THE LONDON SCHOOL OF ECONOMICS AND POLITICAL SCIENCE

Dependencies of Food System Transformation in the Wider Economy and Society

An LSE study commissioned by WWF-UK

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Executive summary

This study explores how wider economic and societal transformations can impact the food system and affect its sustainability. In the past decades, much attention has been devoted to sustainability issues that arise within the food and agriculture sectors (core food system), e.g. food security, agricultural and food policies, agricultural practices, and productivity. Yet, less is known about the forces that influence sustainability from outside the core food system.

Our study has identified four key economic and societal changes and trends, external to the core food system, that are expected to dominate the policy landscape in the coming years and can affect the sustainability of the food system: 1) poverty, inequality, and social security, 2) the pressing need for climate change mitigation actions, 3) the increasing use of preferential or regional trade agreements, and 4) changes in lifestyles as key transformations.

Our analysis relies on a literature review guided by a unifying conceptual framework that illustrates how the food system is impacted by wider societal and economic changes through five main mechanisms: 1) food prices, 2) consumption choices, 3) land-use changes and agricultural decisions, and 4) institutional and 5) technological changes. Our key findings are listed below:

Poverty, inequality and social security:

- Income inequality, poverty, and social security measures are closely linked to the sustainability of the food system through their effects on food prices, consumption levels, and dietary choices.

- Rising living costs, unexpected income shocks (such as temporary increases in fuel expenditure associated with cold weather shocks) and declining working-age benefits are found to negatively affect consumption levels and the food choices of lower-income households.

- Healthy food products are more expensive than less healthy ones and the gap is increasing over time. Income inequality has partially contributed to widening the gap.

- In designing poverty-related policies, attention needs to be paid to limit the possible stigmatizing effect of food-related aid, and to how different policy tools induce can behavioural changes.

- Well-designed social security policies can tackle poverty and favour sustainable food consumption but can also incur the risk of tying agriculture and the food industry to poverty-related policies.

Climate change mitigation policies:

- The relationship between climate policy and the sustainability of the food sector is complex and demands monitoring. Climate change policy is expected to affect the sustainability of the food system through its effect on food and non-food prices, as well as on consumption levels and dietary choices. The effects are strongly dependent on technological discoveries and adoption.

- There are important synergies and conflicts between emission reduction and nutritional outcomes, and a portfolio of policies is needed to implement efficient climate policies without threatening the sustainability of the food system.

- Appropriate economic incentives, e.g. stable prices and long-term contracts, can favour

the transition to emission-reducing activities, such as switching from food production to bioenergy and/or environmental services. Technological developments are increasingly shifting bioenergy production towards sources that compete less with food production.

- Anaerobic digestion and biofuels can help "close the loop" between supply and waste disposal, providing a sustainable alternative to extracting new resources. Closing the resource loops could deliver economic benefits from the additional renewable energy generated, and savings on costs for the infrastructure required for the exclusive digestion of food waste.

Preferential trade agreements:

- Preferential trade agreements with environmental provisions can support the transition to a sustainable food system. Regular monitoring and evaluation can improve the effectiveness of such provisions.

- Modern PTAs have been found to be associated with improvements in environmental outcomes and to be effective in facilitating the convergence in environmental regulatory regimes. PTAs can also favour the international transfer of cheaper and/or more advanced technologies for preventing or mitigating environmental harm.

- Trade agreements between developed and developing countries should also include provisions for specific conservation efforts (such as payments for ecosystem services or creation of protected areas), with reliable and transparent monitoring, to prevent the expansion of agricultural lands into forests and sensitive habitat regions in tropical developing countries.

- International cooperation and coordination, both in the form of multilateral environmental agreements and preferential trade agreements, can help to limit undesired international effects of carbon policy and favour the transfer of green technology across countries.

Lifestyle changes:

- Lifestyle changes are leading to changes in the types of foods, packaging and information demanded both in the UK and globally. Trends towards sustainable and locally sourced products can help decrease food system-related environmental food prints. However, difficulties in public acceptance of food-related innovations may block sustainability opportunities of innovative technologies.

- Lifestyle and dietary changes have made a significant impact on GHG emissions. Urbanization has resulted in a loss of awareness of the seasonality of food products, with modern city dwellers expecting food to be available all year round.

- Reducing work-related stressors and work-related time constraints along with improving the quality of food provision at work can improve health by allowing for the adoption of healthier eating habits both at home and in the workplace.

1. Introduction

This study explores how wider economic and societal transformations can impact the food system and affect its sustainability. In the past decades, much attention has been devoted to sustainability issues that arise within the food and agriculture sectors (core food system), e.g. food security, agricultural and food policies, agricultural practices, and productivity. Yet, less is known about the forces that influence sustainability from outside the core food system.

