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Linking middle-chain actors to the environmental impacts of food producers and consumers: Underlying drivers and policy implications

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Executive Summary

The majority of GHG emissions, pollution and biodiversity loss from food systems come from agricultural and dietary practices - that is to say, what is produced on the farm (and eventually eaten) and how we produce it.

However, whilst farmers and consumers produce the majority of these impacts, they are not necessarily wholly in control of or always have the ability to mitigate the impacts they produce. Rather, farmers and consumers are operating and living in complex networks where relationships with other actors in the system drive certain behaviours while limiting others. Because of their size and buying power, global food manufacturers and retailers in particular have significant weight in these networks of relationships.

A rapid review of the academic literature examining the interface between middle-chain actors and farmers and consumers was conducted. This evidence synthesis showed that, while the drivers of agricultural and dietary practices are multi-faceted and complex, middle-chain actors, particularly food manufacturers and retailers, exert pressures on farmers and consumers that result in behaviours which lead to negative environmental impacts.

In farming, there is strong evidence that, in horticulture, competition between farmers for a limited number of unpredictable retailer contracts in which stringent cosmetic standards are applied leads to over-production and on-farm food loss. In arable and staple food production, emerging evidence suggests the food processing industry has a role in driving on-farm fertiliser use and driving biodiversity loss through the production of ultra-processed foods. These practices are enabled through the mobilisation of middle-chain actors' power in contract negotiations, where retailers and manufacturers are able to off-load the economic and environmental costs of food loss and environmental damage to farmers. This leaves no incentive for these middle-chain actors to measure, report on and adapt their processes to reduce environmental impacts elsewhere in their value chain.

In households, manufacturers and retailers employ a range of tactics to increase sales that drive over-purchasing and consumption of foods at a household and individual level. Interestingly, the evidence is mixed on the impact of some of the more seemingly obvious drivers. It is unclear whether advertising ultra-processed foods (UPFs) to adults drives over-consumption. It is also unclear whether price promotions drive household food waste. Indeed, evidence is thin that processors and retailers are major drivers of household food waste. However, it is clear that promotional strategies such as pack and portion sizes and in-store product placement, underpinned by an 'omnipresence' strategy, play a major role in the amount purchased and consumed, particularly for ultra-processed foods.

The findings of this review point to the importance of taking a policy approach that will facilitate a transition to a value chain of mutual responsibility, where actors along value chains must internalise the risk and costs of Scope III environmental impacts as much as Scope I. This report points to several concrete policy actions that must be taken to ensure that efforts across the value chain are effectively implemented and transparently monitored. Such advances in the EU legislative framework for sustainable food systems will go a long way in advancing value chains towards mutual responsibility for transitioning to a more equitable and sustainable food system.

5 policy priorities for reducing the indirect environmental impacts of middle-chain actors

1. Ensure the upcoming EU *Corporate Sustainability Due Diligence Directive* covers the agricultural sector as part of the high risks sectors and provides for a comprehensive definition of environmental impacts based on a non-exhaustive list approach
2. Update the *Commission Delegated Decision (EU) 2019/1597* to include pre-harvest and on-farm food loss in the definition of food waste and require measurement and reporting of pre-harvest and on-farm food waste
3. Prevent companies from bidding for public contracts if they fail to prove appropriate due diligence for mitigating environmental impacts along their value chain
4. Incorporate negative environmental impacts into *Directive (EU) 2019/633* on Unfair Trading Practices, with a specific focus on contracts that set designated prices, work on farmers' time horizons and protect farmers from undue losses due to fluctuations in harvest amounts
5. Measure, monitor and publish food companies' performance on shifting consumers' purchasing behaviours towards sustainable and healthy diets by an external monitoring body

1.0 Introduction

The majority of GHG emissions, pollution and biodiversity loss from food systems come from agricultural and dietary practices - that is to say, what is produced on the farm (and eventually eaten) and how we produce it (FAO, 2018; Poore and Nemecek, 2018; Crippa et al., 2021; OECD, 2022). Because the impacts from these polar ends of the chain are so pronounced, it seems logical that the vast majority of research, advocacy and policy has focused on shifting dietary and agricultural practices to become more environmentally sustainable. While such efforts are undoubtedly important, there has been comparatively little consideration of actors in the middle of value chains – the wholesalers, processors, retailers and food service businesses – and their role in the production of negative environmental outcomes from food systems (Caleffi et al., 2023).

This lack of focus may be due to the fact that the direct environmental impacts of these actors are relatively quite small (Poore and Nemecek, 2018; Crippa et al., 2021). However, whilst farmers and consumers produce the majority of these impacts, they are not necessarily wholly in control of or always have the ability to mitigate the impacts they produce. Rather, farmers and consumers are operating and living in complex relational networks with other actors in the system who encourage certain behaviours while limiting others (Hawkes et al., 2012; Herforth and Ahmed, 2015; Hendrickson and James, 2016). Due to their size and buying power, middle-chain actors are particularly powerful players in shaping the way these networks function (Howard, 2016; Clapp, 2021).

While the existing suite of tools and policies for shifting agricultural and dietary practices, such as certification and labelling schemes, agri-environmental subsidies, public awareness campaigns, are important, they are somewhat limited in scope. These tools do not yet account for other potentially competing drivers and sources of pressure exerted on farmers and consumers by other actors along value chains. The aim of these strategies is to incentivise a change in behaviour at an individual, household or farm level but these incentives might not be stronger than those that are driving the current production and consumption practices that are so environmentally harmful. This may be one of the reasons that progress towards more sustainable food systems has been slow (Conti et al., 2021).

The drivers of agricultural and dietary practices are undoubtedly numerous and complex. However, given the importance of middle-chain actors in shaping value chains, a clearer understanding is needed of if and how these middle-chain actors drive farmers and consumers to produce negative environmental outcomes. Indeed, a rapid review of the academic literature shows that middle-chain actors drive behaviours that produce negative environmental outcomes on farms and in diets and households. The mechanisms through which these outcomes are indirectly produced show that certification, labelling and agri-environmental schemes will be insufficient at addressing the underlying drivers of environmental impact. Rather, a shift in the relational dynamics between middle-chain actors with their suppliers and customers is necessary.

1.1 Methods and parameters

The way food systems are currently structured drives a wide range of negative social, economic and public health outcomes in addition to environmental outcomes (FAO, 2017; Swinburn et al., 2019). This report focuses exclusively on the indirect drivers of negative environmental outcomes – specifically how farmers and consumers are driven or incentivised by middle-chain actors to generate GHG emissions, pollution, biodiversity loss and natural resource depletion. While there is also a need for middle-chain actors to reduce the direct environmental impacts of their operations (e.g. emissions from transport, pollution from food processing waste), *indirect drivers* are those where negative environmental impacts are created elsewhere in the value chain – on farms, on dinner plates and in household waste bins – as a result of the business operations and practices of middle-chain actors. Drivers were only included if they are based on action by middle-chain actors rather than *in-action*. For example, the imposition of standards on farmers by retailers is an action (see section 2.2) but the failure to impose standards on fisheries is in-action, thus the latter was not included (see Box 1).

The middle-chain actors considered in this study were wholesalers and suppliers, food processors and manufacturers, retailers and food service businesses. Input businesses such as seed and agrichemical companies, finance institutions and farm machinery providers were not considered, nor were adjacent actors such as waste management companies, packaging manufacturers or external transport and logistics companies. The focus was on environmental impacts from farmers and consumers in industrialised countries rather than those in developing countries from which food is internationally imported. While the environmental impacts of food systems are certainly global in scope and international trade is a major factor, a review of the impact of middle-chain actors on farmers and consumers in developing countries was unfortunately not feasible for this report. Future research should delve further into this issue.

Indirect drivers were identified through an extensive review of the academic literature. Academic papers were identified through an iterative search method informed by a categorical framework of the pathways of environmental impacts – food production, loss, (over) consumption and waste (described in Table 1). Web of Science and SCOPUS were searched using a combination of the middle chain actor, the environmental impact and the farmers or consumers. Papers were excluded that focused on the direct impacts of middle-chain actors (e.g. the emissions from food processing itself) and only those papers that discussed the relational dynamics between middle-chain actors with farmers and consumers around an environmental impact were included. As indirect drivers were identified, further iterative searches were conducted to explore the topic which, in some cases, led to the identification of new drivers.

Only empirical research papers were included. Prior reviews that cover multiple drivers were used only as a source to point to original empirical research rather than as a direct source. The exception to this approach was when reviews focused exclusively on a specific driver. Where possible, empirical research was limited to studies conducted in Europe. However, where a specific body of research has emerged from another similarly industrialised country (e.g. Australia or the USA), these articles were included.

1.2 Indirect drivers of environmental impacts

There are two pathways through which food systems impact the environment – through the production of food and the disposal of food. Every actor along the value chain directly generates these impacts as part-and-parcel of producing, consuming and wasting food and there are numerous well-documented steps individual businesses and consumers can take to reduce their own direct environmental impacts. This study, however, identifies the *indirect drivers* of negative environmental impacts produced through farmers (section 2.0) and consumers (section 3.0). *Table 1* shows the various ways that middle-chain actors drive farmers and consumers to produce negative environmental outcomes that has been considered in the academic literature. Each is described in detail below.

With regards to the management of food loss and waste, there is currently a strong emphasis in research and policymaking on redistribution and re-use. However, while such efforts may help with mitigating the impacts of food decomposing in landfills, it does little to mitigate the already-produced impacts of surplus agricultural production. Thus, food loss (on farms, section 2.0) and food waste (in households, section 3.0) are considered here in light of the need for prevention above other modes of waste management (Papargyropoulou et al., 2014; Messner et al., 2020; Messner et al., 2022). Present policy discussions also fail to consider the embedded environmental impacts of food that is produced, processed, transported and stored for the purposes of over-consumption by consumers (Blaire and Sobal, 2006, Swinburn et al., 2019). While this food is not 'wasted' in the traditional sense, it is, by definition, unnecessary. Thus, the framework in *Table 1* reflects that over-consumption is inherently linked to over-production.

