The “Prevention Paradox”: food waste prevention and the quandary of systemic surplus production

Rudolf Messner1 · Carol Richards1 · Hope Johnson2

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Abstract
Preventing food waste is a major global challenge to the sustainability and security of the environment, society and economy. In response to that challenge, a plethora of initiatives addressing food waste have formed in recent years. These initiatives focus on aspects such as the efficiency of resource use, reduction of supply chain food waste, food donations and rescue, consumer behaviour, and above all, innovative ways to add value to food surplus and waste. What many initiatives have in common is that they mainly deal with food waste once it exists rather than preventing it from occurring in the first place, which might thwart efforts to increase long-term food systems sustainability. The idea of food waste prevention itself is beset by several conceptual paradoxes: it is considered the most preferred method to manage waste—which it was supposed to prevent in the first place, and it is an ambiguous ecological behaviour lacking the tangible characteristics of waste composting or recycling (i.e. prevention by its nature is invisible). Most importantly, food waste prevention, like other major sustainability challenges, appears to be in a fundamental conflict of interest with current economic norms and practices. In response to these dissonances of prevention and the inability of waste management to reduce the creation of food waste, researchers have proposed a number of new approaches, including the re-appraisal of food overproduction as a key cause of food waste. Accepting Mourad’s (Environ Soc Berkeley J Sociol 59:26–33, 2015) challenge to “think outside the bin”, this work proposes a “Prevention Paradox” framing as a conceptual link between the bodies of research on food overproduction and food waste prevention, offering a more holistic approach to this major sustainability challenge.

Keywords Food waste prevention · The Prevention Paradox · Overproduction · Overconsumption · Sustainable food systems · Sustainable development goals

Abbreviations
EU European Union
EC European Commission
FAO Food and Agriculture Organisation
FUSIONS Food Use for Social Innovation by Optimising Waste Prevention Strategies
GDP Gross Domestic Product
NGO Non-governmental Organisation
SDG Sustainable Development Goals
UNEP United Nations Environment Programme
WRAP Waste and Resource Action Programme
WRI World Resource Institute

Introduction
The food waste problem sits at the intersection of a number of global mega-issues, including climate change, unsustainable natural resource use, and what is often referred to as the “double burden” of hunger and obesity (Banwell and Dixon 2013, p. 298). At international and domestic levels, stakeholders generally agree that preventing food from becoming waste is the top priority in addressing food waste (see, e.g., European Commission 2008. Directive 2008/98/EC on Waste, [7]). Food waste prevention as an objective has
permeated the public consciousness and governance agendas only over the last decade. As a result, significant progress in reducing food waste has been made within very specific and local-level socio-political contexts (Aschemann-Witzel et al. 2015; Stensgård et al. 2018).

But more typically, responses by governments and industry have been largely symbolic (Corvellec et al. 2012, p. 302) and arguably based around a few marginal changes to business as usual (Mourad 2016, p. 468). For instance, Goal 12.3 of the United Nations Sustainable Development Goals (SDGs) is to halve food waste by 2030. Yet the approaches considered to achieve this target have not only been seen as lacking “effective guidance” (Bengtsson et al. 2018, p. 1), but also country reporting to the “SDG Index and Dashboards Report 2018” revealed that progress on achieving SDG 12.3 is a long way off the target (Sachs et al. 2018, p. viii). Consequently, a recent report by the UN Secretary-General on the Sustainable Development Goals acknowledged that the process of reducing food waste was “challenging” and in need of a “profound transformation” (UN Economic and Social Council 2018, p. 16).

In considering the kinds of governance arrangements required for such a transformation, this paper begins with a critical examination how food waste is problematised and especially how food waste prevention, as the top priority in addressing food waste, is framed and pursued. We show how food waste prevention has been subsumed into measures aimed at diverting or averting waste.

Prevention, therefore, is not being conceptualised as genuine prevention of food waste. Rather, prevailing conceptions of food waste prevention that are embodied in the widely used food waste management hierarchy are a tacit acceptance of the inevitability of excess food and food waste. How we understand food waste prevention determines how we respond to it. By grouping food waste prevention with all other waste management approaches, the associations between food waste and broader food system dynamics have largely been obscured and neglected. Further impeding progress on food waste prevention are the underlying conceptual uncertainties concerning the nature of the food waste and how “prevention” can be known i.e. measured and enabled (Chaboud and Daviron 2017; Corrado et al. 2019).

To address these limitations in current food waste theorising, the following section of the paper proceeds to identify the key conceptual and practical dissonances surrounding the theory and practice of food waste “prevention”. Challenges embedded in pursuing food waste prevention are explored by considering ontological uncertainties, existing levels of investment in waste management infrastructure, ideological dependencies and social values associated with production, consumption, liberty and personal freedom.

The final part of this paper unpacks and problematises key contradictions between food waste prevention and the prevailing socio-economic system. In doing so, this paper argues that surplus food production in excess of demand is a fundamental condition of dominant food systems. These large-scale increases in supply, combined with the ongoing rise of food mass retailing and related dietary transitions, have contributed to food waste creation and overconsumption along the entire food supply chain.

We coin the term “Prevention Paradox” and propose that prevailing mainstream narratives of food waste prevention often fail to genuinely capture the prevention of food waste at the source. In linking the bodies of research on food waste prevention and overproduction, we consider ways toward a more holistic approach to understanding and addressing unsustainable food system outcomes including food waste.