Our study has identified four key economic and societal changes and trends that are expected to dominate the policy landscape in the coming years and can facilitate or block the achievement of a sustainable food system. In particular, we consider growing inequality, the pressing need for climate change mitigation actions, the increasing use of preferential or regional trade agreements, and changes in lifestyles among the transformations that have and will characterise the future of the UK and other western economies.

We have embraced a broad definition of food system and sustainability. Our definition of the food system includes all the elements (environment, people, inputs, processes, infrastructure, institutions, markets and trade) and activities that relate to the production, processing, distribution, marketing, preparation, and consumption of food and the outputs of these activities. Our definition of sustainability is also broad and encompasses economic, social and environmental dimensions. A sustainable food system is expected to deliver food security and nutrition in an economically viable manner to all, and in a way that does not compromise future generations.

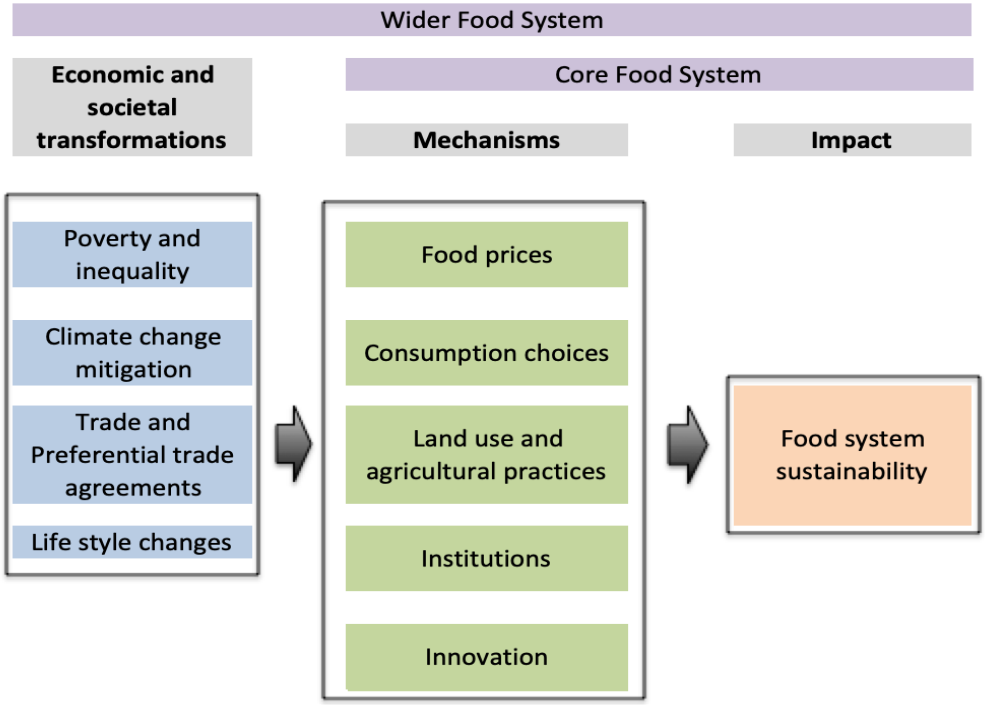
Our analysis relies on a literature review guided by a unifying conceptual framework. We have conducted a review of research studies published in peer-reviewed journals but also relevant unpublished works of high-quality standards. We have combined our review with three in-depth case studies. Besides providing the necessary inputs into our conceptual framework, the review has also served to identify key gaps in the literature.

Our conceptual framework illustrates how the food system is impacted by wider societal and economic changes through five main mechanisms. Our analysis aims to identify the key players and incentives within the food system that play a role in linking external forces to the sustainability of the food system. In doing so, we have paid particular attention to the mechanisms at work by investigating how external forces impact on food system sustainability through their effects on food prices, consumption choices, agricultural decisions, and institutional and technological changes.

2. Conceptual Framework

The aim of this study is to establish how wider societal and economic changes can affect the sustainability of the food system. In this section, we provide the conceptual framework that has guided our investigation of the linkages between external sources and the sustainability of the food system (Figure 1) and has allowed us to frame such linkages through the particular transmission mechanism at work.

Figure 1: Conceptual framework



Our definition of sustainability is broad and encompasses economic, social and environmental dimensions. A sustainable food system is expected to deliver food security and nutrition in an economically viable manner to all, and in a way that does not compromise future generations. This can be summarised under two main dimensions:

1) The **socio-economic dimension,** which concerns adequate access to nutrition and health for all, and in particular for vulnerable groups.
2) The **environmental dimension,** which concerns the effects on the natural environment including biodiversity, water, soil, animal and plant health, carbon footprint, food loss, and waste.