	Through farmers		Through consumers		
	Production Practices	**On-farm losses**	**Pre-store waste**	**Over-Production / Over-Consumption**	**Food Waste**
Retail	• Cosmetic standards (2.1, Low) • Low prices (2.4, Low)	• Cosmetic standards (2.2, High) • Low prices (2.4, Low) • Risks of under-supplying (2.5, Medium) • Time-horizons and demand forecasting (2.6, High) • Promotions (2.7, High)	• Display and availability requirements (2.8, Low) • Cost off-loading (2.9, Medium)	• Price Promotions (3.1, Medium) • In-store product placement (3.3, High) • Strategic category priorities (3.7, Low)	• Price Promotions (3.1, Medium)
Wholesale & Supplies	• Low prices (2.4, Low)		• Cost off-loading (2.9, Medium)		• Pack and portion sizes (3.2, High)
Processing & Manufacturing	• Low prices (2.4, Low) • Food processing specifications (2.3, Medium)	• Cosmetic standards (2.2, Medium)		• Pack and portion sizes (3.2, High) • Advertising and marketing (3.4, Medium) • Product formulation (3.5, Medium) • 'Omnipresence' (3.6, High) • Low prices (3.8, Medium)	
Food Service				• Pack and portion sizes (3.2, High)	• Pack and portion sizes (3.2, High)

Table 1: The mechanisms that drive negative environmental impacts by each middle-chain actor. Each mechanism is listed with the section in which it is discussed and the strength of the evidence that it is an indirect driver. ***Through farmers****: Production practices on the farm result in negative environmental impacts through harmful production practices such as the over-use of fertilisers and pesticides, soil compaction from machinery, etc. On farm losses refer to edible items that are lost on the farm while pre-store waste refers to edible items that are lost due to rejection by middle chain actors and never make it on to supermarket shelves.* ***Through consumers:*** *Over-production/over-consumption refers to food that is produced and eaten but beyond what is needed to properly fuel the body. Food waste refers to items that are or were edible but are never eaten.*

A note on fisheries and aquaculture

Fisheries and aquaculture produce significant negative environmental impacts through over-fishing, biodiversity loss, greenhouse gas emissions and marine habitat destruction (Poore and Nemecek, 2018; WRI, 2019). However, its unique industry structure and regulatory environment means that, there is no evidence that middle-chain actors exert pressure on fishers and consumers in industrialised countries which lead to negative environmental outcomes. Therefore, fisheries and aquaculture were not factored into the framework in Table 1.

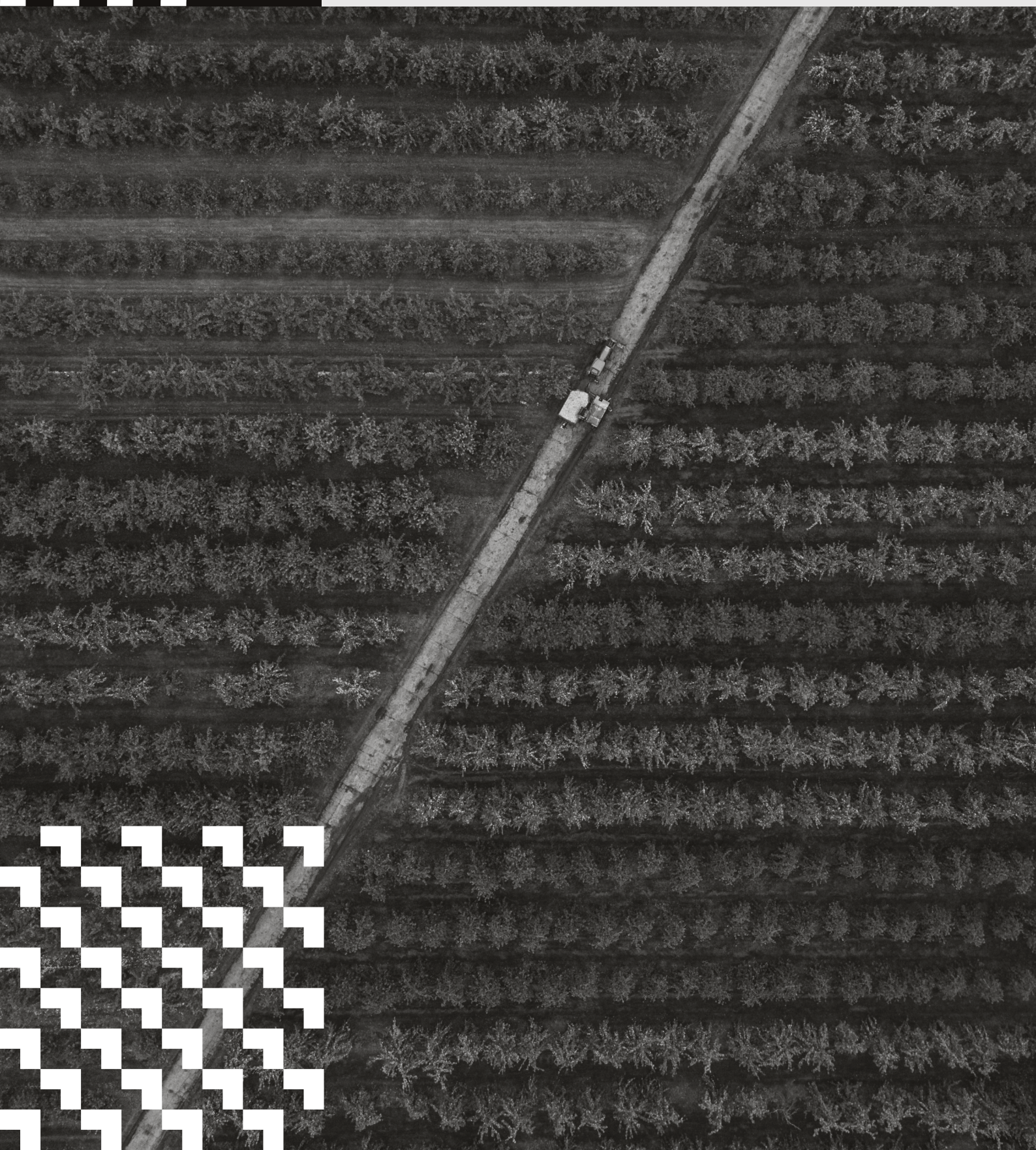
In the aquaculture sector, the tendency for several years has been towards consolidation and vertical integration (Kvaløy and Tveterås, 2008; Primefish, 2017; Asche et al., 2018; Bush, 2018; Ektör and Ortega-Cerdà, 2018; Llorente et al., 2020). In most cases in industrialised countries, the primary producer of the fish is also the processor, trader and transporter. The only pre-consumer relationship is between the producer-processor and the retailer. The only studies that link the relationship between aquaculture firms and retailers to negative environmental outcomes are on retailers' failure to impose sustainability standards on aquaculture producers (Changing Markets Foundation, 2021)(see section 2.0). Bush (2018) proposed that, while vertical integration poses potential problems from a socio-economic standpoint, it provides firms with a greater ability to 'upgrade' to more environmentally sustainable production practices because they have the capital and the capacity to do so.

For marine fisheries, the main negative environmental outcome is overfishing and the depletion of fish stocks, which includes by-catch and discards. In Europe, the marine fisheries industry is trending towards larger vessel sizes, smaller numbers of vessels and fewer fishing companies, but the sector has not yet reached the same degree of vertical integration as is found in aquaculture (Warmerdam et al., 2016; Primefish, 2017). There is still a designation between middle-chain actors and fishers, but no empirical research was found that explicitly linked pressures from middle-chain actors to negative outcomes in marine environments except for a failure to closely monitor illegal fishing (see section 2.0).

Another area of potential concern from middle-chain actors is in the ownership and leasing of fishing quotas by fish processing companies. Quotas – or 'total allowable catches' (TACs) are the main mechanism through which over-fishing is currently addressed in Europe. Different countries within the EU manage their quotas differently. Some countries allocate individual quotas to fishers based on the national total (e.g. Belgium), while others use individual transferable quotas (ITQs) where catch amounts can be transferred and leased between fishers (e.g. Sweden, Denmark, the Netherlands) (see Carpenter and Kleinjans, 2017, for a review). There is some evidence that, if ITQs can be held by food processors, they will be leased to fishers and used to extract greater rents from fishers. This scenario, however, has only been identified in Canada (Haas et al., 2016; Edwards and Pinkerton, 2019) and Australia (Emergy et al., 2014; FRDC, 2019). Reviews of allocation policies in the EU by Carpenter and Kleinjans (2017) and Hoshino et al. (2020) have not identified any cases of non-fisher ITQ ownership in the EU, though note there is potential for it to occur. Countries like Denmark have taken action to prevent such situations by placing limits on ITQ ownership so that only active fishers can own them. More research into country-level ITQ policies would be beneficial but was beyond the scope of this report.

TACs are defined at the international level. Within Europe, TACs surpass scientific advice, so over-fishing continues (Carpenter et al., 2016; Froese et al., 2021). However, it is not clear what role middle-chain actors play in this issue. How quotas are determined and allocated between and within EU member states and among different fishing companies is an intensely political issue and little information has been made public (Hilborn, 2007; Williams et al., 2018). Several studies have pointed out the importance of increasing transparency about the processes for allocating quotas (Carpenter et al., 2016; EASME, 2019). Consequently, the actors primarily discussed in the literature on this issue is fisheries ministers rather than middle-chain actors (Froese et al., 2021).

Despite overfishing being a crucial issue to address in policy, this report provides no policy recommendations on how to handle fishing quotas because of the limited evidence describing the role that middle-chain actors play. However, as middle-chain actors could potentially play a significant role in the political process of quota allocations, more transparency is needed on how decisions on TACs are made in Europe.



2.0 Drivers of indirect impacts through farmers

The decisions farmers make about their agricultural practices is the product of a complex set of economic, social, moral, educational, psychological and environmental factors (Stuart et al., 2014; Hayden et al., 2021). The indirect drivers described below are not exclusively to blame for negative environmental impacts and need to be considered in conjunction with other factors. However, the literature explored below provides a strong sense of the difficulty farmers face in changing their production practices.

2.1 Cosmetic standards driving pesticide use

Cosmetic standards are requirements that food retailers place on the appearance, weight, shape and size of food products. They are primarily applied to fruits and vegetables. A base layer of cosmetic standards is set out in the 'Commission Implementing Regulation (EU) No 543/2011' (2011), but many buyers, particularly retailers, apply additional and stricter requirements on top of these regulations.

Cosmetic standards are most frequently associated with driving food waste (see section 2.0). Some researchers have argued that it is also a driver of pesticide use on farms because the loss of certain cosmetic characteristics in fruit and vegetables can be associated with pests (Pimental et al., 1977; Bosch et al., 1978; Powers and Heifner, 1993). This hypothesis has been tested in California by Zakowski and Mace (2022) who studied the application of pesticides for processing tomatoes and table grapes exclusively for cosmetic purposes from 2009 – 2015. They found that 8.1% of harvested hectares for tomatoes were treated for stink bugs because they leave slight pinpricks and discolouration on tomatoes and, when feeding, can lead the skin to dry and crack. But, the stink bug activity does not impact the taste or shelf life of the plant. The study also found that 57.7% of harvested hectares of table grapes were treated with plant growth regulators, a synthetic hormone that enhances berry size and colour, increasing the marketability of the grapes.