The conceptual and material paradox of prevention in food waste management

There is now a burgeoning literature on the causes and solutions to food waste. Despite the seeming intractability of the food waste problem, its context-specific causes are largely agreed upon and have been comprehensively studied. Systematic inventories pinpointing hundreds of single food waste causes have been presented in official publications by government, non-governmental organizations (NGOs) and international agencies. Key bodies synthesising and disseminating the proximate causes of food waste include the Food and Agriculture Organisation (FAO 2011), the United Nations Environment Programme (UNEP 2015), the NGO Waste and Resources Action Programme (WRAP 2018), and the European Commission’s “Fusions” project (EU FUSIONS 2016). Additionally, a growing body of scientific literature has exhaustively documented the wide-ranging causes of food waste along the food supply chain. These causes include disruption by unpredictable events such as changes in demand, inefficiencies in manufacturing processes, lack of coordination among supply chain actors, food degradation during transportation, food standard regulations, and commercial practices of excessive demand stimulation through aggressive marketing practices (Alexander et al. 2017; Bernstad et al. 2017; Canali et al. 2013; Devin and Richards 2018; Muriana 2017). The establishment of the “Food Loss and Waste Protocol” (WRI 2016) as a global multi-stakeholder framework represented a significant step towards harmonization of various food waste definitions, standards and reporting guidelines. Importantly, the protocol replaces problematic distinctions in, and a lack of consensus regarding, terms such as “loss” and “waste” (Bernstad et al. 2017; Chaboud and Daviron 2017; FAO 2011) or “avoidable” and “unavoidable” (WRAP 2018). A more flexible and context-dependent understanding of these terms has
emerged with standards and guidelines based on the final destination of material flows.

Within the more specific debates about causes, definitions and measures of food waste, broader conceptual and practical dissonances between waste prevention and waste management become evident. How food waste is defined, classified and measured changes how the problem of food waste is understood, compared and addressed. The EU, for instance, measures food that is thrown out by consumers, retailers or producers but does not measure food by-products diverted to animal feed. Thus, little is known about how much food is diverted to animal feed, and how much of this food/feed that is intended for humans is then consumed by non-human animals (Corrado et al. 2019, p. 94).

Similarly, the use of food to produce animal feed as well as biofuels, referred to as “non-human agricultural production”, is left out of such accounting (Chaboud and Daviron 2017, p. 4). This means what could be considered key waste streams diverting food from human consumption, are not within the purview of food waste or its prevention. By contouring food waste accounting in these ways, it is difficult to obtain a complete idea of how much food is produced for humans and then not actually consumed by humans. A lack of knowledge about the extent of the problem prevents discussion about how to respond to food waste’s various other, interrelated dimensions including: the adverse dietary and environmental impacts of livestock production (Alexander et al. 2017; Kummu et al. 2012); the desirability of biofuel production over other renewable energy sources in terms of environmental impacts (Götz et al. 2017; McMichael 2010) and the problem of the overconsumption of food associated with the prevalence of diet-related non-communicable diseases worldwide (Alexander et al. 2017, p. 190; Papargyropoulou et al. 2014, p. 108; Vandevijvere et al. 2015, p. 446; Vulcano and Ciccarese 2017, p. 9). By isolating food waste from other activities affecting food system sustainability, the strategies open to decision-makers in preventing food from existing only to be wasted are significantly reduced.

In regards to “open” strategies, the “food waste management hierarchy” is the predominant framework used to conceptualise and address food waste across government, industry and the third sector. On the food waste hierarchy, the most preferable category of prevention is followed by re-distribution to people, waste transformation (e.g. feeding to animals, valorisation, energy recovery, composting), and finally disposal in a landfill. Landfill disposal is invariably the least-preferred option for waste management and should only be employed when all other avenues are exhausted (Marin et al. 2017a; Papargyropoulou et al. 2014; Salemdeeb et al. 2017a; Van Ewijk and Stegemann 2016). Food waste is represented by its own food waste management hierarchy largely because food differs from other waste (such as solid waste) as it is organic and highly perishable, is largely compostable in the right environment and fulfills a basic and universal need (Bloom 2010; Mourad 2016).

Prevention, i.e. source reduction, tops all major waste management frameworks and is recognised as the highest priority in food waste management (Corvellec et al. 2018; Hutner et al. 2017; Van Ewijk and Stegemann 2016; Zorpas and Lasaridi 2013). In other words, when designing ways to respond to food waste decision-makers should prioritise actions to avoid producing food that will not be utilised, and in doing so, reducing the unnecessary use of resource inputs such as water, fuel and labour.

Prevention is preferred because it is the only option that saves natural resources from being used unnecessarily, whereas all other options respond to food waste after it has been produced. Preventing food waste before it happens has the potential, therefore, to reduce the consumption of energy, water and other resources associated with production, transportation, storage, and preparation embodied in food waste (Cuellar and Webber 2010; Hoekstra 2012; Quested et al. 2013; Vittuari et al. 2016). Equally, food waste prevention avoids direct and indirect waste impacts such as packaging, effluents as well as the greenhouse gas emissions caused by the production, management and disposal of food waste (Kummu et al. 2012; Vermeulen et al. 2012).