We consider four major external forces that are driven by current and expected trends in societal and economic transformations occurring outside the core food system:

1) **Poverty, inequality and social security**: Income inequality in the UK has remained stable over the last decade, yet it is substantially higher than several decades ago. While absolute poverty has been on a stable decreasing path, after a long period of gradual decline, relative poverty has been on the rise again since 2012/13. Over the last decade, there have been widespread reforms to social security resulting in extensive cuts to the welfare state. The universal credit system, to be fully rolled out by 2023–24, is expected to introduce further cuts to benefits. These issues are discussed within a context where food consumption can compete with other living expenses such as housing costs.

2) **Climate change mitigation policies**: Consensus is growing over the need for the reduction of Greenhouse gases (GHG) emissions. The UK is committed to bringing all greenhouse gas emissions to net-zero by 2050. Because the food system plays a major role in contributing to global GHG emissions, it is likely to be directly or indirectly affected by climate policies.
3) **Preferential trade agreements (PTAs)**: Preferential trade agreements are adopted to promote international trade and to grant beneficial access to certain products to the partner countries. A growing number of PTAs are being negotiated, which increasingly entail broad cooperation over policies extending beyond trade barriers. PTAs are, therefore, key in shaping the future of international trade.
4) **Lifestyle changes**: Lifestyles—defined by dietary patterns, consumer preferences, and working habits—characterise day-to-day activities. With changing information environments, social norms, and working habits, influential factors for decision-making are key to the types of products demanded.

When analysing the relationship between the above economic and societal changes and the sustainability of the food system, we will frame the linkages within the following five mechanisms:

1) **Food prices**: Economic and societal changes can have a direct or indirect effect on food prices and affect the affordability of food products. These effects are closely associated with the socio-economic dimension of sustainability and can have both local and global implications.
2) **Consumption choices**: External forces can shape consumption choices by altering the distribution and availability of income and resources, and by affecting the relative prices or desirability of consumption goods. Consumption choices cover decisions over food and non-food products, food characteristics (e.g. nutritional quality and sustainability), and food waste. Consumption choices can have consequences for both the socio-economic and environmental dimensions of sustainability.
3) **Land use and agricultural practices**: This mechanism is concerned with the relationship between external forces and land-use changes, including the preservation of forest areas, the use of marginal land, crop choices, the use of agriculture inputs and resources, and other decisions concerning agricultural practices. Changes in land use and agricultural practices are most relevant for the environmental dimension of sustainability.
4) **Institutions**: External forces can impact the sustainability of food systems by inducing changes in national and international regulation or policies that govern the production, distribution or consumption of food products and can have implications for both the socio-economic and environmental dimensions of sustainability.
5) **Innovation**: This latter mechanism refers to technological changes within the food system that are induced by external factors. It considers, among others, new food products and the transfer of green technology through trade. In this study, technological changes are mostly relevant for the environmental dimension of sustainability.

When implementing the above conceptual framework, it is important to note two characteristics of food system sustainability that enhance the complexity of the field. First, while each external force is explored independently, they are interconnected and influence each other. For example, diet and lifestyle patterns are certainly affected by income, and energy demand and supply are influenced by climate change mitigation policies. Second, while we focus on investigating the strict pathway of causation (socioeconomic trends to food system sustainability) to the best of our abilities, it is necessary to recognise the inherent feedback loops existing within each area. For example, income inequality may lead consumers to purchase unhealthy foods, which might have greater or lower environmental impacts, leading to potential trade-offs.

3. Poverty and Inequality

Income inequality in the UK is substantially higher than several decades ago but has remained stable over the last decade. In the UK, the decade of the 80s was characterised by a dramatic increase in overall inequality. Since 2007, instead, there has been no clear trend in inequality (Hills et al., 2019). Lately, the Gini Index[1] (a broad measure of inequality) has decreased from 34 in 2014/15 to 33.2 in 2015/16 to then return back to 34 in 2016/17 (IFS, 2018). Yet, inequality remains substantially higher than in the 70s. The top percentile of the population in the country, for example, holds about 8% of the country's income versus 3.5% in the 70s.

Absolute poverty has been gradually decreasing. After a long period of gradual decline, relative poverty has been on the rise again since 2012/13. There has been a gradual but continuous fall in absolute poverty since 2012/13. More recently, while overall absolute poverty[2] has remained virtually unchanged since 2017/18, absolute child poverty rose by 1 percentage point due to a reduction in working-age benefits. According to the ONS, an estimated 2.4 million working people were in poverty in 2017, of which 31% also experienced in-work poverty. Persistent poverty[3] was experienced by 8% of the population equivalent to roughly 4.7 million people, comparable with 2008 levels. The share of all households in relative poverty has remained broadly stable since the early 2000s (Borquin et al., 2019). As for income inequality, relative poverty experienced a rapid increase during the 80s until the early 1990s. From the early 1990s until mid-2000s relative poverty gradually fell with a temporary increase during the Great Recession of 2008. Since then, relative poverty before housing has been declining faster than relative poverty after housing costs. It is only from 2012/13 that relative poverty has been on the rise again.