However, in a study of comparative levels of pesticide use across different crops in California, Rosenheim et al. (2020) found that there was no difference in the amount of pesticide applied to crops that were intended for processing (where cosmetic standards would not apply) compared to those that were to be sold unprocessed. Rather, as other non-US studies have shown (Galt, 2008; Grovermann, 2013; Grovermann, 2017), the potential monetary value of the crop is the largest predictor of pesticide use; farmers apply more pesticides to higher value crops in an attempt to protect their investments.

Identifying and quantifying the relationship between pesticide use and cosmetic standards can be challenging because several pesticides are multi-purpose, making it impossible to distinguish the reason for their use. Perhaps for this reason, very little empirical research has been conducted on this subject. The research that has been done comes from California where pesticides have long been a major political issue. Additionally, research conducted with farmers in Germany (Ludwig-Ohm et al., 2019) and Flanders (Roels and van Gijseghem, 2017), found weather to be the largest cause of losses due to cosmetic standards, not insects. Thus, more empirical research, particularly in the EU, is needed to understand the complex relationships between crop value, cosmetic standards and pesticide use versus other drivers.

2.2 Cosmetic standards driving on-farm food loss

Food retailers in Europe routinely require that products meet certain aesthetic requirements. If products, particularly fruits and vegetables, do not meet cosmetic standards, then buyers can reject the order, leaving farmers with portions of their harvest unsold. Rejection based on cosmetic standards is largely considered to be the main and most pressing issue related to on-farm food waste (Joensuu et al., 2020).

When this occurs, farmers and producer organisations in European countries look for alternative market options, such as selling to food processors (Beausang et al., 2017; Roels and van Gijseghem, 2017; de Hooge et al., 2018). However, the ability for farmers to sell their crops for processing is dependent on the crops' transferability of use. Willersinn et al. (2015) and Ludwig-Ohm et al. (2019) note that, in many cases, crop varieties used for processing are different to those sold directly to consumers which closes this alternative pathway to market for several varieties (see also section 2.3). In a study on supply chains in France, Redslingshöfer et al. (2017) also found that transferability between end uses was only available for certain fruits, like apples and apricots, and to a lesser extent for peaches and red berries. Another factor that might prevent the re-purposing of rejected crops is if there is a mismatch between the amount of surplus of 'downgraded' fruit and veg and demand from the processing industry. Selling for processing is also only a benefit to farmers if it covers the cost of production and harvesting, which is not always the case (Priefer et al., 2016; Porter et al., 2018).

Producers in several studies reported that, if they are not able to find a market for their crops, they are either destroyed, transferred into cattle feed, biogas or manure, or ploughed back into the ground (de Hooge et al., 2018). Several studies also reported that famers may not harvest crops they know will not meet buyer standards to avoid the costs of harvesting (Redslinghöfer et al., 2017; Roels and van Gijseghem, 2017; Johnson et al., 2019; Herzberg et al., 2022) (see section 2.4). Whilst composting and anaerobic digestion might be considered to mitigate the negative impact of emissions from sending food surplus to landfill, these products still contain all of the embedded environmental impacts of their production (Porter et al., 2018; Messner et al., 2021).

It is widely accepted that cosmetic standards drive food loss on farms. Consistently and definitively measuring the quantity of these losses and the associated environmental impacts caused by cosmetic standards is, however, difficult. The 'Commission Delegated Decision (EU) 2019/1597' does not require reporting of un-harvested food losses since, prior to harvest, crops are not considered food. Measures are made more difficult by different definitions of 'food loss' and different methods of calculation (Hartikainen et al., 2018; Caldeira et al., 2019; Joensuu et al., 2020; Hoehn et al., 2023). Several European country-level studies have been conducted to measure the quantity of on-farm food losses from cosmetic 'down-grading' (see Joensuu et al. [2020] for an overview). At a European level, Porter et al. (2018) estimated these losses to be between 4-37% of total farm production in the European Economic Area (EEA), equating to up to 51,500 kt and as much 22,500 kt CO_2e of embedded production-phase GHG emissions annually. However, they note that there is considerable uncertainty in these results due to measurement challenges. It is also unclear what percentage of these losses are re-purposed for other uses such as food processing.

Some retailers and box schemes have begun selling 'downgraded' fruits and vegetables. In a German study by Herzberg et al. (2022), producers pointed out in interviews that, while they see the benefit of such schemes for raising awareness among consumers, they only exist for certain products. Additionally, the price for 'downgraded' fruit still does not cover the cost of harvesting and storage. In interviews with de Hooge et al. (2018), both producers and retailers identified several other reasons why the sale of 'downgraded' fruit is undesirable from a market standpoint. The first was that, unless demand increases, competition would increase if sub-optimal products were sold alongside optimal products, lowering the price of 'optimal' products. Second, if 'sub-optimal' products were sold at lower prices, this would lower the prices for products that meet a certain cosmetic standard. Third, there are limits on shelf-space. If a retailer only has room for three boxes of tomatoes, they are not going to add a fourth box full of deviant tomatoes. Retailers are going to pick the products that sell easily. Hermsdorf et al. (2017) found that retailers in Germany held concerns about the extra marketing costs, extra storage, transport and disposal required for handling sub-optimal produce.

Retailers frequently point to consumer expectations as the reason for the application of cosmetic standards (Hermsdorf et al., 2017; de Hooge et al., 2018; Herzberg et al., 2021). However, the evidence does not clearly show whether consumers prefer to buy 'pretty' or 'odd-looking' produce (see for example Loebnitz et al., 2015; de Hooge et al., 2017; Grewal et al., 2019; van Giesen and de Hooge, 2019). One notable example where the application of cosmetic standards seems to be suspended is for organic produce. In Germany, Hermsdorf et al. (2017) interviewed organic retailers who said they regularly sell odd-looking produce which their customers consider 'more natural'. This finding challenges the assumption that i consumer demands necessitate cosmetic standards. However, a study with Danish consumers found that, while there was no difference in consumers intention to buy either 'normal' and 'moderately abnormal' products, consumers were less likely to want to buy 'extremely abnormal' organic products. This finding may be due to the higher price of the organic produce (Loebnitz et al., 2015). Across these studies, the evidence suggests that consumers are more willing to buy products that fit within familiar visual categories (Porter et al., 2018). How and by whom these visual categories are created and perpetuated, and who is responsible for addressing cosmetic standards remains debated by stakeholders (Priefer et al., 2016).

Regardless of where consumers' cosmetic standards originated, there is currently no incentive for supermarkets to actively lower cosmetic standards to reduce on-farm food losses given the highly competitive environment between supermarkets.

2.3 Food processing specifications driving nitrogen use and agrobiodiversity loss

Food processors have strict specifications that they require for the crop inputs they use in their products. Processing specifications are distinct from cosmetic standards (section 2.2) because they are related to biochemical, varietal and species requirements rather than the aesthetic properties of the crop. Researchers have recently begun to consider the various environmental impact of these specifications.

First, achieving biochemical specifications can require farmers to use certain production practices. For example, the requirement from industrial bakeries in Western Europe for wheat with high protein levels necessitates high doses of nitrogen fertilisers, without which wheat could not reach the necessary protein levels (Hawkesford, 2014; Meynard et al., 2017; Zörb et al., 2018; Magrini et al., 2019). Meynard et al. (2017) point out that the nitrogen

fertilization requirement for cereal crops in Europe provides a good illustration of how policymakers might put pressure on farmers to decrease their fertilizer use while millers, grain merchants and processors pressure those same farmers to increase fertilizer use to achieve their specifications.

In addition to driving certain production practices, there is a growing body of evidence showing that the food processing industry and rise of ultra-processed foods is driving agrobiodiversity loss; mostly through the large-scale reliance on a narrow set of crop species and varieties (Fardet et al., 2020; Seferidi et al., 2020; Anastasiou et al., 2022; Leite et al., 2022). For example, at the varietal level, again in the case of wheat, the need to meet certain specification requirements leads farmers to plant a narrow selection of genetically homogenous wheat varieties. In the UK, preferred wheat varieties are selected by millers for farmers to grow (AHBD, 2023). At the species level more broadly, ultra-processed foods are produced with ingredients from a narrow set of high-yield staple crops, primarily sugar, wheat, vegetable oils, corn, soy and milk (Leite et al., 2022). These crops are bought and sold as global commodities, meaning that farmers are always guaranteed a market for them. This systemic situation incentivises the intensive production of a limited number of crop varieties at the expense of other crops, particularly those from traditional diets (Leite et al., 2022). Land conversion and subsequent habitat loss have also been attributed to the increased production of staple crops for the processed food industry (Lee et al., 2016; Seferidi et al., 2020).

Despite the long-time prevalence of food processing specifications, recognition of their impact on production practices and agrobiodiversity - and processors' potential role in restricting farmers' ability to adopt new practices or grow different varieties, crops or rotations - is only just starting to emerge. More research is needed to quantify the impact biochemical, varietal and species specifications of UPFs has on nitrogen use, agrobiodiversity loss and land conversion.

2.4 Low prices driving farm intensification, overproduction and food loss

In a study in Australia, farmers told Messner et al. (2021) that high competition between farmers for a limited number of low-paying supermarket contracts pushed farmers towards greater specialisation and intensification. Prices proposed in buyer contracts do not take the cost of primary production in account (Devin and Richards, 2018; Messner et al., 2021). Thus, to compete with other farmers and make their farms viable on such tight margins, farmers must maximise their output. Farmers described going into debt to make investments in the technology and inputs needed to enable them to increase their productivity. The cost of these additional investments is barely covered by the narrow profit margins, if at all. A 'debt spiral' results, forcing farmers to produce more, further driving greater amounts of intensification and overproduction. Farmers then have to take a gamble that supermarkets will purchase harvests from them over a competitor (see section 2.5).

Messner et al. (2021) do not go into explicit detail about what this intensification entails except to say that farmers' crops were exposed to greater risks from pests and diseases. It is not possible to explicitly link low prices to specific farm practices from this study. However, despite growing interest in the concept of 'sustainable intensification', 'intensification' has primarily been associated with a set of production practices that result in negative environmental impacts. In particular, soil compaction from heavy machinery, N20 emissions from the heavy application of nitrogen fertiliser, insect die-off from the use of pesticides, overgrazing from livestock, and negative animal welfare outcomes from dairy and broiler chicken production. Intensification can also lead to overproduction and surpluses which result in food losses on the farm (see sections 2.5,2.6).