Accordingly, prevention has a role in not only mitigating environmental harms but also in addressing the threats to food security and food system sustainability posed by climate change and natural resource depletion (Berry et al. 2015). Strategies to prevent food waste to the extent that meets the aspirations of the SDGs need to address the over-production of food in the global food system and overconsumption of food beyond that required to meet energy needs, which is a global dietary trend associated with diet-related non-communicable diseases (Friel et al. 2014).

While prevention is regularly hailed as the undisputed policy priority of waste management, the act of preventing waste is significantly different in nature to the act of dealing with existing waste (Corvellec et al. 2018). A generally accepted definition of waste management is: “the collecting, treating, and disposing of solid material that is discarded because it has served its purpose or is no longer useful” with the term “waste” applying to material products (see, e.g., Nathanson 2018). As this understanding illustrates, waste management does not infer actions to prevent waste material but rather actions that address existing waste material. Correspondingly, prevention stops waste from needing to be managed, highlighting the ontological dilemma flagged earlier, that is, a food waste management hierarchy assumes materiality (the existence of something that might be wasted), whereas prevention in its truest meaning, does not.

Compared with physical management or transformation of real and tangible waste then, prevention has different
ontological quality. After all, it is difficult to delineate prevention since it is challenging to comprehend what did not occur or exist (Zorpas and Lasaridi 2013, p. 1047). The real problem apparently is the waste itself; once it is there it is too late for its prevention (Corvellec et al. 2012, p. 300). Hence, in less philosophical terms, using prevention to manage waste is akin to “fixing a flat tyre by reminding someone to avoid nails” (Bloom 2010, p. 145). The conceptual dissonance between preventing waste and managing waste once it exists suggest that waste prevention requires an entirely separate range of activities from waste management (Zacho and Mosgaard 2016).

If “prevention” is not a material and substantive method of waste management, then its inclusion in the waste management hierarchy is indeed problematic. Waste management has attracted highly significant levels of investment in its research and development, while preventative efforts have been arguably under-studied and under-developed (Corvellec 2016). The waste management industry has captured substantial investment into infrastructure and technologies, which has a reinforcing effect on how food waste is framed and communicated as something to be managed rather than avoided at the source. This observation is supported by Thyberg and Tonjes (2016), who note that waste prevention has been ignored by states in favour of a focus on recycling and diversion.

It can be argued that the socio-technical structures currently in place to address waste management, generate a “lock-in” (Geels et al. 2014) to systems that manage rather than prevent waste. Further, the resources and systems dedicated to waste management serve to impede the paradigm shift necessary for non-material food waste prevention (Corvellec 2016, p. 7; Zacho and Mosgaard 2016, p. 990), that is, through preventing the overproduction of food in the first place. An adjusted focus away from food waste management to food waste prevention conceived as a reduction in material throughputs and waste (Van Ewijk and Stegemann 2016) thus contradicts the socio-technical waste management regime. Prevention does this by not only seeking to reduce the levels of waste to manage, but also by contesting, and perhaps undermining, the need for investment in waste management.

Besides physical infrastructure and investments reinforcing a focus on waste management over prevention, the rules, customs, actors and signals that regulate societies are ill-suited to preventing over-production in the first place. Even before markets were increasingly liberalised from the 1980s onwards, regulatory measures to reduce the number of consumer goods being produced was uncommon, unless the goods and services posed an immediate and direct threat to human or societal well-being and garnered enough political support for intervention. Rather, continually increasing levels of production have been incentivised through government supports and market mechanisms based on economies of scale. Moreover, the freedom to produce and to waste (Stuart 2009, p. 203) is protected via national and international legal regimes. Waste prevention strategies could, for instance, violate international trade and investment law (Li and Zhao 2017). Meanwhile, a cultural and social emphasis on consumption and a free-market fundamentalism ideology condone and rely upon a system of obsolescence and waste generation to further economic growth (Carolan 2018; Meadows, et al. 1972; Patel 2007).

Having outlined the conceptual and practical underpinnings of what we term the “Prevention Paradox” and its inherent contradictions, this research will proceed to a critique of mainstream approaches to food waste prevention. Accordingly, the next section reviews prevailing food waste prevention approaches paying close attention to overcoming the Prevention Paradox.

Unpacking the “Prevention Paradox”

We present the ‘Prevention Paradox’ as the contradiction between the following two dimensions: The publicly-proclaimed preference for “food waste prevention” versus industry and government responses to food waste, which focus upon managing rather than preventing. The Prevention Paradox seeks to draw out the material and ideological constraints that underlie this contradiction and the conflicts of interest, which hinder food waste prevention from being genuinely pursued. It unpacks how governments and industry prioritise food waste prevention on paper, and how their failure to prioritise preventing the creation of waste contributes to increased waste generation.

To evidence these claims, the following sub-sections demonstrate the ways in which the Prevention Paradox is conceptually and practically present within three main archetypes of food waste responses, which sit on different levels along the waste hierarchy. These are: “preventing surplus food from becoming waste”, “educating consumers not to throw away food”, and “zero waste (to landfill)”.

Preventing surplus food from becoming waste

In relation to the first prevention paradigm, i.e. preventing surplus food from becoming waste, food surpluses exist at all stages of the food supply chain including farming, manufacturing, logistics, retail, and foodservice (Alexander et al. 2017; Bernstad et al. 2017; Göbel et al. 2015). Overproduction and surplus are necessary, perhaps even intended outcomes of the present food system to safeguard against supply chain risks and to satisfy trade and consumer demand (Papargyropoulou et al. 2014; Raak et al. 2017). Importantly, empirical evidence shows a very close relationship between
food surplus and food waste (Hic et al. 2016; Vulcano and Ciccarese 2017) and consequently Papargyropoulou et al. (2014) have emphasised the importance of minimising food surplus for sustainable solutions to food waste.

