realize raising such issues is treading on thin ice but if we are to tackle the problem head on then some home truths might need to be explored. The idea that the customer is always right recognizes the power of a consumer led society; in this scenario - money talks; the problem here is that sometimes money talks a language all its own. To elaborate on this, a crude parallel can be drawn between a petulant or spoilt child and a person who spends without regard for the consequences. Buying food that is deemed aesthetically pleasing at the expense of the wasted produce that did not make the grade (and in the face of undernourishment around the world) smacks of the spoilt child within. This of course would be a different story were there options (graded options) on the shelves, then customers, if they so choose could pay a premium for the grade A carrots, etc. On the flipside, however, consider this—if carrots grew like gnarled root ginger; would we then be willing to

spend that extra time trying to peel such an awkward vegetable? Undoubtedly some would, yes, especially if there was a cost saving involved (Monier et al., 2010). This begs the question then, who exactly decided we all wanted uniformly straight vegetables? Market surveys? Wholesalers? Retailers? Is this a product of industrial needs, requirements? Or are we being led?

The problem of conformity is not limited to the straightness of vegetables either, oranges, or tomatoes for instance with a less than uniform hue might be seen to be of an inferior quality; misshapen or non-uniform sized and shaped fruit and vegetables too also fall within this category (EC, 2011a). In this sense, aesthetics' is an ugly word, mere shameful examples of style over substance; a frivolous distraction. There is light, however, at the end of the EU tunnel, for as of 2009, new rules were introduced relaxing regulations on the uniformity of fruit and vegetables vis-à-vis size and shape. This goes some way to addressing the legal requirements of heterogeneous foods but a more fundamental shift in the quality-perception dynamic of foods might be needed in the longer term.

10.6.4 Stock management

All across the supply chain, inefficiencies in business operations, especially in the area of stock management have been highlighted as an area for concern in the food wastage issue. Of particular note concerns the area of forecasting which is constantly blighted with the difficulty in predicting market demand and by extension-stock holding. Also, of interest here include the carrying of too much stock as a result of such "take-back" schemes; the often-contractual obligations of suppliers to accept the return of unsold goods with up to 75% residual shelf life from retailers. This adds to stock holding and premature spoilage as well as the difficulties previously mentioned of inaccurate ordering and demand forecasting. Anticipating demand and the resultant issue of overstocking is prevalent across most product groups and can be exacerbated by seasonal fluctuations (OECD, 2002; Wansink and Cheney, 2005; Monier et al., 2010). Take Christmas cakes or Easter eggs for example whose demand is notoriously difficult to predict and which are inherently sensitive to spoilage because of their short shelf lives.

10.6.5 Overordering

Being habitual and intuitive, household food behaviors are a little more involved and causes of waste can be attributed to a wide variety of actions that the consumer may not even think about.

Across the nations of Europe, a large portion of food (37 million tons) is thrown out by households every year (Monier et al., 2010). Furthermore, based on evidence from the UK it has been said that as much as 60% of this could be avoided, translating to an average per-household saving of about €565 each year (Monier et al., 2010). Complicating the picture are notions of the undervaluation of food; the lack of necessity in utilizing food efficiently (overordering, taking notice of sell-by dates, etc.) or using up leftovers as well as a general lack of knowledge in such things as the environmental problems that food waste presents among other things. Add to this the widely recognized problem of food labeling vis-à-vis misinterpretation and confusion over sold-by dates, use-by dates and display-until dates,

etc., and it's not difficult to see just how the problem of waste grows. Poor food planning too plays a major role in the food waste profile of the EU at the household level. This, according to Monier et al. tracks back to the relative abundance and low cost of food in relation to household income, throughout the member states. Arising from this then is the practice that sees far too many people continuing in the bad habit of poor food shopping planning or simply buying too much food. Food purchased that perhaps does not combine well with other unplanned food purchases in the household meal; food that was not wanted by the other members of the household; or food that just could not be eaten before being spoiled are all too common excuses of food waste (Monier et al., 2010). Retailers and wholesalers too must take some responsibility for compounding this problem with on-going promotional sales of two-for-one deals, etc.