Low food prices are the result of a complex economic system and no single actor is entirely responsible. However, specifically in the relationship between farmers and their buyers, the inability of farmers to set the price for their products is noteworthy. In some sectors such as arable farming, this issue takes the form of selling to commodities traders where prices are set in the future trading marketing. In other sectors, like horticulture and dairy, prices are largely set by processors and retailers through the exertion of buyer power that is the result of market concentration (Dobson et al., 2003; Rindt and Mouzas, 2015; Porter et al., 2018). A recent OECD report (Deconinck, 2021) notes that, if markets were perfectly competitive, farm prices would be 24% higher than those currently observed. This study also noted that the mechanism through which buyers tend to exert their power is through threatening to withdraw the deal if the supplier does not accept (see section 2.5). In a study of unfair trading practices in the dairy industry across in regions of Spain, France and Poland (Di Marcantonio et al., 2018), 30% of farmers (the max was 49.7% in Galicia) said that prices were set unilaterally by the dairy company? compared to 0.8% by the farmer.

Several studies have linked low prices from buyers to food losses. In a case study farm in the UK, a farmer said that the supermarket 'held all of the cards' and that if the price they were offering was less than the cost to harvest the crop, they would just leave their whole crop unharvested (Porter et al., 2018). Farmers in North Carolina reported similar impacts of price negotiations on harvesting (Johnson et al., 2018). Research into on-farm food loss in Canada by Soma et al. (2021) found that farmers are "pushed to overproduce in a landscape of uncertainty." The study highlighted that overproduction benefits buyers because it decreases prices. Similarly, findings from a study on tomatoes in New Zealand showed that a farmer was forced to dump 32 tons of tomatoes because the processor offered a price that was 30 cents less than the cost to ship the produce (Thorsen et al., 2021). Across these case studies, farmers overproduce in order to ensure farm viability in the face of low prices, but a glut of product from the overproduction subsequently further reduces prices, creating a vicious downward cycle.

Messner et al. (2021) is the first study to explicitly link low prices from middle-chain actors' buyer power with farming intensification. No research to date has quantified the effect low prices from buyer power has on the environmental impacts of this intensification.

Research on the drivers of intensification show that farmers' practices are determined by a wide range of factors. Agriculture markets and price competition – both domestic and international – have, however, been noted as key drivers in several studies (see Vliet et al., 2015 for a review and Clay et al., 2020 for an example from the dairy

sector). Decades of policy, subsidies, technology diffusion and research funding has targeted greater farm productivity and higher yields in an explicit effort to lower prices (Benton and Bailey, 2019; Richards et al., 2021). While it must be noted that middle-chain actors are not directly responsible for intensification, the power they are able to exert to achieve low prices in contract negotiations with farmers may be perpetuating farmers' lock-in to intensive production systems and overproduction.

When considering solutions to break the perpetual loop of intensification and overproduction, higher prices may not necessarily be the answer, especially if farmers have the technology to increase their output. Farmers may still overproduce to capitalise on high prices when they occur (Gunder, 2012). As a farm association employee stated in Soma et al. (2021), farmers "are doing everything they can to make as much money as they can." Laws that focus exclusively on ensuring that farmers are paid enough to cover the cost of production (see section 4.2) may help farmer livelihoods but would not automatically reduce environmentally harmful production practices.

2.5 Risk of under-supplying driving over-production and on-farm food loss

When a farmer produces more than a buyer needs, the surplus is turned into food loss. Qualitative research indicates that farmers intentionally produce more than what they think their buyer will need, regardless of the forecasted demand. Research by Ludwig-Ohm et al. (2019) in Germany found that producers would routinely plant a buffer of up to 15-20% more than their contracted amount to guarantee compliance with contracts that include pre-defined volumes and delivery dates, they. If the crop is good, but retailers do not want to take the surplus, the excess can be left unharvested, ploughed back into the ground or diverted to animal feed. Research from the UK by Porter et al. (2016) points out that farmers who do not produce enough to meet their production contracts can be forced to source it from elsewhere at additional cost or risk being de-listed by the buyer. One study reported that 89% of dairy farmers interviewed from Spain, France and Poland had no protection if they failed to fulfil the contract (Di Marcantonio et al., 2018). Rindt and Mouzas (2015) also discuss the risks producers face not adhering to contract terms and conditions.

In Australia, work by Messner et al. (2021) found that despite whether volumes have been pre-determined, farmers had to be ready to fill orders year around – perhaps even more than the amount set in the contract if demand increases - to 'safeguard' their relationships with supermarkets. If the farmer doesn't have the desired product, the retailer will purchase it from another farmer who does, putting that other farmer in a more privileged position with the supermarket. One farmer said, "undersupplying [is] a very bad business." This situation was confirmed in a similar study from Australia (Richards et al., 2021) where a farmer said, "If you have a contract with a supermarket directly, you, no matter what the price or what your profit, you really need to supply what you said you were going to supply, otherwise you'll lose the contract." Such a situation is exacerbated in cases where buyer markets are highly concentrated. In a study from North Carolina, one grower said, "Basically we only have two customers…so if either one of those didn't need us anymore, that would hurt" (Johnson et al., 2019). The risk of being 'de-listed' – or dropped by a buyer - as a driver of overproduction was also identified in England by Porter et al. (2018).

Concern over the risk of under-supplying large retailers and the 'winner-take-all' competition between farmers may be tied to the expectation that large middle-chain actors prefer to work with a small number of large suppliers rather than many different suppliers (Otsuka et al., 2016). Evidence from Canada found that, among a mixed sample of farms, those that sold to major retailers through distributors generated more food losses due to flexible contractual arrangements (Janousek et al., 2021). Contracts could either be reduced during the growing season or, conversely, offer opportunities to sell excess.

The extent to which risks and fears over under-supplying middle-chain buyers drives over-production and food losses in production has only just begun to be explored. Strict contract terms between buyers and farmers have been noted as a driver of overproduction and food loss (Gustavsson et al., 2011; European Parliament, 2013), but empirical and quantified research is lacking. Existing evidence is based on a small number of quantitative studies, mentioned above, only two of which explicitly link supply requirements to overproduction (Ludwig-Ohm et al., 2019; Messner et al., 2021). Conversely, some farmers explicitly say contractual demands from middle-chain actors is no longer a problem, with retailers becoming much more flexible and accommodating to under-supply issues (Beausang et al., 2017). To establish with certainty the impact this issue has on environmental outcomes more empirical research is needed. It would be beneficial for future research to focus in particular on: (1) the prevalence of contracts that include pre-determined supply volumes vs. those that do not, (2) how much farmers produce as a result of the contractual arrangements, and (3) the amount of production that is left un-purchased by the buyer.

2.6 Purchasing time horizons and short-term demand forecasting that drives on-farm food losses

Mismatches in supply and demand have long been recognised as a key driver of food loss and waste along the supply chain (see Moraes et al., 2021). Retailers place orders based on predicated consumer demand, not based on the supply available on the farm. While farms operate on year-long or sometimes years-long time horizons, the time horizon which retailers look at to forecast demand can be as short as a few days. Beausang et al. (2017) interviewed farmers in Scotland who said that if a retailer sees that it will be rainy on the weekend, orders will be smaller on the prior Wednesday and Thursday.

Farmers in Germany discussed how short-term ordering leads to food losses (Herzberg et al., 2021). As discussed above (section 2.5), the prospect that middle-chain buyers might place an order and the importance of being able to supply that order motivates farmers to plant more than they initially forecasted. As described to Messner et al. (2021), farmers in Australia have adopted these practices in order to supply year-round requests, even if these deviate from original contracts and regardless of what volume amount is contracted or forecasted. If retailers buy less than the forecasted amount based on very short time horizons of predicted demand, farmers are left with the surplus.

Retailers frequently ensure that their contracts with growers give them flexibility to only purchase amounts as needed. Research from Australia (Devin and Richards, 2018; Messner et al., 2021; Richards et al., 2021) and Germany (Herzberg et al., 2021), described farmers agreeing to contracts in which middle-chain buyers do not agree to purchase a set amount. Rather, the written contract establishes details of business conduct if a transaction is to take place, but an exchange is not guaranteed. After such a contract is in place, a subsequent verbal and informal agreement on actual purchase quantities is proposed which farmers use as a rough estimate to guide the amount they plant, incorporating the prospect that buyers might need more. Buyers will then place orders as needed but are under no obligation to purchase everything that a farmer produces or, indeed, anything they produce. Farmers in Australia described that, when there is no obligation for a retailer to purchase a set amount, buyers can also reject what a farmer has grown if they already have a supply from somewhere else at a better price using the range of 'get out clauses' in the contractual agreements (Devin and Richards, 2018).

In the study by Herzberg et al. (2021), one farmer in Germany also described instances where exclusivity clauses prevented them from selling products to alternative buyers without the contracted buyers' permission. Such exclusivity clauses may be in place to protect buyers from the risks of a farmer reneging on the contract and selling to an alternative buyer who offers a higher price while masking it as a production failure (see, for example, Barrett et al., 2012 – although this study is focused on smallholders in developing countries; see also Otsuka et al., 2016). The extent to which side-selling is actually prevented by middle-chain buyers in cases where the buyer does not want to purchase the produce is unknown.

Oft-proposed solutions to this issue of overproduction focuses on improved demand forecasting techniques (e.g. Miguéis et al., 2022) and increasing the flow of information regarding demand forecasting between retailers and their suppliers, particularly for perishable food supply chains (Kaipia et al., 2012). However, the majority of research on this topic focuses on information exchanges between retailers and processors, not between retailers and primary producers, like farmers. For example, Taylor and Fearne (2009) studied demand management in fresh food supply chains but only examined the relationship between the retailer with vegetable packers and abattoirs, not the farmers. These studies also focus on food products that can operate on as-needed production schedules rather than the discordant time frames or forecasts between retailers (demand) and farmers (supply). For example, Mena et al. (2011) interviewed actors across the supply chain in Spain and the UK, including producers, asking about demand forecasting and information sharing, but there was no discussion of time horizons. Kaipia et al. (2012) studied the positive potential for information sharing in the supply of milk, fish and poultry which do not operate on time horizons that are as long as produce.

Recognition of the paradox between supermarkets' just-in-time logistics systems and the natural systems of fruit and vegetable production and their potential role in detrimental environmental outcomes is only just emerging. The issue was mentioned in a recent study on food losses in Australia horticulture (Richards et al., 2021), but this remains an area for further research.

As-needed ordering allows retailers to be more responsive to consumer demands and can reduce their risk of food loss at the store. This point of food loss prevention is an important priority given that food losses by retailers not only include the embedded impacts of production but of processing and transport (Gillman et al., 2019). However, this evidence suggests that while the impacts of food loss might be decreased by losing it on the farm rather than at retail, the quantity of food loss is not impacted by improvements in retail waste if changes do not ripple back to primary producers. Again, quantifying volumes of overproduction and losses due to poor demand forecasting is difficult and no studies were found that have done so to date.