While evidence suggests a long-term positive association between poverty and inequality, policies can alter such a pattern. Over the last fifty years, a study by Hills et al. (2019) finds a clear positive empirical association between income inequality and relative income poverty. Yet, the more recent fall in relative poverty (from 1990 to 2010) was not matched by similar falls in income inequality. Indeed, during that period the emphasis was on reducing poverty for children and pensioners, rather than reducing inequalities.

Over the last two decades, the average property price in England has risen dramatically. Market forces can affect poverty and inequality. According to the IFS, (2018) average property prices grew by 173% after adjusting for inflation, and by 253% in London since 1997. Higher housing costs in London have led to a large gap in relative poverty between London and other English regions. This has compensated for by more generous housing benefit in London given limits on eligible rents (Borquin et al., 2019). The last 20 years have seen a substantial fall in homeownership among young adults (IFS, 2018b). In 2016, the UK ranked 6th from the top in terms of incidence of housing costs. Housing costs (including mortgages and rents but excluding the portion of rent paid via Housing Benefit) made up 24.5 percent of disposable household income compared to 19 percent for the median household in the EU (Eurostat).

Since the economic recession of 2008, there have been widespread reforms to social securing resulting in extensive cuts to the welfare state. According to Farnsworth and Irving (2011), the last decade has been termed the 'age of welfare austerity' given the extensive cuts to services which form part of the welfare state. A study by Borquin et al. (2019) shows

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[1] The Gini coefficient is a commonly-used measure of income inequality that goes from 0 to 1: the higher the number, the greater the level of income inequality.

[2] The ONS defines people in absolute poverty as those living in households with income below 60% of (inflation-adjusted) median income in 2010/11. While people in relative poverty are those living in households with income below 60% of the median in a given year.

[3] Persistent poverty is defined as being in poverty in the current year and at least two of the three preceding years.

that over the period 2011-2017, changes to taxes and benefits offset the fall in pre-tax income inequality contributing to maintaining high levels of inequality. The effects are still evident. A report by IFS (2018) shows that reductions in working-age benefits pushed down incomes of poorer households in 2017/18. This depressed the net incomes of poorer families, while incomes for middle- and high-income families only slightly grew. Absolute child poverty has also increased by 1 percentage in 2017/18 due to cuts to working-age benefits and tax credits. The overall less generous universal credit system, which is expected to be fully rolled out by 2023/24 is expected to introduce additional substantial cuts to working-age benefits (IFS, 2018).

3.1. Linkages with the Food System

While the evidence is sparse on the direct linkages between poverty and income inequality on food system sustainability, we can rely on a larger literature on the indirect effects. In particular, we can focus on two main mechanisms 1) the effect of poverty and inequality on the supply and demand of certain types of food products, hence their relationship with food prices, and 2) the effect of poverty and inequality on the preference for certain food products. For both mechanisms, we aim at establishing a link with the socio-economic and environmental dimensions of food system sustainability and focus on three main aspects: income growth and inequality, costs of living, and social security measures.

3.1.1. Income Growth and Distribution

Income distribution shapes consumers' food purchasing behaviour both in terms of quantity and quality of food consumption. A well-established relationship in economics, the Engel's curve, relates income levels to the demand for particular types of goods. Evidence is consistent with an increase in absolute food expenditure on food as income rises but the proportion spent on food falls. Evidence from the impact of the Great Recession in the UK shows that negative income shocks, combined with a rise in food prices, led to a decline in real food expenditure. It also led to switch towards more calorie-dense types of food (Griffith et al., 2019). Indeed an increase in income also brings about a wider spread of spending patterns and a demand for higher-quality goods. As a result, products targeted at low-income consumers can be substandard comparatively, both in nutrition and condition (O'Connor, 2012).