There are two other important areas recognized within this report and this concerns demographics and preferences (Monier et al., 2010). It would seem that single person households as well as the younger generation are in the habit of wasting more but more widely, food preferences across the whole socio-dynamic cause for concern. Within the more developed EU for instance, people are nowadays commonly discarding often nutritious parts of food due to personal preferences, such things as bread crusts, apple skins even potato skins are often discarded because people simply don't like them or are fussy.

10.7 Foodservice styles

The various foodservice outlets have to be considered too whether food is served at hotels, restaurants, hospitals, army mess halls, corporate canteens, airlines, cruise ships. In fact, everywhere food is served to the public, employees or guests, etc., and each has its challenges in terms of wastage. To help understand the different challenges consider the various foodservice styles from a la carte (cooked to order); table d'hôtel (fixed or menu of the day/week); or buffet style, whether served or self-served. It is worth noting too that the majority of outlets can employ one or several of these service styles based on a number of considerations including manpower, economic costs, perceptions of quality and speed or convenience among others. So, whether serving buffet style lunch at your place of work or a la carte menus at your local restaurant the challenges are many and varied (Monier et al., 2010). A quick note on a face style service appears that customers often expect that nothing will run out. This is especially so in the luxury market which encourages businesses to prepare more, sometimes substantially more than is likely to be consumed Within a la carte style foodservice food is cooked according to the "just in time" principle. The difficulty here is when food is overcooked or not cooked in time with the other ordered dishes, the food can, in far too many instances be discarded and the process is restarted (Monier et al., 2010).

In all cases there are common difficulties shared across foodservice styles. The challenge of not knowing how many people dining might be being a constant source of frustration. To reduce this unknown variable, encouraging customers to make better use of reservations perhaps with some form of incentivized deal might place less pressure on stock holding and other logistics. Also encouraging the practice of taking home restaurant leftovers could substantial reduce the prevalence of restaurant food waste; a practice unfortunately which is frowned upon frowned upon in some parts of the world, particularly in Europe.

10.7.1 Staff feeding

Staff feeding at foodservice businesses can be a sensitive issue. At the point of production, whether processers or foodservice retailers, food waste is generated for a variety of reasons ranging from overstocking, difficulties in forecasting demand, canceled orders, overcooking, and poor management among others. Whatever the reason though, while some establishments allow employees to eat leftovers or to take food home with them at the end of their shift, others ban the practice outright. The problem is a complex one. The difficulty here is that there are two sides to the equation. In restaurants, or factories where too much food has been produced, or is coming close to the end of its useful shelf life the issue is what to do with the leftover food. On the one hand if the staff are allowed to eat it for free or take it home, they are happy and fed, after-all the food was only going to be thrown away wasn't it? It's a win-win situation the restaurant was going to lose valuable stock, irrespective of what was going to happen to the food postdiscard; staff morale is raised and the company's standing among its employee's increases. On the other hand, consider this, waste food in this sector comes from numerous sources; overordering, poor management, difficult forecasting, and mistakes among others. With this in mind, if the staff are to be fed from the over stock or leftovers, or canceled orders what is to stop the chef or food manager from overordering in the first place? By ordering or cooking too much food, the chef might be erring on the side of caution but he also might be under peer pressure to feed a potentially otherwise disgruntled workforce. That is to say, if there are no leftovers, to feed the staff or to supplement existing staff feeding then unhappy staff can be difficult staff. The easy way out is purposely over order, over stock, and over cook. It is a culture that this author has witnessed first-hand over two decades, in many foodservice style operations and across many continents.

That said, employers are not blind to the practice and the resulting difficulty is two-fold. On the one hand a lot of these practices are gray areas and employers have to rely on the trust and professionalism of their workforce. On the other hand, many establishments, for fear of abuse, simply ban the practice; that is staff are not allowed to eat any of the establishment's food under any circumstances other than as customers. In this case any leftovers generated are just binned; discarded (Monier et al., 2010).

Retailers and other food stockists too are fearful of allowing or encouraging this practice and far too often the default line is to bin-it. Take into account too that the majority of the developed world operates within a market economy where capitalist forces prevail and, in many instances, the surest way to avoid abuse is to ban the practice in the first place. As a counter measure, the alternative to binning this waste has to be a priority; whether; allowing more flexible staff purchasing schemes, animal feed or redistribution; this waste stream is one that requires considerable business cultural modification. However, in this last regard, much more work needs to be done as Veronique et al. comments; the lack of clearly defined channels in which excess food from retailers and the hospitality industry in general can be redirected toward charitable organizations is sorely missing.