2.7 Promotions driving on-farm food loss

Variability in consumer demand is frequently pointed to as one of the reasons why it is so difficult to accurately forecast demand, which leads to overproduction and food losses (Mena et al., 2011). Seasonality and weather are typically pointed to as the main drivers of this variability. However, in a study on consumer demand variability in Europe, Taylor and Fearne (2009) found that, the most common cause of variability was the promotional activity of the retailer. They also found that promotions do not only have an impact on the demand for the promoted product, but also of associated products. For example, if a retailer had 20 different types of potatoes available, the promotion of one type of potato would cause erratic demand for the other types.

Farmers said that promotions rarely align with what they have available on the farm. In interviews with Herzberg et al. (2021) in Germany, retailers said they would notify their suppliers of an upcoming promotion between two and six weeks in advance to reduce the likelihood that news of the promotion might be leaked to competing retail chains. Other participants in this study said that promotions are becoming "increasingly inflexible and prematurely fixed," so they cannot be adjusted to spontaneously take advantage of harvest peaks. This concern was also mentioned in interviews with farmers and retailers in the UK who said that, while promotions can help to drive demand by between 20-50%, some retailers are not flexible enough to turn on promotions in response to surpluses (WRAP, 2011).

2.8 Display and availability requirements driving overproduction on-farm

Retailers strive to ensure that their shelves are full of product, even if they have no expectation that the product will sell. Interviews with stakeholders in the retail and wholesale sectors in Sweden (Stenmarck et al., 2011), found that the belief customers expect full shelves is a major obstacle to reducing food waste. Similarly, interviews with actors along the supply chain in Australia, conducted by Richard et al. (2021), noted that supermarkets rely on a consistent supply of product to meet their in-store display requirements. This type of over-ordering by retailers drives over-production (Raak et al., 2017; Richards et al., 2021) and generates food waste if the products are not purchased and is particularly an issue for fresh products.

Fierce competition with other retailers and the risk of losing a customer from being out-of-stock of their preferred product has been a key concern of retailers and led to the principle that poor customer demand forecasting is to blame (Corsten and Gruen, 2003). In interviews with actors across supply chains in the UK, Mena et al. (2014) found that 'on-shelf availability' – how often a product is not on display for sale – was a key performance indicator for retailers. Interviewees said there was a tendency to over stock items 'just in case.' In another study of retail ordering practices in high-income countries, store managers said they often order in excess of the forecasted quantities to guarantee a safety stock and, if not sold, they return the products to the supplier (Gruber et al., 2016) (see section 2.9).

These results suggest that particular in-store aesthetics are likely to drive retailers ordering practice. There are no studies, however, that have examined the extent to which retailers over-order simply to keep shelves looking full rather.

2.9 Cost off-loading as a driver of overproduction and food waste

There are two contract tactics by which retailers are able to return food that they purchase to their suppliers if/when that food will be turned into waste. The first tactic is *reclamations* which is when retailers reject a shipment that has already arrived at the facility due to, for example, failure to achieve cosmetic standards (see section 2.2). The retailer then reclaims the cost for the goods from the supplier and disposes of the produce at the store rather than shipping it back to the supplier. Reclamation and the fact that the store technically did not 'own' the products when they were turned to waste effectively means that it is not reported as retail waste. Eriksson et al. (2012) studied reclamation claims in six retail stores in Sweden and found that 4.3% of fruits and vegetables delivered were wasted and 'pre-store waste' – fresh fruit and vegetables items that are rejected by the store at delivery – accounted for 3.01%. Put another way, 70% of fruit and vegetables wasted at the store were rejected items but are not considered as part of the in-store waste. By contrast, while reclamations are mentioned as being present in contracts for fruits and vegetables in Germany, widespread returns were not seen as a problem by farmers (Herzberg et al., 2021).

The second tactic is through *take-back agreements* where a retailer returns unsold product – typically bread – to the processor after it has been on the shelf and the retailer is only required to pay for the quantity sold, not the quantity ordered. Another study from Sweden investigating take-back agreements found that suppliers faced approximately 30% returns on total volume delivered, implying that 30% of the bread purchased is turned to waste with the cost of collection, transport and disposal held by the bakery (Ghosh and Eriksson, 2019). Take-back agreements are considered a 'grey' trading practice in Directive (EU) 2019/633 meaning that the practice is prohibited unless agreed to in clear and unambiguous terms by both parties. The effect of this trading practice has yet to be measured, but Ghosh and Eriksson (2019) argue that buyer power, the threat of de-listing (see section 2.5) and the difficulty of proving that the practice is actually harmful leads to such practices continuing.

A final study in Sweden (Eriksson et al., 2017) measured the impact of reclamations and takeback agreements on the production of pre-store waste, comparing bread, fresh fruits and vegetables and milk. Across six retailers, bread was wasted in large amounts at the suppliers' expense, fruits and vegetables were wasted in moderate amounts at an expense to both the retailer and the supplier, and milk was wasted in very low amounts and almost entirely at the expense of the supplier. These findings imply that the amount of waste increased as the cost to the retailer for that waste decreased. Eriksson et al. (2017) argue that the absence of a penalty means there is no incentive for retailers to improve their ordering practices and that, more broadly, this situation contributes to continued rates of on-farm overproduction. A lack of incentive to improve ordering as a driver of food waste is similarly echoed by Stenmarck et al. (2011) during interviews with stakeholders in the wholesale and retail sectors in Sweden.


Thousands of
ROLLBACKS
across the store.
#1
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3.0 Drivers of indirect impacts through consumers

Consumers contribute to negative environmental outcomes through two channels: (1) what and how much food they eat and (2) what and how much food they waste. Regarding the first channel, the growing attention paid to sustainable diets is concerned with how to get consumers to eat less of certain foods and more of others. Definitions and recommendations for sustainable diets vary, but for the purposes of this study, the focus has been limited to the impact of middle-chain actors on the consumption of animal-based foods and of ultra-processed foods (Garnett, et al., 2015).

What drives certain consumption patterns is not straightforward. As research into unhealthy diets has shown, the wickedly complex system of social, demographic, temporal, economic, psychological, and educational factors that drive diets cannot easily be untangled. As such, responsibility for current unsustainable and unhealthy diets cannot easily be placed on individual food system actors.

Nevertheless, there is no doubt that certain actors have an outsized influence in shaping diets and these actors are driven by economic rather than environmental incentives. While consumers have choices on how much they eat based on their personal circumstances and the environments they find themselves in, as Swinburn et al. (2019) point out, consumers "have biological, psychological, social, and economic vulnerabilities that industry exploits through food environments that influence people's preferences." The exploitation of these vulnerabilities has been well-researched in the field of public health, but less so specifically for environmental health and in light of sustainable diets.

Regarding the second channel, households produce a significant amount of food waste in developed countries, implying that households are purchasing more food than they can or are consuming. In this case, actors along the entire supply chain, including farmers, have an economic incentive for consumers to over-purchase food, even if it ends up as waste. So while, as with diets, consumers have some degree of control over how much they purchase and waste, it is important to understand if and how actors along the supply chain are driving over-purchasing.

A note on date labelling and food waste

Consumer confusion over 'sell by', 'use by' and 'best before' date labelling on foods is considered one of the primary drivers of food waste (Toma et al., 2020). An EU study found that up to 10% of food waste is linked to date marking (European Commission, 2018) Thus, clarification over or the removal of date labelling is heavily advocated for by those seeking to reduce food waste. While this is, indeed, an important issue, it is not included as one of the indirect drivers of negative environmental impacts from middle-chain actors because, while manufactures and retailers determine the dates on labels and these dates can vary widely (Newsome et al., 2014; Aschemann-Witzel et al., 2016), there is no scientific evidence that dates are intentionally chosen to drive increased purchasing and consumption by consumers. Some journalistic accounts have noted that middle-chain actors benefit from the increased turnover that results from consumers throwing away food more frequently, which may factor into their political lobbying against changes in date labelling rules (Stuart, 2009). However, no academic evidence was found to support this claim during this review. Rather, it was identified that date labelling was introduced as a way to manage stock (Milne, 2012) and for supermarkets to guarantee 'freshness' and food safety standards (European Commission, 2018), and avoid litigation from customers (Milne, 2012). Thus, contrary to the other indirect impacts on food consumers discussed in this section, there is no evidence that manufacturers and retailers directly benefit from mis-representing shelf and storage life on date labels.

3.1 Price promotions driving food waste

In store marketing promotions such as multi-buys, buy-one-get-one-free deals, Y for £X and temporary price reductions have long been discussed as a key driver of household food waste, with consumers purchasing more food than they end up using. Some studies have indeed shown that in-store promotions drive an uptick in unplanned purchases which can result in food waste. In a study of 380 youths in Spain and Italy, Mondéjar-Jiménez et al. (2016) found that offers, promotions and store layouts (see section 3.3) can strongly influence consumer behaviour and food waste. Surveys in both Portugal and Greece showed that consumers who frequently divert from their shopping list and purchase promoted foods tend to throw away more food (Fonseca et al., 2013; Ponis et al., 2017). In another study that involved household interviews, photos and participant observations, Farr-Wharton et al. (2014) found that participants who showed a strong proclivity towards 'buy bulk and save,' in combination with a lack of awareness of what they already had in their house, led to greater food waste.

However, other studies have argued that, while it is clear that promotions increase purchasing, it is not clear that this food was then wasted. In a survey of retail consumers in the UK, WRAP (2011) found that, while promotional purchases make up one third of grocery spend, there was not a strong link between purchasing food on offer and the associated wasting of that food as reported by households. (They noted this may be due to difficulties in participants' accurate reporting of food waste levels.) A 2-week food waste diary study with 380 Finnish households actually showed that food waste was larger in households where promoted and discounted food products were not often bought (Koivupuro et al., 2012). Similar findings were confirmed in Denmark (Tsalis, 2020). Most recently (the article is still in peer review), a 9-week survey of supermarket shoppers in the Netherlands showed that shoppers who bought products on promotion actually wasted less than those who did not. Furthermore, the study identified that multi-unit promotions trigger 'food waste concern' that leads to new waste-preventing behaviours (van Lin et al., 2023). These findings seem to be confirmed by another study in France on consumer attitudes towards promotions in light of food waste which found that a higher concern for food waste may actually lead to purchasing more promoted products as a result of being simultaneously favourable to deals and concerned about food waste (Le Borgne et al., 2018). The authors also noted that consumers who are more concerned about food waste may feel they know how to avoid food waste, and thus perceive a lower probability of wasting from buying on promotion.

Thus, the findings on if price promotions drive household food waste are inconclusive, as recognised in several reviews of the literature (Schanes et al., 2018; Tsalis et al., 2021). However, after reviewing the various studies and finding no clear outcome, Tsalis et al. (2021) caution that differences in the strength of the methodologies applied tend to point in favour of those studies that found price promotions do not drive food waste as these were based on food diaries and measured food waste. Those studies that found a positive association between promotions and food waste were based on consumers' self-reporting in interviews and questionnaires, a less reliable method. Also, since interviews and questionnaires do not follow consumers from an actual shopping trip through to wasting food, they are unable to trace a food from being promoted in store to being wasted at home meaning it is unclear if the foods that consumers report they are wasting are the same as those that are promoted in store. There is no delineation in these studies between perishable foods, which are promoted less frequently and go bad faster, and UPFs which are more commonly promoted and have quite a long shelf life (Bennett et al., 2019).