Researchers and practitioners regard food surpluses as an issue that can be addressed via improved food chain governance (Canali et al. 2013; Garrone et al. 2014). Thus, the focus has been, for instance, on reducing errors in production planning, inventory management, and packaging and labelling, which cause otherwise perfectly edible food to become surplus and ultimately waste (Garrone et al. 2016; Mena et al. 2011; Midgley 2013). Surplus and waste are also created within the production process itself due to steps such as cutting, trimming, packaging, equipment change-over as well as cosmetic standards such as size and shape (Devin and Richards 2018; Midgley 2013; Parry et al. 2015; Raak et al. 2017).

As a result of the focus on food surpluses as a food chain governance issue, “surplus management” has been cited as a distinct capability of food system actors, resting on the dual pillars of “surplus control systems” as well as the “cooperation with food rescue organisations” (Garrone et al. 2016, p. 1076). Food system actors undertake surplus control by developing capabilities to anticipate, recognise and respond to surplus before or as it occurs. Surplus management refers to the activities undertaken once the surplus begins to form at some stage of the food system, namely disposing of the surplus via secondary channels and discounting and promotion.

Large retailers, for example, use a high-volume mass distribution business model, which inherently enables the movement of very large amounts of food surplus further down the chain into households. Calvo-Porral et al. (2016, p. 57) describe the mechanisms involved in such surplus transfers, including multi-buy promotions, upsizing coupons and high-pressure advertising campaigns. Importantly, they found that stopping such advertising and marketing strategies activities would result in food waste reduction at the household level. Additionally, food retailers, due to their significant capabilities and influence over the entire food supply chain, are uniquely well-positioned to cause significant reductions in food waste. Indeed, Young et al. (2017) described the highly positive effects of retail mechanisms and communication in influencing consumers on food waste reduction. However, the researchers conceded that it is in the retailers’ natural interest to sell more product and not to address issues of mass consumption and its associated waste (Young et al. 2017, p. 12). Indeed, retail mechanisms, interdependent with consumer responses, have resulted in prevailing consumption norms of oversupply and abundance that are highly conducive to waste creation (Pedersen et al. 2015, p. 14; Raak et al. 2017, p. 463). Hence, the ways in which retailers operate, and the context of so-called consumer choices, again serves to illustrate the Prevention Paradox at work.

Moving upstream into the supply chain to processing and manufacturing, surplus management also refers to the reuse the unavoidable surplus of ingredients or by-products through “up-cycling” into new innovative products (Bhatt et al. 2018; Lin et al. 2013). This method to create value-added products seeks to exploit the “food surplus resource” (Midgley 2013). However, as will be discussed in the context of landfill prevention further below, the treatment of food surplus or, inadvertently, food waste as a resource can have a perpetuating effect on surplus creation and thus contradict preventive and reductive approaches of surplus avoidance, hence reflecting another tension in preventing waste (Raak et al. 2017).

A dominant surplus management strategy, particularly in recent years, has been for major food suppliers and retailers to work with food rescue organisations to redistribute surplus food. Such initiatives include food rescue, food banks, food donations, social supermarkets, and a variety of different approaches to redistribute surplus food from manufacturers, retailers, and foodservice institutions (Booth et al. 2014; Evans et al. 2012; Garrone et al. 2016; Lebersorger and Schneider 2014). Whilst some would argue that the food waste/food relief nexus highlights problems in both in terms of the food system dysfunction and growing income inequality (Richards et al. 2016; Devin and Richards 2018), others have noted that surplus food donation is a desirable and just method of managing food surplus (Garrone et al. 2016). Surplus food donation is often approached from a normative standpoint, reflecting the immediacy of need for those seeking food relief, and the visible excess food that would ordinarily reach landfill. In the absence of alternatives to both growing income inequality (Piketty 2014) and the food waste problem, the practical and charitable principles of donating food rather than throwing it away have been largely embraced by supply chain actors, academics, policymakers and civil society (Mourad 2016; Lebersorger and Schneider 2014).

Empirical research regarding food re-distribution initiatives in developed countries further supports food waste redistribution with findings that such schemes make a positive contribution to economic, social, and environmental sustainability (Hoisington et al. 2001; Mirosa et al. 2016). However, there are also detracting voices that question the extent to which this dumping of excess food onto socio-economically marginalised populations addresses the dual and related issues of food waste and food security. For instance Booth et al. (2014) noted that at best food rescue and re-distribution is a band-aid solution, whilst Richards et al. (2016) argue that neoliberal rollback in countries such as Australia has reduced social issues such as poverty and
hunger to a new space for the expression of corporate social responsibility in an essentially dysfunctional food system.

Despite the growing attention on food rescue and food relief, only a small percentage of excess food is actually donated by corporations. Not all surplus food is donated, and not all hungry people are fed. A study by Lebersorger and Schneider (2014, p. 1914) on 612 supermarkets in Austria states the amount of food donated as low as 2.3% for the fruit and vegetable category and about 7% on average across other categories such as bread, dairy and packaged foods. While the absolute impact of redistribution on food waste prevention might be modest, it is an important initiative for highlighting the problems of food waste and responding to immediate household food security.