Food-related environmental impacts increase as income increases, but at a certain level, the trend stagnates and eventually even begins dropping. A similar analysis to the one presented above can be done for the environmental burden of consumption and income levels. Environmental Engel curves describe the relationship between household income and the pollution embodied in the goods and services consumed, often in terms of CO2 emissions. Evidence tends to show that richer households are responsible for more overall pollution. However, although pollution increases with income, it does so at a decreasing rate. The relationship is supported by empirical evidence (Levinson and O'Brien, 2015, and Sager, 2017) and can be related to the specific case of food consumption. Wealthier households can offset their impact of consuming more by consuming healthier and less environmentally detrimental foods (fruits and vegetables). In the UK, the dietary adjustment towards an increase in fruit and vegetable intakes translates into a relevant reduction in GHG emissions (Castiglione and Mazzocchi, 2019). A study by Vranken et al., (2014), for example, shows evidence for an inverted U-shaped relationship between meat consumption and income, meaning that – at a certain level of income – average meat consumption will stagnate or even decline. Indeed, a healthier consumption structure is able to offset the detrimental environmental effects of a higher level of consumption. A study conducted by Csutora & Mozner (2014) demonstrates that for the upper three income deciles, ecological footprints for food consumption are not notably higher, as the individuals in these groups use their higher incomes to purchase and consume healthier food products, i.e. fruit and vegetables, which have a lower environmental burden.

The middle classes, which have yet to make the switch to the more expensive healthier foods, are at greatest risk to adopt environmentally unsustainable consumption patterns. Considering the fast-paced growth of the middle-class in some countries, the possible effects this group could have to decrease environmental impacts by consuming healthier diets would be greater than the lower-income deciles (Csutora and Mozner, 2014). A large majority of adults in Western European countries live in middle-income households. In 2010, the middle-income population ranged from 64% in Spain to about 80% in Denmark, the Netherlands, and Norway. However, while most Western EU countries experienced shrinkage of the middle class between 1991-2010, France, Ireland, the Netherlands and notably the United Kingdom, experienced opposite trends as the share of middle-income adults increased between 1991-2010, mostly by lifting those in poverty out of lower-income tiers. While some argue that there are direct links between growing middle-income shares and increased meat consumption in the UK (Ritchie, 2019), there is insufficient evidence to confirm a causal link in the UK specifically. Studies that assess the implications of fast paced-growth of the middle-class on meat consumption in other countries may be informative within certain limitations. For example, fuelled by rising incomes rather than urbanization, meat consumption in China grew six-fold since 1978, driven by its growing middle-class population — the largest in the world (Woetzel, 2019). According to an analysis by Mckinsey & Company, China's population spends almost 2.5 times more than it did a decade ago, and much of it on meat. The meat-eating rate and increased production are said to be detrimental for both the country's human and environmental sustainability.

There is limited evidence on the relationship between income inequality and food prices. There is yet little research on the linkages between income inequality and food prices. A study by Frankel and Gould (2001) found that higher prices are associated with the absence of a middle class, hence greater income inequality raises the prices that poor households face. More recent research shows that newly emerging middle-class households are more price-sensitive than established affluent households, hence exercise downward pressure on food prices (Eizenberg and Salvo, 2015).

Healthy foods and beverages are more expensive than less healthy ones. Most studies find that healthier foods cost more than less healthy ones (see for example Jones et al., 2014). This has important implications for the affordability of a healthy diet. A study by Scott et al. (2018) finds that 26.9% of households had to spend more than a quarter of their disposable income, after housing costs, to meet the Eatwell Guide costs due to the higher prices of healthy products. The Eatwell Guide is a UK Government's guide that outlines a diet that meets population nutrient needs. Similarly, higher fruit and vegetable prices have been found to partially offset the positive outcomes of the 5-a-day campaign in the UK (Capacci and Mazzocchi, 2011).

The gap between healthy and less healthy food products has been growing over time. Cross-country evidence shows that the price gap between healthy and less healthy products has increased over the last 30–40 years with processed foods becoming cheaper relative to less energy-dense fruit and vegetables (Wiggins et al., 2015). Evidence for the UK confirms this pattern. Jones et al. (2014) find that prices of healthy food products have been growing faster than unhealthy products over the period 2002-2012. The price of healthy items rose by £0.17/1000 kcal per year compared to £0.07 on average for less healthy items. There is no single explanation for such a trend. On one side the trend can be partially associated with improvements in quality (e.g. tomatoes being marketed as vine tomatoes). On the other hand, the lack of competition between UK supermarkets in the market of healthy products did also contribute to widening the gap. A study by Lan and Dobson (2017) suggests that there are differences in the degree of competition across vegetable and fruit products, the evidence is indicative of keen competition for bigger selling products but weaker competition for slower selling products. Finally, the vegetable and food consumption in the UK is largely reliant on imported fruit and vegetables (Capacci and Mazzocchi, 2011), hence are subject to exchange rate fluctuations and higher transportation costs.