Given the complexity in these findings – and of the task of measuring promotion-to-waste accurately – it is yet unclear if limiting or halting price promotions would have any effect on levels of food waste. Rather, Boulet et al. (2021) suggest that household food waste should be seen not as a single behaviour but as an outcome of a "larger complex network of antecedents" and that the characteristics of the shopper and their attitudes about money and waste have more to do with waste levels than external factors.

3.2 Pack and portion sizes driving over-consumption and food waste

While the impact of price promotions on food waste is unclear, there is a much stronger link between packaging, plate and portion sizes, over-consumption and food waste (Hollands et al., 2015).

It has been firmly established in the public health literature that pack sizes for UPFs have been increasing over time (especially in the USA) and that larger pack sizes lead to over-consumption (Zlatevska et al.. 2014; Aerts and Smits, 2017). This finding is true for both meal-related foods like spaghetti and snack foods (Wansink, 2004). Wansink (2004) proposes that over-consumption from packaging is due to how packaging sets a norm or expectation of what is an appropriate amount to eat. Interestingly, the literature on the effect of introducing small packages of UPFs does not necessarily indicate that it leads to less consumption. In fact, it might still encourage over-consumption by getting people who wouldn't otherwise buy a large portion size to buy a small one (at a price premium) because they think it is healthier (Wertenbroch, 1998; Scott et al., 2008). So, while it is clear that larger portion and pack sizes lead to overconsumption and waste, it does not necessarily follow that small portion sizes lead to a reduction in intake, particularly for UPFs (Jain, 2012). Jain (2012) also finds that there is not necessarily any financial incentives for food manufacturers to introduce smaller pack sizes.

For unprocessed foods, in several studies of household food waste, pack sizes were found to be an underlying factor that led to food waste. Wilson et al. (2017) found that consumers are more willing to waste food that comes from larger packs. In Poland, Ankiel and Samotyja (2021) found that only a quarter of consumers who buy food in large packages consume the entire product. In a study in Finland, Koivupuro et al. (2012) interestingly found that people who think bigger pack sizes leads to food waste are also the ones that waste the most food. Interviews with consumers in Australia showed they frequently had to buy more food than they actually needed because the items came pre-packaged (Langley et al., 2021). Based on similar findings in the UK, WRAP (2014) advocated for food manufacturers and retailers to offers foods in 'appropriate' pack sizes and minimise the difference between price p/ kg to reduce household food waste. However, Koeningsberg et al. (2010) shows that a financial incentive only exists for food producers and packers to decrease the pack sizes of fresh food products if they can increase the price p/ unit.

Similarly, to the findings from van Lin et al. (2013) on promotions and food waste (section 3.1), Petit et al. (2020) found that consumers exhibit a decreased intention to purchase larger packages, even if there were cost savings, because of their anticipation of food waste. The contradiction in findings from this body of evidence highlights that the underlying drivers of consumer food waste are quite complex and difficult to parse (Bhattacharya et al., 2021).

In food service settings, large portion sizes are associated with both overconsumption and waste. Several studies have found that changing portion sizes and plate sizes in buffet dining settings has a measurable difference on both the amount consumed and of waste created (Sarjahani et al., 2009; Freedman et al., 2020; Kim and Morawski, 2012; Thiagarajah and Getty, 2012; Juvan et al., 2017). Offering reduced portions was also shown to decrease over-consumption in restaurants and workplace cafeterias in the US (Berkowitz et al., 2016) However, restaurants might not always be incentivised to adopt this approach. A study of waste by different restaurant types in Canada showed that quick-service restaurants used large portion sizes as a value proposition to stay competitive, anticipating and accepting that a good amount of food would come back and be wasted (McAdams et al., 2019). The importance of portion sizes to customer satisfaction was also shown in interviews with restaurateurs in the UK and the Netherlands (Filimonau et al., 2020). In interviews with restaurateurs in Germany, participants reported that the default practice is to serve large portions because a customer leaving hungry is the 'worst case scenario' and seen as inhospitable (Hennchen, 2019).

3.3 In-store product placement driving over-consumption of unsustainable foods

In conjunction with the literature on in-store promotions (section 3.1) and marketing (3.4), the impact of store layouts and product placement on driving consumption behaviours is a topic of interest. Supermarkets design the layouts of their stores – putting staples like milk at the back to maximise the number of products a customer must walk past - to increase the number of items purchased (Aghazadeh, 2005; Hawkes, 2008). The impact of prominent product displays in stores is also well documented. Wilkinson et al. (1982) showed that while more shelf space increases sales by 19% and 39%, end-of-aisle display units increase sales between 77% and 243%. Inman et al. (2009) found similarly that displays increased unplanned purchases by 40%. Vogel et al. (2016) showed that this effect is more pronounced for shoppers from more socioeconomically disadvantaged backgrounds.

Conversely, a number of studies have shown that altering product placement and signage with healthy food alternatives increased their sales (Glanz et al., 2012; Foster et al., 2014; Shaw et al., 2020; Vogel et al., 2021) although, again, these effects are mediated by other personal factors such as price, habitual choices and personal preferences (Moran et al., 2019; Thorndike, 2020; Young et al., 2020).

Prominent placement for UPFs is the usual practice for middle-chain actors. A study of product placement in supermarkets in the UK found that two thirds of foods in checkouts, end-of-aisle displays, store entrances and freestanding display units were UPFs (Obesity Health Alliance, 2018). Another study in Australia found that 100% of checkout displays in the majority of stores had candy and that snack foods were prominent in end-of-aisle displays. A cross-country comparison of snack food displays that included the Netherlands, Denmark, Sweden and the UK showed similar densities (Thornton et al., 2013). The prominent placement of UPF may be linked to the use of expensive slotting fees which only large food manufacturers can afford (Caruso et al., 2018) (see section 3.6).

3.4 Advertising and marketing that drives over-consumption of unsustainable foods

While evidence on the link between promotions and food waste is still ambiguous (section 3.1), advertising by food manufacturers and fast-food restaurants through formats like TV commercials and out-of-home billboards have long been understood to be a major driver in the continued growth in consumption of UPFs, particularly among children (Boyland et al., 2016; Qutteina et al., 2019; McCarthy et al., 2022) and in low and middle income countries (Huse et al., 2022). However, the results for adults in high-income countries has been more equivocal. Consumption of UPFs was found to have plateaued in high-income countries overall (Stuckler et al., 2012). Also, a series of systematic reviews of the impact of food marketing on adults in developed countries found that there is little evidence to say conclusively whether advertising shapes adult behaviours or attitudes towards the foods while noting that the studies were of poor quality (Mills et al., 2013; Boyland et al., 2016). In a study in the UK, Boyland et al. (2017) found that exposure to food commercials had no impact on increased intake.

These findings, combined however with the high prevalence of UPFs consumption, indicates that there are other drivers of adult consumption of UPFs than marketing (see section 3.3, 3.6). It is clear though that advertising does effects children and children effect what their parents purchase. Overall this body of evidence needs to be considered in light of the multiple co-existing drivers of food choice, with particular sensitivity to the role of UPFs for low-income families (Moran et al., 2019).

While marketing and advertising is essential to brand recognition for food manufacturers (3.2.2), brand recognition, and therefore consumer-targeted marketing, has a much smaller role in meat consumption. The meat industry still communicates to consumers, but rather than through TV ads and billboards, it is primarily in the media and through the distribution of biased knowledge and evidence (Bogueva and Phau, 2015; Bogueva et al., 2016; Fuchs et al., 2016; Sievert et al., 2021). While this is no doubt an important space where public debate is taking place on meat consumption, there is little evidence to show that such communication strategies have a measured impact on meat consumption beyond those mediated through cultural perceptions (Schally, 2014).

3.5 Product formulation that drives over-consumption of unsustainable foods

While advertising is the most frequently discussed issue associated with the consumption of UPFs (section 3.4), the lack of evidence in support of their impact on adults combined with high rates of consumption and proof of their effect on children suggest different drivers are at play in the consumption of UPFs among adults.

An alternative proposed hypothesis is that the formulation of the product itself encourages consumption and over-eating. A US study comparing the calorie intake between two groups – one served a diet high in UPFs and the other served unprocessed foods – found that the first group consumed ~500 calories a day more than the second group even though the diets were matched for presented calories, sugar, fat, fiber and micronutrients (Hall et al., 2019). This finding implies there is something about UPFs that drives higher consumption levels irrespective of the amount of nutrients available. Follow-up studies suggest that this is due to the texture of the foods (which impacts the speed at which it is consumed) and their energy density (the amount required to feel full) (Forde et al., 2020; Teo et al., 2021). Combined, these factors make it very easy to overconsume UPFs. These studies and others discuss how the texture and formulation of foods can be manipulated to increase or decrease consumption, with several researchers arguing UPFs are addictive (Gearhardt and Schulte, 2021; LaFata and Gearhart, 2022; cf. Onaolapo and Onaolapo, 2018).

Moodie et al. (2013) and Swinburn et al. (2019) suggest that food processing companies intentionally formulate these foods to make them highly palatable and to drive their excessive consumption, a contention that is supported by journalistic reporting (Moss, 2013), in academic commentary (Hall, 2017; Rao et al., 2018) and most recently in a review of company documents by Nguyen et al. (2019). Again, these findings must be considered in the context of the multitude of dietary drivers that lead to food purchasing decisions. While it is clear that the formulation of UPFs encourage their overconsumption, more academic research is needed on the extent to which food manufacturers intentionally drive this effect (particularly in light of current reformulation efforts). Also, while Kesse-Guyot et al. (2022) showed that the environmental impact of UPF consumption is linked to calorie intake, more research is also needed on the point at which moderate consumption passes into overconsumption that has a negative environmental impact.

3.6 'Omnipresence' tactics driving over-consumption of unsustainable foods

It goes without saying that, for food to be consumed, it must be available. Recognising that availability in the food environment is a key factor in consumption levels, the availability of ultra-processed foods – what Moodie et al. (2013) refer to this as the 'omnipresence' - is frequently mentioned as a major issue. However, availability itself does not drive over-consumption. Many foods that are available that are not over-consumed. However, there are two commonly discussed pathways through which the availability of UPFs may be linked to over-consumption.