In sum, the understanding of food surplus causes and its prevention as a supply chain management issue focuses on efficiency, innovation, and charity. A closer look, however, revealed that the methodologies suggested for their preventive potential are more essentially focused on surplus disposal rather than avoiding surplus from existing. Ultimately, treating and measuring prevention as if it is efficiency in surplus disposal reinforces, perhaps even encourages, producing more surplus.

Educating consumers not to throw away food

The concepts of consumer education and behavior change are the predominant approaches to food waste prevention. Indeed, academic literature and official reports have implicated the consumption phase as the largest contributor to food waste in Western developed countries (Aschemann-Witzel et al. 2015; Calvo-Porral et al. 2016; FAO 2011). A comprehensive literature review by Principato (2018) is entirely dedicated to “Food Waste at Consumer Level” and pinpoints the lack of consumer awareness as well as related incorrect behaviour as the key reasons for consumers wasting food. Once consumer education and behavior is identified as the cause, the logical solutions put forward centre on practical interventions into everyday lives of consumers and their decision-making processes as well as social campaigns (Principato 2018, p. ix). Consequently, the emphasis in this paradigm is placed on personal responsibility and influencing how it is exercised.

Certainly, consumers and households are one of the points along a value chain where food is wasted, and so initiatives to influence personal food waste are important. Yet the emphasis on consumers is disproportionate. Some suggest the early focus on household surveys and waste composition analysis resulted in comparatively high levels of data on consumer and household food waste (Campbell et al. 2017; Höjgård et al. 2013; Van der Werf and Gillyliland 2017). Another reason why the emphasis on consumer and household food waste is disproportionate stems from the position of the consumer at the end of the supply chain. All the cumulative effects from production, transportation, storage, and retail can be measured in the food wasted by consumers, thus creating a higher environmental impact compared to products wasted earlier in the supply chain (Bernstad et al. 2017). There is also, potentially, cultural tendencies among consumers to feel guilt and anxiety about their food waste that support the emphasis on personal responsibility (Evans et al. 2012). Arguably, these various factors contribute to the impression, particularly in popular discourse, that consumers and households should be the main group targeted if food waste is to be reduced (Campbell et al. 2017; Principato 2018; Quested et al. 2013; Vermeulen et al. 2012).

The strong emphasis on consumers and households as the key to solving the food waste problem is prominent in food waste discourses, but it is by no means universally accepted. In his aptly titled article “Blaming the consumer—once again”, Evans (2011) disagrees with the proposed view of food waste as a consumer behavior problem. He joins other researchers in arguing that the social and material conditions of food consumption and the impacts of the prevailing food system on consumer behaviour need to be taken into account as well (Carolan 2018; Chaboud and Daviron 2017; Quested et al. 2013; Mylan et al. 2016; Urrutia et al. 2019).

In response, research has focused on consumer impacts from supply-side mechanisms such as purchase inducements, choice editing, smart defaults, and strategies of advertising communication, which utilise cognitive biases in humans (O’Rourke and Lollo 2015). Indeed, the findings suggest that a substantial part of consumer waste is generated by practices upstream, such as packaging, promotional offers, restaurant portions sizes, fast food consumption habits, and overprovisioning (Butler and Dixon 2012; Evans 2011; Göbel et al. 2015; Langen et al. 2015; Mylan et al. 2016). This indicates that food waste creation at the household level cannot be explained by consumer behavior as a sole cause, but has to be regarded within the structural context of the whole food supply chain.

We take as an example the fact that consumers buy more than they need, which has been cited as a behaviour leading to food waste (Quested et al. 2013). It may be argued that the appropriate response, in that case, should be to teach consumers not to purchase waste rather than not to throw away waste. It may also be questioned whether teaching the consumer is at all a salient approach to the problem of overpurchase. Critical food scholars like Dixon (2002) and Parker (2014) described the comparative lack of power of consumer purchase choice versus retail marketing mechanisms as a series of inconsequential decisions and a fallacy. Concerning the impact of available supply upon consumer behaviour, Chaboud and Daviron (2017, p. 5) argue that it has not been shown conclusively how reduced consumer purchases and
reduced household waste will result in reduced production and natural resource use further up the supply chain.

The excessive focus on consumer behavior and education is an example of the Prevention Paradox. Influencing consumers to throw away less food does not necessarily or directly result in an absolute reduction in food produced only to be wasted. Rather, the narrative of prioritising teaching, nudging or forcing consumers not to throw away food leads to a reductionist understanding of food waste that distracts from broader food system dynamics including an economic system built upon aggressive marketing alongside neoliberal ideologies of unfettered growth.

**Circular economy and zero waste (to landfill)**

The third paradigm entails diverting organic matter to prevent it from going to landfill and it centers around the concepts of “zero waste” and “circular economy". The framing of “zero waste” arose from the EU landfill directive (European Commission 1999), which understood “zero waste” as “zero waste to landfill”. During this period, other countries and international institutions adopted “zero waste to landfill” and landfill prevention policies (Bloom 2010; Evans et al. 2012; Ghisellini et al. 2016; Zaman 2015). Since this time, landfill diversion has become a core target for waste managers in many countries with the “diversion rate” still widely used to measure success in combatting waste (Zaman and Lehmann 2013).