10.7.2 Lunch timings

One consideration that is given little thought is that of timings of institutional meal breaks. Particularly in this category are schools; according to Jonathon Bloom, studies in the USA

have found that scheduling lunch after break-time when children have exercised, creates an appetite that reduces the occurrence of waste. Also, it has been suggested that if break-times came after lunch then there is the possibility that children might be a little preoccupied with the opportunity of play and socializing which might interfere or distract them from the task of eating (Bloom, 2010).

Mirroring this issue of meal times, again within institutional environments such as hospitals, prisons and the like is the lack of individual's autonomy over meal times, choice or even the size of the meal. This could result in patients or inmates, etc., not being hungry at the allotted time eating less than they might otherwise.

10.7.3 Transportation/distribution

Related to the above, transportation, is another area of concern that can lead to both packaging and storage problems. Poor packaging standards and poor packaging performance can lead to damage during transportation and the ultimate discarding of the product; often too, irrespective of whether the food itself is damaged or not. On top of this, any drastic changes in temperature during shipment can also lead to the premature shortening of shelf-lives, or worse actual spoilage during the journey. This is an area in which meat and fish are particularly susceptible. In fact, current research has just been carried out that successfully tracked temperature changes in food products along the supply chain. The idea of these Time/Temperature Indicators (TTI) was to introduce an active "smart label" that could record measurable, time-temperature dependent changes reflecting the full or partial temperature history of a food product to which it was attached (FRESHLABEL, 2008). The technology has been tested and is now ready for industry roll-out. Identifying these breaks, which by themselves or cumulatively lead to spoilage has the potential to drastically reduce spoilage due to temperature fluctuations and perhaps at the same time alter certain characteristics of the food chain itself along the way.

10.7.4 Storage, handling and packaging

Inappropriate or poor storage and packaging practices contribute to the premature spoilage of food. Of course, conditions of climate and household temperatures vary with region but in the UK, WRAP has indicated that as much as two million tons of food is being stored incorrectly contributing enormously to the wastage problem (WRAP, 2008). It would seem too that this is not just an issue at the household level alone either. Poor storage, distribution, and transportation (next section) practices at all stages from processing to wholesale distribution and retailing can and do lead to premature spoiling—issues of light (overexposure), temperature, improper, or inadequate packaging materials.

The difficulty here is the trade-off between storage and packaging for while some products, say cucumbers might have their shelf life extended fivefold by simply wrapping them in plastic film, the wastage of the packaging material must also be considered. In many instances, the use of reusable plastic containers for fresh fruits, pasta, and grains, for instance, might markedly lengthen shelf life at minimal cost to the environment. In sum improved knowledge of preservation or storage techniques, must prevail.

10.8 Data limitations

Significant gaps exist in the overall understanding of the food waste problem. From quantification to identifying poor food practices to technological challenges through to policy and social and economic dimensions, food waste knowledge is still in its infancy. That said, there is mounting evidence that agrees that losses are much higher at the harvest and immediate postharvest stages in developing countries while being higher in affluent economies at the postconsumer levels. However, on the other hand, the conventional view that postconsumer food waste is the sole preserve of industrialized countries alone is challenged with some countries and regions, especially the BRIC countries (Brazil, Russia, China and India), experiencing similarly high levels of food wastage (Parfitt and Barthel, 2010).

The lack of reliable data on food waste at every level seems to be a recurring obstacle in bottom line figures as well as in the comparability of studies. Difficulties continue in terms of defining waste: what is diverted to animal feed, what is unavoidable waste (bones seeds and skins) as well as the unavailability of time series data.

This presents major difficulties when attempting to accurately identify trends, in addition investment in data collection and analysis will go a long way to improving recognition and reporting accuracy. Indeed, one only need take a leaf out of the Danish Environment Agency which conducts a national food waste study every 10 year at a cost of several hundred 1000 Euros.