The first is in the retail strategies of food manufacturers. Wood et al. (2021) conducted a systematic review of the market strategies used by UPF manufacturers which revealed a collection of tactics designed to increase firms' seller power and to shape the food retail environment. The first is through 'forward' vertical integration where firms simply buy up retail points, such as the ownership of in-shop soda dispensers and vending machines to achieve 'retail featuring' – the priority presentation of products in retail outlets (Warren, 1992). The second is through 'risk-spreading' strategic alliances between manufactures and retailers that leads to the prioritisation of manufactured products (Cante et al., 2003). A third is through unfair trading practices. An example of these practices includes exclusivity agreements that prevent retailers from selling a different brand. Slotting fees are also used and involved manufacturers pay retailers large sums to have their items displayed prominently in the store – much more than suppliers of non-value-added products (e.g. unprocessed foods) would be able to pay (Carameli, 2004; Klein and Wright, 2007; Rivlin, 2016). A case study on Tyson Chicken in the USA indicates that similar practices may be used by the meat industry (Thomas and Koonce, 2007). In aggregate, such tactics (combined with many others not focused on food environments) increase market concentration and power, which Wood et al. (2021) argues provides manufacturers with more capital to feed into the continued promotion of their products and re-shaping of food environments.

Many of the studies in the review by Wood et al. (2021) are more than 20 years old and are not focused on Europe. However, stocking, marketing and promotion fees remain a 'grey' unfair trading practice in the EU (meaning they are legal but have to be agreed in advance), indicating they are a tactics being used across this region and which, in effect, means that retailers are still able to demand large fees.

The second pathway is in the make-up of a local food environment and the mix of restaurants, fast-food restaurants, convenience stores and supermarkets. With issues pertaining to large retail outlets discussed above, 'food swamps' is a helpful descriptor here in understanding the role that fast food restaurants and convenience shops play in driving UPF consumption and, in the case of fast-food restaurants, animal food consumption. Several studies and systematic reviews have shown that greater exposure to fast-food restaurants is associated with poor health outcomes for children, people on low incomes and people with lower education levels (Cobb et al., 2015; Burgoine et al., 2016; Jia et al., 2019; van Rongen et al., 2020 [in the Netherlands]; Atanasova et al., 2022; Bauer et al., 2022 [in Germany]). Again, these findings need to be considered in conjunction with the many complex determinants of how people interact with their food environments (Elton, 2018; Bauer et al., 2022). Also, nearly all of these studies measure the impact of the presence of restaurants on health outcomes like obesity but not specifically on the consumption of foods that cause negative environmental impacts. Unfortunately, there is no parallel research into the growth tactics and strategies of restaurant chains that indicates they are over-asserting themselves into food environments in the same way that food manufacturers are. This is an important area for future research.

3.7 Strategic category priorities in driving consumption of unsustainable foods

Some research has begun to explore the role retailers play in promoting the consumption of certain foods over others. On the issue of UPFs, in a seminal study, Hawkes (2008) found that supermarkets' overarching goal is to increase the amount of food that consumers buy from all product categories, not only UPFs. However, the author notes that UPFs are a product category for which it is easy to cut costs to stay competitive and improve their margins, creating an incentive to promote them. As discussed in section 3.6, large food manufacturers are able to pay large slotting fees to supermarkets in exchange for more floor and shelf space. A study in New Zealand found that 83% of packaged foods in supermarkets were classified as ultra-processed and that

the ten largest food manufacturers accounted for 35% of all packaged foods available (Luiten et al., 2015). Similar outcomes were found in the US (Farley et al., 2009), UK and other European countries (Monteiro et al., 2017).

Interviews with several retailers in Sweden revealed that, while retailers are keen to promote certain labels like organic, Fairtrade and local, no retailers considered it feasible to reduce the selection of meat on offer or to nudge consumers away from purchasing meat (Tjärnemo and Södahl, 2015). Rather, meat was considered an important category financially as it makes up a large portion of sales and that they would risk losing customers to other stores if they reduced their meat offer. Again, promotions were shown to play an important role as retailers compete with each other on price offers.

3.8 Low prices driving over-consumption of unsustainable foods

Price is a major driver of consumer food purchasing behaviour. For decades, policymakers have made a concerted efforts to lower food prices and, indeed, low food prices have been considered a social good by many (Benton and Bailey, 2019). This has been accomplished through a long-standing package of R&D funding and government subsidies that support increasing yields and productivity on farms. Over time, this has led to the growth in food processors, meat packers and retailers that simultaneously benefit from the supply of super-cheap inputs and the added value of processing to grow to large multi-national industries (Lang et al., 2012). While the negative environmental impacts of productivist farming increasingly recognised, the debate over whether reducing these negative outcomes must necessarily involve a decrease in yields and therefore an increase in food prices for consumers is a hotly debated issue. This context is important for understanding that middle-chain actors are not the originators of low food prices, but they have emerged from them and benefit from them and thus have a vested interested in keeping prices low, both for inputs and for the consumer.

The drivers of meat consumption are a confluence of complex macro-issues: economic development, income growth, globalisation, urbanisation and culture (Clonan et al., 2016; Milford et al., 2019; Hielkeme and Lund, 2021). It is difficult to pin down the precise role of the meat industry in these macro-processes (perhaps with the exception of their discursive role in shaping culture [see section 3.4]). Price is also an important driver of meat consumption (Pitt and Bendavid, 2017; Milford et al., 2019; Garnett et al., 2021). Yet even on this issue, the role of the meat industry is convoluted and indirect. As discussed above, the meat industry of today is a product of rather than the originator of low meat prices. However, they have a vested interest in keeping prices low to maintain present consumption levels. In review of the literature, Sievert et al. (2021) say that the meat industry keeps prices low by exerting their market power, accrued through increasing mergers, acquisitions and vertical and horizontal integration, to (1) put pressure on suppliers to keep input prices low (see section 2.4) (2) and (2) to lobby policymakers to maintain subsidies and supports that are flowing to the industry (Howard, 2017). Ironically, the impact of market concentration on meat prices is confirmed in studies that assess if concentration is having a negative impact on consumers. These studies deem that concentration is not a problem because there is no evidence that concentration is leading to higher prices for consumers (Wohlgenant, 2013).

The majority of the research in this area is conducted in Australia and the USA where intensive animal food production dominates and the market is intensely concentrated. There has been much less research on the levels of concentration in the European market. Given that the major meat producers are international and operate in Europe as well as their 'home' countries (Belk et al., 2014; Howard, 2017), it might be assumed that similar tactics are pursued. However, research into the degree and manifestations of market structures in the meat industry in Europe on meat prices is needed.

4.0 Policy implications

The power of middle-chain actors is recognised in discussions on the future EU legislative framework for sustainable food systems (European Commission, 2020a; SAPEA, 2021; Bock et al., 2022). New policy measures are necessary that account for the fact that no single actor in the value chain is solely responsible for the production of environmental impacts. Focusing on individual points along the chain through policies like agri-environmental schemes will fail on their own. Rather, policies need to incentivise and necessitate a shift from an 'impact off-loading' value chain model – wherein actors are able to off-load impacts to others in the value chain - to a *chain of mutual responsibility* for mitigating environmental impacts, where actors must internalise the risk and costs of Scope III impacts as much as Scope I. Such a model, where everyone along the value chain is responsible for the impacts they produced collectively, could facilitate a more collaborative approach to transitioning to sustainable food systems.

Below, three policy pathways are proposed that would facilitate a transition to a chain of mutual responsibility. Case studies are provided to show where they have been implemented at a national level.

4.1 Due Diligence Laws

As evidenced by: i) the ability of retailers to reject edible food and not pay for it (section 2.2), ii) to avoid committing to purchase and promote what has been grown on the farm (section 2.5, 2.6) and iii) the ability to off-load the cost of waste management onto suppliers (Section 2.9), retailers have little economic incentive to change their practices that lead to environmental harm (sections 2.6, 2.7). Such tactics allow retailers to report that they have minimised their level of food waste production when, in actuality, they have simply off-loaded that waste elsewhere in the value chain.

Discussions on how to ensure companies tackle their environmental impacts along their value chains have significantly advanced in some European countries with the introduction of value chain due diligence legislation (see sections 4.1.1 and 4.1.2). In addition to the country-level advances, there has also been a growing pressure from various stakeholders (including civil society and investors) to develop cross-sectorial mandatory due diligence requirements at the EU level. As a result, in February 2022, the Commission proposed a Corporate Sustainability Due Diligence Directive (CSDDD). According to the legislative proposal, companies will be required to establish a due diligence process to prevent and mitigate potential adverse human right and environmental impacts within their operations and value chains, as well as end or minimise actual ones. This proposal was tabled after a report showed that voluntary initiatives were generally ineffective and uneven (European Commission, 2020b) – a finding that casts doubt on the ability of the Farm to Fork's Code of Conduct (European Union, 2021) to generate marked impact.

The current proposal would cover EU companies of more than 500 employees with a worldwide net turnover exceeding EUR 150 million. The proposal also foresee a two-year phase-in period for smaller companies active in high risks sectors, including "agriculture, forestry, fisheries (including aquaculture), the manufacture of food products, and the wholesale trade of agricultural raw materials, live animals, wood, food, and beverages", with more than 250 employees and a net worldwide turnover exceeding EUR 40 million in, if at least 50% of this net turnover is generated in one or more of these high-impact sectors.

'Adverse environmental impacts' are currently defined by the Commission as those resulting from the violation of the provisions of a number of multilateral environmental conventions – a list far from complete as it does not even include the Paris Agreement. The Environmental Committee of the European Parliament has notably proposed to adopt a different approach to defining 'adverse environmental impacts' to keep the definition consistent with other pieces of EU legislation (in particular the Corporate Sustainability Reporting Directive, the Taxonomy Regulation and the Batteries Regulations). Much will depend on the outcome of current negotiations.

While the Council already adopted its General Approach, the Commission proposal is currently being discussed in the European Parliament. If the legislation were to pass, it would complement existing sectorial due diligence legislations at the EU level, such as the Deforestation-Free Product Regulation, the Conflict Minerals Regulation and the Batteries Regulation. The EU CSDDD presents an important opportunity to ensure middle-chain actors identify, assess, prevent, mitigate their adverse potential and actual environmental impacts throughout their value chains.

Applying such a law to food value chains would require changing the 'Commission Delegated Decision (EU) 2019/1597' to require measuring and reporting un-harvested food losses. It could potentially go further by requiring measurement of the GHG emissions associated with food wasted due to rejection from retailers. The effectiveness of such a law would also depend on the specific environmental impacts that buyers are required to mitigate against. Food losses, including pre-harvest losses due to cosmetic standards, should be included as one of these impacts. If designed effectively, measurement and reporting of on-farm pre-harvest loss would require middle-chain actors to mitigate against these losses, providing a promising pathway for reducing food losses from cosmetic standards.