The more recent concept of a circular economy seeks to shift linear production and consumption systems towards keeping materials in use, which approach has been embraced by states (e.g. the EU and China) and international institutions (Zacho and Mosgaard 2016; Zaman and Lehmann 2013). Similar to zero waste, circular economy approaches focus on recycling and reuse, and it also uses landfill diversion rates as a key measure. These concepts are useful for waste management and do denote some kind of waste prevention i.e. that the goal is to reduce the extraction of natural resources indirectly by reusing and recycling waste. Although zero waste and circular economy approaches are holistic, systematic literature reviews find they tend to be narrowly interpreted in practice as largely aimed at reducing landfill while systems-change is often not emphasised (Zaman 2015; Kirchherr et al. 2017).

As the success of these approaches rely on the amount of food diverted, the responses have tended to focus on enabling innovation and technological developments to repurpose end-of-pipe food waste, often referred to as waste transformation of food waste valorisation (Ghisellini et al. 2016; Mena et al. 2011). As mentioned above, a favoured approach is to turn food waste into animal feed (Salemdee et al. 2017b). Another solution as mentioned above in the context of food surplus is upcycling into what Bhatt et al. (2018) refer to as “value added surplus products”. These are beneficial products, which can be extracted from food surplus and waste. Raak et al. (2017) have presented a review of commodity-specific waste prevention and value-adding approaches, which address a variety of food processing by-products, surplus products and waste, all of which pose different operational challenges to extract value. Crucially in this context, value-adding is not just an ad-hoc waste management or prevention measure. Rather it requires an underlying business model that considers the source of inputs, the processing and packaging equipment needed, and successful marketability of the resulting valorised products. Further, there is evidence that depending on specific types of waste and manufacturing processes, such as micro-nutrient extraction for the health supplements industry, only small amounts of surplus are captured with the balance destined for landfill (Mehta et al. 2014). Because such approaches rely on substantial investments into waste to generate value, those socio-technical systems in place to transform waste may ultimately demand and encourage the continuous and reliable supply of surplus and waste (Raak et al. 2017, p. 467).

Energy generation is another popular form of advanced waste transformation. Food waste generates energy through processes such as incineration or anaerobic digestion. Compared to composting food waste to recover nutrients, which produces “dirt instead of energy” (Bloom 2010, p. 259), industrial energy recovery is a significant technological and infrastructural step-up. However, research has also shown that a significant part of the energy from food waste is irrecoverable due to the “double energy” embodied in food waste, the non-consumed nutritional energy combined with the energy consumed to make the food (Vittuari et al. 2016, p. 2).

Preventing organic waste from entering landfill may address one source of highly negative environmental impacts of food waste i.e. greenhouse gas emissions (Marin et al. 2014; Vermeulen et al. 2012). Yet, there are still significant trade-offs and barriers to zero waste circular economy approaches. Food waste treatment and recovery requires costly infrastructure, technology, economies of scale, investment, and returns on investment. It does not, however, reduce the amount of food waste generated—but presents a more palatable conceptual shift where waste is no longer seen as an output or externality but as a resource and input into energy production. The technological and commercial optimism of creating a business around food waste may thus even contribute to more waste as the market mechanisms require a supply of food waste to achieve viable volumes for investment and production (Bloom 2010, p. 279; Corvellec et al. 2012, p. 303). This is partly because the costs of goods may decline as reused inputs cost less. Further, the emphasis on technological transformation and disposal of waste (Evans et al. 2012, p. 22) contributes to a normalization of
unsustainable production and consumption while preempting questions of responsibility and social license to create waste (Corvellec et al. 2018, p. 18).

By emphasising the limited ways in which dominant approaches to waste prevention focus on responding to the material presence of waste, it is argued here that no approach has been developed for implementation that primarily seeks to reduce waste in absolute terms. Thus, the approaches that do exist could be a distraction from food waste prevention by promoting competing methods (Mourad 2016) or even a hindrance of food waste prevention by committing long terms investments to waste transformation or disposal infrastructures (Corvellec 2016). Having addressed the food waste Prevention Paradox and three distinct but problematic conceptions of food waste prevention, the next section turns to an exploration of the relationship between the overproduction of food and food waste prevention, an area that is currently under-theorised and absent from key debates, despite the well-established need for the prevention of food waste.

Addressing food surplus, food waste and avoidance of overproduction

The previous section addressed how prevailing prevention paradigms are to different extents succumbing to the Prevention Paradox. While they appear to be prevention strategies, the broad types of approaches are rendering them incapable of directly addressing the avoidance of food waste creation in the first place. It follows that a broader, holistic, whole system approach is necessary to address the problem of food waste at the source. To do this, it is important to understand the historical evolution of the agri-food sector, which has led to the current outcome of excessive food waste.

An emerging focus in the food waste literature looks beyond internal supply chain dynamics by positioning food waste as a problem of overproduction (Bloom 2010; Chaboud and Daviron 2017; Evans et al. 2012; Mourad 2016; Pritchard 2012; Weis 2007). Situated firmly in the global political economy of food and agriculture, the overproduction thesis maintains that food produced in excess of demand promotes both overconsumption and waste. Both of these outcomes have been observed by researchers and have been strongly associated with negative impacts on health and the environment (Hall et al. 2009; Hic et al. 2016; Vandevijvere et al. 2015; Vulcano and Ciccarese 2017; Weis 2007). Overproduction represents a well-known area of scholarship into global food systems, generally with an emphasis on agricultural dumping, aid, trade and global geopolitics (Clapp 2014; McMichael 2009; Pritchard 2012), but has only recently been posited as a key influencing factor of food waste, with more work needed to fully explore these dynamics.