10.9 The challenge ahead

With regards to being fed, the difficulty inherent in this notion is, that on the surface there appears to be a shortfall of food; that is presently, and for many years now, there still exists a large cohort of the population (approximately 815 million people) who are, and have been year-on-year persistently undernourished; are not being sufficiently fed. This situation taps into the issue of food security that is ensuring everyone has access and available food supplies. Further compounding this problem is the expected population growth that will see close on 9 billion people living off the planet by 2050. Couple this with improved nutrition standards and shifting dietary p and it is not hard to understand that the global food supply chain is coming under further increased pressure.

The challenge then is that any increase in the food supply has to meet not only present shortfalls but also future projected needs of an extra 2 billion people by 2050. With this in mind, the global community is without doubt in its agreement on the need to increase the global food supply; and such a rise has been estimated to be in the region of around 70% (Caronna, 2011; IMechE, 2013a,b). Of course this is perhaps an unforgiveable oversimplification and without getting into too much detail for the moment, the elephant in the room here is there currently does exist sufficient production to feed the existing population on a daily basis (Gibson, 2016). The problem is one of food security, discussed in more detail later in the book.

Adding to these notions is the fact that food production and consumption patterns have changed drastically over the last three decades. Changes in production have resulted from shifting agricultural and retail paradigms that witness more and more of the vertical

integration of an increasingly larger part of the supply chain as well as the propensity for larger farm sizes. Technological innovation too has further increased the availability and variety of foodstuffs in ever more variations of packaging, shelf-lives and states (cured, smoked, freeze dried, etc.). Changes in consumption patterns too have largely been the result of rising per capita incomes, lifestyle changes and demographic shifts (rural-urban shift as well as the increase in single person household (Gibson, 2016). Within the context of these changes then, and despite the advances in food waste management systems, with many innovations in waste treatment including the increased practice of home-composting, waste volumes continue to grow (Monier et al., 2010).

Such difficulties present mankind with unprecedented and far-reaching social, economic, environmental as well as political challenges, which need to be addressed if any semblance of a sustainable future for all is to be achieved. Yet while political will is on the increase and while engineers, scientists and agriculturalists have the know-how and the tools that can help achieve the required productivity increases for instance, pressure is still set to grow on the finite resources of land, energy, and water. The key issue here is just how to produce more food in a world of finite resources while at the same time reducing the significant environmental, economic, and social impacts of food waste (IMechE, 2013a,b).

Indeed, for a while there was much talk by the United Nations and others of the need for a 70% increase in food production - only now though are people beginning to accept alternative views that rely less on big production increases but more on a suite of initiatives that promises to reduce food waste and the concomitant strain on the natural resource base. In fact, by simply eliminating losses, the potential exists to provide between 60% and 100% more food while simultaneously freeing up land, energy and water resources for other uses (Monier et al., 2010; Kummu et al., 2012; IMechE, 2013a,b).

10.10 What can be done: waste prevention initiatives?

As has been mentioned food is wasted all along the food supply chains (FSCs). On top of this there is much anecdotal evidence suggesting strong links between food wastage patterns or profiles with the economic development of countries and regions. From this it can be determined that under these different conditions, food supply chains (FSCs) are organized and work completely differently; they are malleable and heterogeneous. FSCs then, reflect both individuals and countries wealth status, their attitudes and their respective relationships with food. There is no doubt where the blame lays according to the UK's Institution of Mechanical Engineers (IMechE). Comprising several areas of culpability, the first firmly resides with the market mechanism of the unnecessarily strict sell-by and buy-one-get-one free dates. This only encourages UK households to buy more than they actually need. In 1-year UK households can throw away up to 20% by weight of the food purchased for that year equating to over 7 million tons. Of this figure more than 60%, about 4.4 million tons, was still edible at the point of discard (WRAP, 2013a). It has been argued too, that by preventing such waste the average UK family could save over £680, while simultaneously adding to the environmental benefits of less landfill, transport costs as well as storage among others, thus mitigating some of the worst proponents of climate change. Further still, in postharvest losses, especially along the transport, distribution and retail lines there is the potential to

substantially increase, through good practice, available foods for the consumer while encouraging more efficient use of the resource base (WRAP, 2013a,b). While despite several decades of awareness, food waste is still regarded as being in its infancy, furthermore, as awareness of the problem is disseminated so waste prevention is rapidly gaining momentum.