In terms of spatial inequality, there is mixed evidence on the presence of food deserts. Food deserts are defined as areas, usually found in impoverished areas that have limited access to fresh fruit, vegetables, and other healthful whole foods. In turn, this is often associated with higher prices for healthier food products. There is mixed evidence in the literature in regard to the presence of food deserts[4]. On one side, evidence from the UK demonstrates that poor households do not pay systematically higher prices than other households for identical food products (Blow and Leicester, 2012). This is consistent with other broad-based studies mostly based on US data. However, concerns remain regarding physical rather than financial access to sustainable foods, in specific contexts. In addition, some studies in the USA and the UK have found that stores located in areas with higher concentrations of low-income people, tended to stock fewer choices of food and those that they did stock were of poorer quality and more calorically dense (Hendrickson et al., 2006; Lee et al., 2010).

3.1.2. Costs of Living and Income Shocks

At low-income levels expenditure demands, such as for fuel, water, local taxation, debt repayments often take priority over nutritious food. Spending pressures and priorities of households change with age and income levels. Besides adequate food consumption, the ONS (2017) recognises items such as rent/mortgage payments, television, mobile phones, heating and washing machines as essential in modern-day life and crucial in determining material deprivation. Older households tend to spend more on food, and similarly, households at lower levels of income tend to spend a larger share of their income on food. Multiple studies have established that many consumers cut back on food purchases and skip meals as a result of inadequate income to cover essential consumption (Cooper & Dumpleton, 2013; McHardy, 2013).

Rising housing costs, in particular, exercise pressure on food consumption. Numerous studies delineate the link between rising housing costs and food insecurity. A study by Fletcher et al. (2009) found considerable evidence that increases in rental costs lead to higher rates of food insecurity for low-income households. Similarly, a more recent study by Kirkpatrick and Tarasuk (2011) found that households in standard market housing where housing costs consumed more than 30% of their income, had increased odds of food insecurity. Unsurprisingly, rent debts were also positively associated with food insecurity. Indeed, the proportion of income allocated to housing has been found to be inversely associated with food expenditures.

Temporary expenditure shocks are also related to a decrease in food consumption. A study by Beatty et al. (2014) analyses the effect of cold weather shocks on household expenditure in the UK. They find that elderly households respond by increasing fuel expenditure, and, for those at the lower end of the income distribution, by reducing food consumption. Similarly, evidence from the United States shows that low-income households trade-off between food and heating costs during cold weather which ultimately shows negative effects on nutritional outcomes (Bhattacharya et al., 2003).

Rising living costs have an additional behavioural effect on the inability to engage in at-home meal preparation due to poor quality cooking facilities. Research suggests that at-home meal preparation paired with the consumption of fruits, vegetables, and meat alternatives is a more sustainable manner to increase energy and nutrient intake (Mclaughlin et al., 2003). There is some evidence that the quality of cooking facilities may affect food security as one study found that low-income households with poorly equipped kitchen facilities had three

[4] Food deserts are areas (particularly urban areas) where cheap, healthy food is inaccessible to those without private transport.

times the rate of food insecurity compared to those with better food preparation resources (Broughton et al., 2006).

3.1.3. Social Security and Policy Measures

In general, there is less emphasis on food-specific anti-poverty measures in Europe when compared to the US. Countries can provide poverty assistance in the form of generic social and economic policies or more specific food assistance programmes. Shogren (2011) reviewed the available policies in major developed countries and found that policy response to poverty among European countries gives less emphasis to food. In the UK, for example, food security is the responsibility of the Department for Environment, Food and Rural Affairs (DEFRA) and there appear to be limited links with relevant issues such as income levels or retail provision in local communities that are the responsibility of other departments (Lambie-Mumford, 2015). In relation to this, most evidence, often from developing countries, suggests that unconditional transfers[5] to poor households are not spent on inessential consumption (Evans and Popova, 2017). This suggests that social benefits do not need to be linked to specific uses, such as food consumption, for them to be spent on basic items of need.

In the last decade, emphasis on food poverty has received a strong response from the charity world through the proliferation of foodbanks. Foodbanks are non-profit charitable organisations that distribute food to those who have difficulty purchasing enough to avoid hunger. According to the largest charity network in the UK, the Trussell network, there were over 2,000 UK food banks in 2017. While discussing the effectiveness of foodbanks is beyond the scope of this report, we have identified a vast gap in the literature regarding the effectiveness of food banks and their relationship with consumer preferences, and ultimately healthy food choices.

Labelling social security policies[6] can incur the risk of carrying a negative connotation (stigma). There is evidence suggesting that welfare participation is stigmatizing (Celhay et al., 2017). This is particularly so when social security policies are associated with food consumption as food has an important role in defining people's identities (Purdam et al., 2016). Stigma was indeed one of the reasons, among others, for changing the name of the Food Stamps program in the US to SNAP. In the UK, a study on food banks in the northwest of England has found that a substantial number of food bank users had concerns about the social stigma of food aid (Purdam et al., 2016). Stigma has been linked to the limited choices regarding the food received.