The structural overproduction in food systems received focused attention in the work of critical political-economists, Friedmann and McMichael (1989). Their theory recounts the rise of a post-war food regime, which was aptly described as a “chronic and expanding state of surplus” (Weis 2007, p. 63). Technological advances, cheap fossil fuels and sustained public subsidies, predominantly in the US and Europe, drove food production to historically unprecedented surplus levels (Pritchard 2012; Weis 2007). The continued escalation of food production was realised by fast growth of output volumes and also by concentrated industrialisation primarily achieved through the accelerated production of livestock and durable processed foods (Evans et al. 2012; McMichael 2009). The invisible fats and the unneeded and low-cost nutrition surplus (Butler and Dixon 2012) in turn produced consumption levels “inconsistent with healthy bodies, societies, and cultures” (Friedmann, 2008, p. 618). The run-away food production of the last half century has no longer been bound by the purpose of feeding people food to meet their nutritional needs, by market demand or by the necessity to create sufficient safety stocks to secure food availability (Papargyropoulou et al. 2014). Food production has simply carried on for its own sake and the accumulation of capital (Pritchard 2012). Accordingly, the overproduction of food has become entirely normalised as the prevailing and likely the only known mode of production and consumption in developed, and increasingly middle-income, countries (Mourad 2016; O’Rourke and Lollo 2015; Weis 2007).

The relationship between overproduction and food waste has been considered by researchers examining different food production systems and comparing the waste generated as one of their outcomes (Parfitt et al. 2010; Vulcano and Ciccarese 2017). Based on studies in the EU, this body of work provides evidence for the fact that industrial agricultural production and distribution models produce a significantly higher rate of waste than contrasting short and alternative supply chains (Vulcano and Ciccarese 2017, p. 41). These findings belie the intuitive claim that large-scale, industrial agri-food systems are the most resource efficient (Ericksen 2008; Parfitt et al. 2010) and add to the substantial existing evidence that alternative food systems tend to produce more sustainable outcomes (Burch and Lawrence 2005; Carolan 2018; Dixon and Richards 2016). Food waste is, therefore, interwoven with dominant modes of food production and food system designs that depend upon chronic oversupply.

Some studies sought to quantify the scale of food surplus. Hic et al. (2016, p. 4269) analysed data on the amount of food physically available on a global scale against the different projections of human nutrition requirements. Their research indicated that current levels of food surplus intended for human consumption alone (i.e. not including animal feed and biofuels) already exceed nutrition requirements by approximately 20%. Most alarmingly, however,
since food production has been outpacing actual food (over) consumption, which is already in excess of, and growing faster than, nutritional requirements, the growing future surplus is expected to be predominantly “generating food waste rather than further overconsumption” (Hic et al. 2016, p. 4275). Thus, it appears that global food production will increasingly find its purpose in producing food waste rather than feeding people—the natural landing point for an economy based on continued growth.

The amount of food surplus closely corresponds with the trend-line of the world population classified as obese and with the upward trend for food waste generation (Hall et al. 2009; Vande Vijvere et al. 2015; Weis 2007). Indeed, some scholars consider the problem of food waste as a problem of food surpluses (Carolan 2018; Papargyropoulou et al. 2014; Vulcano and Ciccarese 2017; Weis 2007). Of course, correlation is not causation. Yet, this research, especially in the context of the systems-based understanding of food processes, evidences close interrelationships between the prevalence of diet-related NCDs, food waste and food surplus generation. In studying these interrelationships further, scholars have provided various understandings. For instance, Hall et al. (2009, p. 2) suggested that the “food intake in the US has been unable to match the increasing physical availability of cheap food”, and processed foods in particular, resulting in a “progressive increase of food waste”.

If systemic and endemic overproduction is a significant contributing factor to the food waste problem, prevention of surplus food production or “supply restraint” (Weis 2007, p. 63)\(^1\) should have the potential to deliver equally significant social and environmental benefits (Quested et al. 2013; Van Ewijk and Stegemann 2016; Vulcano and Ciccarese 2017). The key debate in the food waste prevention literature does not, however, consider the environmental benefits of supply restraint as much as the impacts that reducing or avoiding food production might have on the economic system as a whole (Mourad 2016; O’Rourke and Lollo 2015; Rutten 2013).

Economic theorists evaluate positive and negative net outcomes by applying a method of theoretical modeling, which allows for a comparison of a variety of food waste prevention variables. Some research in this specific field indicates significant positive outcomes from supply restraint as a measure of food waste prevention for areas such as greenhouse gas emissions, household income and agricultural land use with positive flow-on effects for economies and societies (Parry et al. 2015; Rutten et al. 2013). It has been argued, however, that the benefits of supply restraint cannot be assessed merely as the equivalent of the avoided resource use, as a host of other intended and unintended impacts must be taken into consideration (O’Rourke and Lollo 2015; Rutten et al. 2013). Some economists assert that the potential overall benefits of supply restraint as a measure of food waste reduction are overstated once economic counter-effects such as increased use of alternative resources and compensatory impacts like the “rebound effect”\(^2\) are fully taken into account (Högård et al. 2013; Köster 2014; O’Rourke and Lollo 2015; Salemdeeb et al. 2017a).