10.10.1 Production

One of the many ways we can help reduce the wastage in the areas of pre- and postharvest production is to become less wasteful. While this might sound like an oversimplification, it is also the basic truth. The obsession of standardization as well as the perception of quality of uniformly straight cucumbers, odd or misshapen fruit is frankly absurd (WRAP, 2013a,b). Indeed, following the lead of the European Union's hierarchical Waste Framework Directive, in which priority is given to waste reduction at source while observing a preferential list including reusing, recycling and waste management, the US Environmental Protection Agency adopts a similar practice. However, EPA waste treatment options does not differentiate between anaerobic digestion, incineration and landfill. Of course, most environmentally friendly of these options is the anaerobic digestion (EPA, 2018). Having said that, these are not the only options. As far as the European Union is concerned one third of all food waste is in edible so alternative disposal methods must be found. Anaerobic digestion is one method; however, options such as diversion to animal feed, energy capture, industrial uses, especially of recycled cooking oils and composting are perhaps the more environmentally friendly options of choice (WRAP, 2009; Caronna, 2011; WRAP, 2013a,b; EPA, 2018).

10.10.2 Targeted awareness campaigns

As far as information dissemination goes, without a doubt, the last three decades have seen a steady increase in general environmental awareness for all. Having said that, however, food waste has not been at the forefront of policy priority since the First World War. This, according to Monier et al. (2010) can be laid at the feet of complacency in the face of abundance. Historically, as food production increased and became cheaper so, not surprisingly, not everyone thinks about what they are throwing away. Indeed, wasteful behavior or profligacy might for some actually be an entirely unconscious way of living (Monier et al., 2010). Consequently, and as has been mentioned, despite a growing awareness of the issues it would seem that food waste prevention is not yet well-established. Thus, if this turns out to be the truth so the early stages must deal with increasing awareness to initiate change. In doing so, this will be an important first step on the road to the new food revolution.

Stakeholders tend largely to agree that targeted awareness campaigns are essential if humanity's profligate behavior is to be adjusted. The direct benefits of such strategies too are thought to be closely linked to the amount of money invested in such strategies with expected potential savings, at the household level at least, might just turn out to be considerable. Indeed, there is much evidence pointing to the fact that the largest proportion of avoidable food waste is being generated at the personal or household level. Moreover, while individuals and households have been identified as the principle generators of avoidable food waste, many of today's awareness campaigns are principally targeting this group. There are many good examples of effective approaches that aim to tackle this dilemma which

include engaging schools and institutional feeding in places like hospitals and the like, as well as privately owned restaurants too. In awareness campaigns then, the is huge, acting as a first line of defense, not just in the examples given but rather in engaging all sectors of industry in the fight against food waste (Monier et al., 2010; Caronna, 2011; WRAP, 2013a,b).

In addressing this worrisome state of affairs, two potential targeted streams are identified that may together initiate significant change. In the first instance, strategies are aimed at producers and retailers to help prevent or at least reduce individual and household food waste. Of course, the good news is that by simply drawing attention to the extent of the wastage problem with awareness campaigns and the like, the cumulative effect can be disproportionately effective. As an example of just how successful targeted awareness campaigns can be in initiating behavioral change just take a look at the UK's "Love Food Hate Waste" campaign which, in a single year, managed to prevent an amazing 137,000 tons of food being wasted—a near 3% reduction in avoidable individual and household food waste; equal to about 1.8% of overall total food waste (WRAP, 2009).

In practical terms, taking a leaf out of our grandparent's book can shed light on many lost and forgotten practices. Take leftover items such as meat, bread, rice or pasta, for instance, these were historically reemployed by our forefathers in many classic dishes throughout the European Union; the same items which are now being discarded on a regular basis. Even the much heralded classic regional bread dish, great British bread pudding, Panzanella in Italy, Pain Perdu in France, where commonly made with old stale bread (Monier et al., 2010).

Affecting long-term behavioral change is a key in such strategies and is also the motive behind encouraging households to separate out food waste from other rubbish discarded within households, restaurants, and cafeterias. In this simple action, the awareness generated (as touched upon earlier) has the potential simply to draw much needed attention to the waste individuals are responsible for (Monier et al., 2010).

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