Research shows that labelling unconditional cash transfers has an effect on the way in which recipients spend them. One aspect of food-specific policies is the clear association between welfare transfers and food expenditure. Labelling unconditional cash transfer, for example, is one way to make them salient to food poverty but yet without imposing any constraint on how they are used. A study by Beatty et al. (2014) looks at the "Winter Fuel" payment in the UK, a universal annual cash transfer paid to households with at least one individual aged 60. The authors find that if households are given an unconditional cash transfer labelled "Winter Fuel Payment" of £100 they would spend between £15 and £66 on fuel versus £3 for an unlabelled transfer. Indeed, behavioural experiments find that when a label is attached

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[5] Unconditional (cash) transfers are cash payments provided to financially disadvantaged people without requiring them to be spent on particular goods or services or to comply with specific conditions.

[6] This refers to support policies that have a explicitely stated objectives, e.g. food stamps or winter fuel support. These forms of support can be conditional (i.e. can only be spent on specifit items that are related to the objectives, e.g. food) or unconditional (the recipient is not constrained in how the financial support is spent, e.g. winter fuel support payments are labelled but unconditional, meaning that payments are made to elegible households but there is no obligation to spend them on household fuel).

to a part of their budget, subjects change consumption according to the label even if they are not legally required to do so (Abeler and Marklein, 2016). They also find that subjects with lower cognitive abilities are more likely to be influenced by such labelling and change their consumption patterns.

Similarly, in-kind food transfers[7], such as food stamps, are also found to alter consumer behaviour towards food consumption. Social security policies aimed at alleviating food poverty can be implemented in the form of conditional payments, e.g. food stamps can only be used for at-home food consumption. This form of support has been largely used in the US through the SNAP programme which assists low-income households in accessing sufficient food and nutrition. Food stamps are received in the form of payment cards. Because the transfer can only be spent on food-at-home, it is considered as a form of in-kind transfer. Economic theory would predict that households should treat in-kind transfers no differently than an equivalent cash transfer given the fungibility of money[8]. Hence, food-specific policies such as food stamps should not induce households to spend more on food than they would with an equivalent cash transfer. While earlier academic literature brought contradicting results, recent research has consolidated findings towards the non-fungibility of in-kind transfers. Beatty and Turtle (2015), for example, studying the SNAP programme find that the in-kind transfer induces households to increase their food expenditure share by more than they would with an unconditional cash transfer. Results are also supported by a study by Hastings and Shapiro (2018), who argue that the non-fungibility is due to households treating in-kind benefits as part of a separate mental account.

Research findings have implications for the linkages between poverty-related policies and the food sector and for excluding certain food products. The violation of fungibility of money in the presence of labelled or in-kind income transfers implies that such policies can have a larger than expected effect on spending in the food retail sector linking the performance of the food sectors to changes in poverty-related policies. It can also have implications for the treatment of unhealthy or environmentally unsustainable items, and the effect depends the mental accounting adopted by beneficiaries. Understanding how policy changes affect the mental accounting of benefits and spending, however, requires future empirical and theoretical research.

On the opposite side of the policy spectrum, behavioural economics offers relevant insights on how to affect food behaviours. A nudge alters people's behaviour in a predictable way without forbidding any options or significantly changing economic incentives. Hence, a nudge should not raise prices, change incomes, or restrict consumer choice (Thaler and Sunstein, 2008). In the context of food choices, putting the fruit at eye level, for example, counts as a nudge while banning junk food does not. Requiring calorie information to be displayed on food menus is also a nudge, but in this case it carries additional information to consumers. Nudges have been found to be effective in altering consumer behaviour (Leicester et al., 2012). Other strands of behavioural economics also find that consumers may respond more to taxes than to equivalent subsidies if the tax is perceived as a loss whilst a subsidy is perceived as a gain. In an experiment, researchers compared the effects of a reduction in the price of healthy products (simulating a subsidy) versus an increase by the same proportion in the price of unhealthy products (simulating a tax). Taxes on unhealthy products were found to have significant effects

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[7] In-kind transfers are so called because, since the financial support can only be spent on certain products, e.g food in the case of food stamps, it is equivalent to provides recipient with actual food products. Yet, food stamps differ from proper in-kind transfers as the recipient has some agency over they type of food products to be purchased.

[8] Fungibility of money is an economic principle that implies that any unit of money is substitutable for another and that the composition of income is irrelevant for consumption. So whether a household receives money in the form of conditional or unconditional transfers should not matter as both adds up to total household income, i.e. what matters for consumption is total income not its composition.

on improving the nutritional composition of the purchased baskets, whereas subsidies to healthy products did not (Epstein, 2010)[9].