Theoretical modeling has suggested that a broader systemic approach, such as influencing populations to adopt healthier diets, would result in more sustainable environmental and economic outcomes than a single-minded focus on supply restraint to reduce food waste. Without even considering the long-term gains from improved public health, adopting a healthier diet has arguably less negative impact on GDP and a highly positive environmental impact in terms of reduced agricultural land-use (Rutten et al. 2013, p. 11). Moreover, considering the close relationship between unhealthy diets and food waste generation, a systemic approach of promoting healthy diets is likely to cause food waste reduction as a side-benefit.

Apart from specifically environmental and economic consequences, measures to restrain production and consumption as a means of preventing food waste would also impact, and come up against, societal customs and norms (Mourad 2016; Mylan et al. 2016; O’Rourke and Lollo 2015). Customs and traditions often encourage the over-supplying of food, especially around celebratory events, and may be adversely affected by measures to restrict production and consumption (Parfitt et al. 2010). Mylan et al. (2016, p. 4) argue “society is accustomed to a life that requires a multitude of materials and services. A detailed examination of the practices of daily life brings to light the problems consumers face in even changing quite mundane parts of their life”. Surplus production and the over-consumption of food are associated with diet-related, non-communicable disease. Banwell and Dixon (2013, p. 298) offer the term “consumptogenic environments”, to demonstrate how high levels of consumption are encouraged and condoned by external factors like food marketing, food retail strategies and the loss of clear cultural norms around eating as diets converge and become more Westernised (Banwell et al. 2012; Banwell and Dixon 2013). The changes required to depart from the production and consumption mechanisms deeply ingrained within the prevailing food surplus regime go beyond what the efforts of

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\(^1\) “Supply restraint” can be described as a set of interventions to prevent supply from exceeding demand, thus avoiding unneeded surplus production.

\(^2\) The “rebound effect” or Jevon’s Paradox describes the negative consequence of increased consumption resulting from resource efficiency gains (e.g. O’Rourke and Lollo 2015, p. 241).
consumers alone can achieve (McMichael 2009; Principato 2018).

It would be a mistake, therefore, to focus on supply restraint solely as a technical means of preventing food waste, simply by reducing production amounts. Any efforts to constrain supply must be also complemented by a change of social and cultural practices and values. Accordingly, the kinds of transformation required to address food waste will involve changes to behavior, culture, infrastructure and economic values in a holistic and integrated way (Canali et al. 2013, p. 17; O’Rourke and Lollo 2015, p. 252).

Discussion and conclusion

In response to the UN Secretary General’s call for “profound transformation” (UN Economic and Social Council 2018), this paper has proposed a more holistic understanding of food waste prevention beyond the confines of waste management. Arguably, cultural values around food, an economic paradigm grounded in the concept of continued growth and investment in food waste management infrastructure, have enabled a socio-technical lock-in to a structure that manages rather than reduces food waste. Couple this with the ontological difficulties of measuring absolute prevention, or in other words, measuring something that is not there, and absolute prevention may be difficult to attain. Despite this, if aspirations of food waste reduction are to be achieved, a re-articulation of food waste and loss and its prevention are necessary. This requires recognition and acceptance of the problem of structural overproduction and overconsumption.

By highlighting the contradictions in approaches that aim to prevent surplus going to waste, educate consumers, and achieve zero waste to landfill, the “Prevention Paradox” supports a conceptual reorientation towards overproduction and overconsumption. Research on food surplus indicates that the possibility of prevention as absolute reduction exists, but this approach lacks ideological support and clear implementation methodologies. Considering the conceptual uncertainties that underpin food waste prevention, there is a need to advance the theoretical and practical understanding of what large scale food waste prevention beyond waste management should constitute. This involves an ontological and normative enquiry to clarify what is being wasted, what is being prevented, what absolute reduction should mean, and how it is justified in relation to sustainable food systems and finite limits to growth (Clapp and Swanson 2009; Corvellec et al. 2018; Sandberg et al. 2019; Savaget et al. 2019).

Based on a more open and holistic understanding of food waste prevention, new approaches and methodologies outside of the prevailing waste management paradigms are required to better enable sustainable production/consumption. Either way, we argue government and industry need to identify responses to overcome the systemic socio-economic quandaries described by the “Prevention Paradox” to get more traction. This might imply that sustainable solutions will have to address substantial trade-offs rather than acquiesce to business as usual. The nascent literature that links the well-trodden areas of food waste and overproduction may well be the pathway to understanding the root causes of food waste. Given the economic hegemony of the unfettered growth paradigm, this approach will not be without controversy—however, the increasing acceptance of the “limits to growth” argument will necessitate a space for such debates.

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Rudolf Messner is a PhD Candidate at the School of Management, QUT Business School. His research area is food surplus and waste, with a specific focus on food waste and its prevention in primary agricultural production and early supply chain stages.

Carol Richards an Associate Professor at the School of Management, QUT Business School, Australia. She is a food and agricultural sociologist specialising in sustainable food systems, food insecurity and food governance. She has contributed to academic and public debates on issues relating to power and social justice in the global food system.

Hope Johnson is a lecturer at the Faculty of Law and a socio-legal researcher, who studies food and agricultural law, governance and policy at QUT School of Law, Faculty of Law, and with the Institute for Future Environments.