4.1.1 Germany: Supply Chain Due Diligence Act (LkSG)

In 2022, Germany passed *Lieferkettengesetz* or the 'supply chain law' which requires that companies with more than 3,000 employees must take responsibility for social or environmental abuses by their suppliers (BGBL, 2021; BMAS, 2022). Companies' supply chain commitments were previously voluntary. However, this law makes it mandatory for companies to implement defined due diligence requirements. It also establishes that the duty of care is held by these companies (BAS, 2022).

This law applies only to companies with over 3,000 employees and this drastically limits the extent of its application. In fact, only 39 food companies in Germany meet this criterion (Kropshofer, 2022). But the scope of this law is expected to be extended in 2024 to cover companies with 1,000 employees. Also, the law is primarily focused on social issues, with environmental issues only of concern if links to human rights abuses (BMZ, 2022).

In Germany, the penalty for not complying with the law is a fine and exclusion from winning public contracts. In the food sector, there could be a natural cross-over with efforts to advance laws that integrate environmental standards into public procurement contracts for public kitchens.

4.1.2 France: LAW No. 2017-399 of March 27, 2017 relating to the duty of vigilance of parent companies and ordering companies

A similar law was introduced in France in 2017 which applies to companies with more than 5,000 employees. This requirement limits the scope of this French law even further than the current Germany law. Companies must develop a 'vigilance' plan for identifying risks and preventing severe human rights and limiting the environment impacts from their suppliers.

Since the law was passed, several cases have been brought against private companies for failing to adhere to the law.

In 2021, a group of NGOs, in partnership with indigenous communities in South America, filed a lawsuit against a supermarket chain for its links to deforestation in Brazil from its meat supply chain (Business and Human Rights Resource Centre, 2021).

4.2 Unfair trading practices (UTPs)

Many of the negative environmental outcomes identified on farms are driven by price pressures (section 2.4) and unpredictable purchase quantities (section 2.5, 2.6, 2.7) from their buyers. Middle-chain buyers are able to command such low prices and avoid sticking to pre-designated purchase quantities because of their buyer power.

The European Commission has pointed out that buyer power is the driver behind unfair trading practices that impact farmer livelihoods. Extensive work has been underway to mitigate against UTPs between producers and retailers. This development led to, in 2019, the European Union passing 'Directive (EU) 2019/633' that regulates against unfair trading practices (European Union, 2019). Farmers are now protected against ten black UTPs and six grey UTPs. The primary focus of the UPT directive is on improving farmers' livelihoods. Currently it does not protect farmers from UTPs that lead to them creating negative environmental impacts on their farms. Some of the regulated UTPs have the potential to simultaneously target the UTPs that are driving negative environmental impacts on farms, but would need to be adapted to do so.

For example, short-notice cancellations are considered a 'black' trading practice and prohibited. However, 'Directive (EU) 2019/633' designated that this only applies to cancellations that are shorter than 30 days, meaning a retailer can still cancel an order if it is more than 30 days prior to the agreed exchange. Paragraph 20 says this clause is to allow appropriate time for farmers to find alternative buyers. However, as discussed in section 2.6, a 30-day period does little to mitigate against the discrepancy in time horizons between buyers and suppliers. Moreover, as discussed in section 2.2 and 2.3, there are many reasons why farmers may not be able to find alternative buyers even with a 30-day notice period.

The Directive also prevents unilateral contract changes by buyers, such as delisting products covered by a supply agreement (paragraph 21), which may help mitigate against concerns that drive over-production (as discussed in section 2.5). The Directive, however, still allows the buyer to establish specific elements of the contract – such as purchase quantities or price – at a later stage which does little to address the issues of discrepant time horizons (section 2.6) and promotions (section 2.7). As another example, the Directive also prevents "payments not related to a transaction," to address issues such as shelving fees. However, this does not prevent the use of payments for marketing and promotional fees, such as expensive slotting fees, discussed in sections 3.3 and 3.6, that are used to promote the over-purchasing and consumption of UPFs by large manufacturers.

These examples show that the legislation on UTPs, while perhaps helpful in protecting farmer livelihoods, could do much more to incorporate the impact of UTPs on negative environmental impacts.

4.2.1 France: EGalim 2 protecting the incomes of farmers in contract negotiations

In 2021, France passed the EGalim 2 aimed at ensuring the fair renumeration of farmers (Légifrance, 2021; MASA, 2021). This legislation builds upon the original EGalim 1 passed in 2018 [Légifrance, 2018] by focusing more on contractualization. First, a written contract must be in place that establishes a framework for the relationships that must last a minimum of three years (perhaps removing fears of de-listing). Second, the law launched a trial of what is called a 'price tunnel' – the minimum and maximum price limits set in a contract to control variability of price. Contracts must also include the methods by which prices are determined and the terms for automatic review of prices. Third and most notably, the law also requires contractual commitments on forecasted volumes (see section 2.5-7).

4.3 Mandatory reporting

Several of the indirect drivers of environmental impacts in diets overlap with a number of issues that have been the subject of public health debate for many years - specifically, the advertising and marketing tactics of food manufacturers (section 3.1, 3.3, 3.4, 3.6) and pack and portion sizes (section 3.2). While evidence is mixed on the impact of advertising and marketing on consumption of UPFs among adults, it has been confirmed as a major issue and driver of overconsumption among children. Also, while TV ads are not a major driver of food purchasing among adults, in-store product placement and promotions have been proven to increase purchases substantially which, while not leading necessarily to food waste, is likely leading to over-consumption.

Restrictions on marketing to children have been the subject of public health debate for many years. Different EU countries have their own sets of codes of conduct and restrictions on marketing to children, some voluntary and some regulatory (European Commission, 2021). However, regulatory action has yet to be taken at a European Union level and discussions on the subject have yet to consider how marketing and advertising may have a negative environmental component in addition to public health. The exception to this is the 'Regulation (EU) 2022/2065', the Digital Services Act, which prevents ads targeted to children online, including food ads.

Improved marketing and promotional practices are a major feature in the Code of Conduct (European Union, 2021) but significant doubts have been cast on if it will prove effective (BEUC, 2021). Some companies address marketing to children in their 2022 Code of Conduct reports. For example, in Coca-Cola's 2022 report for tracking progress on the Code of Conduct, they have committed to "not to sell soft drinks in primary schools and only sell no/low calorie soft drinks in secondary schools in unbranded vending machines across the EU." The report also specifies the company will "not market any of our beverages to children younger than 13 years with an audience threshold of 30%" (Coca-Cola, 2022). The impact of such efforts will need to be monitored over time, not only to assess if companies stick to their commitments, but how their commitments aid reductions in consumption across the population and among specific high risk sub-groups.

While marketing and advertising are a frequently discussed issue, in-store promotions may be most important to address considering their effect on adults and their much wider reach than advertising platforms (e.g. all supermarket shoppers). This issue is addressed in the Code of Conduct (European Union, 2022). However, the impact on retailers' promotional practices is less clear. For example, in Carrefour's 2022 report, while there are many commitments to apply environmental standards to their suppliers, the only mention of a change in promotional practices towards more sustainable and healthy diets is to have 15% of their sales be organic. They also commit to target "Improvement of +15 points in our client satisfaction barometer which gauges customer satisfaction around our local and organic products and our actions to reduce food waste" (Carrefour, 2022). There is no mention of limiting the promotion of UPFs or animal-based foods.

The Commission states that it will "consider legislative measures if progress is insufficient" through the Code of Conduct. 'Directive (EU) 2022/2464' on corporate sustainability reporting may offer a potential pathway through which to make reporting on progress mandatory. This directive requires certain large and/or listed companies to report or disclose information on environmental issues that arise from their activities. The European Financial Reporting Advisory Group recommends that reporting guidelines should consider negative environmental impacts along a company's value chain (EFRAG, 2022). Based on the findings of this report, in addition to the attention paid to upstream indirect impacts (section 4.1), attention should also be paid to monitoring and reporting on the impacts that companies have downstream and on their customers. Rather than rely on voluntary commitments on marketing such as those in the Code of Conduct reports, middle-chain actors should be monitored for progress achieved in driving a measured shift in the purchasing behaviour of their customers towards healthy and sustainable foods.

4.3.1 United Kingdom: Food Data Transparency Partnership

In 2019, the UK Government commissioned an external review of the challenges facing the country's food system, asking for recommendations on the action government should take to improve food security and public health and reduce negative environmental impacts. One of the recommendations made in the resulting National Food Strategy was to introduce mandatory reporting for large food companies (Dimbleby, 2021). As a result, the UK Government is now launching the Food Data Transparency Partnership (FDTP) (Defra, 2022). The partnership, comprised of representatives from industry, government and civil society, has been set up for five years to establish a system of mandatory measurement and reporting of the food industry's performance on specific measures related to public health, animal welfare and Scope 3 emissions (Quinn, 2023). Measures will be determined by the partnership rather than at an individual company level so as to ensure consistency and comparability across businesses. The *National Food Strategy* also recommended that manufacturers and retailers should publicly reports their annual sales of core product categories – fruit, vegetables, legumes and pulses, red meats, UPFs, etc. – although it has yet to be seen if this will be included in the final mandatory requirements.

There is currently no proposal that companies must limit their Scope 3 emissions to a certain amount or that they will be required to show improvements in decreasing their environmental impacts over time. However, consistent, transparent and mandatory reporting of key environmental metrics is an important step forward.

5.0 Conclusions

The findings of this review point to the importance of taking a policy approach that will facilitate a transition to a *value chain of mutual responsibility*, where actors must internalise the risk and costs of Scope III impacts as much as Scope I. This report also shows that labelling schemes, agri-environmental schemes and public awareness campaigns, on their own, will fail to drive a transition in behaviours from farmers and consumers. A more comprehensive approach is necessary.

This report points to several concrete policy actions that must be taken to ensure that efforts across the value chain are effectively implemented and transparently monitored.

5 policy priorities for reducing the indirect environmental impacts of middle-chain actors

1. Ensure the upcoming EU *Corporate Sustainability Due Diligence Directive* covers the agricultural sector as part of the high risks sectors and provides for a comprehensive definition of environmental impacts based on a non-exhaustive list approach
2. Update the *Commission Delegated Decision (EU) 2019/1597* to include pre-harvest and on-farm food loss in the definition of food waste and require measurement and reporting of pre-harvest and on-farm food waste
3. Prevent companies from bidding for public contracts if they fail to prove appropriate due diligence for mitigating environmental impacts along their value chain
4. Incorporate negative environmental impacts into *Directive (EU) 2019/633* on Unfair Trading Practices, with a specific focus on contracts that set designated prices, work on farmers' time horizons and protect farmers from undue losses due to fluctuations in harvest amounts
5. Measure, monitor and publish food companies' performance on shifting consumers' purchasing behaviours towards sustainable and healthy diets by an external monitoring body


Natural meat
IAMS
ONE

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