The relationship between food-related support measures and environmental sustainability has not been sufficiently explored. The question at hand remains whether food assistance programs, including food banks, food stamps, and cash transfers, encourage sustainable food consumption. While some evidence is available on whether such initiatives lead to the consumption of nutritious food, the literature fails to capture arguments on the environmental sustainability of consumption. Food banks have sometimes been framed as more than a financial safety net, but also as champions against food waste (Gustavsson et al., 2011; Michelini, 2017)[10]. Yet, the lack of rigorous empirical evidence prevents us from establishing the overall impact on food waste. More recently, approaches that specifically target food waste have been encouraged. Social supermarkets, for example, receive surplus food and consumer goods from partner companies (e.g. manufacturers, retailers) for free and sell them at discounted prices (Michelini et al., 2009). On the other hand, a study by Caraher and Furey (2017) highlights how using food waste to feed the hungry undermines calls for direct actions to both reduce producing food waste and to address underlying causes of food insecurity. As we have seen for in-kind transfers, linking food waste to poverty-related policies can tie social policies to the performance of the food industry. This can potentially alter the market incentives for food suppliers and make them reliant on poverty-related policies. According to the authors, it also has the additional drawback of absolving the responsibility of the government to address food insecurity.

3.2. Summary

Our review of the literature has shown that poverty, income inequality, and social security measures are closely linked to the sustainability of the food system by affecting the consumption of sustainable and healthy foods. Our findings can be summarised under the following mechanisms:

1) **Food prices:** Healthy foods are more expensive than less healthy ones and the gap has been increasing over time. This implies that healthy eating guidelines are increasingly less affordable, in particular for those at the bottom end of the income distribution. Among the multiple factors that can explain the increasing price gap, higher food prices have been associated with greater income inequality. On the other hand, there is mixed evidence on the link between spatial inequality and food prices and availability. These aspects are particularly relevant for the socio-economic dimension of food system sustainability.
2) **Consumption choices**: Temporary and permanent increases in non-food expenditure, including housing costs, have been found to depress food consumption and ultimately affect nutrition. Similarly, low-income levels are associated with both low levels of consumption and poorer dietary quality. Indeed, negative income shocks have been linked to a decrease in food consumption, in particular of healthy food products. Higher-income is associated with higher food consumption, however, the environmental burden of consumption decreases at sufficiently high-income levels. Social security policies, either in the form of unconditional but labelled transfers, in-kind transfers or nudges, can

[9] A paper by Salois and Tiffin simulate the effect of a fat tax and a corresponding revenue-neutral subsidy on fruit and vegetable. The paper shows that a fat tax reduces the intake of saturated fat and also of other important nutrients. The decrease in nutrients are not fully compensated by the subsidy on fruit and veg. It is, however, worth noting that as this study relies on simulations behavioural aspects, such as the perception of a loss, are not taken into account.

[10] Food surplus from manufacturing, retail and hospitality can be redistributed via charitable and commercial routes or being diverted to produce animal feed. Both of these options are usually classified as waste prevention..

effectively alter consumption behaviours with relevance for both healthy and environmentally sustainable food choices.

3) **Institutions:** There are pros and cons in the use of food-specific poverty-related measures. On one side, such policies can be used to incentivise healthy or sustainable food consumption. On the other side, depending on the type of policy, they can tie the agriculture and food industry to changes in poverty-related policies or incur the risk of stigmatising their recipients. In addition, insights from behavioural economics can help design policy to alter consumption behaviour. These can have implications for both the socio-economic and environmental dimensions of sustainability.

4. Climate Change and Mitigation Policies

The UK plays a leading role in the global effort to reduce greenhouse gas emissions. With the ratification of the Paris Agreement in 2016, 55 countries have committed to the reduction of Greenhouse Gases (GHG) emissions to limit the temperature increase to 1.5 degrees Celsius. The Agreement requires countries to put forward their best efforts to reduce national emissions and to report regularly on their emissions and mitigation actions undertaken. The UK is one of the ratifying countries and has been playing a leading role in the global effort to reduce emissions by setting a legal target to bring all GHG emissions to net-zero by 2050. Across stakeholders and political parties in the UK and worldwide, consensus is growing on the need for the reduction of GHG emissions.

The agricultural and food sectors play a major part in contributing to global GHG emissions and are likely to be increasingly targeted by climate change mitigation policies. Estimates suggest that the food system is responsible for 15-28% of the totality of GHG emissions from developed countries (Garnett, 2011). About 15-20% are the result of agricultural practices and land-use changes, while the remaining 5-10% are from the processing and distribution of food products (Vermeulen et al., 2012). In the UK, the food system is responsible for about 19% of man-made GHG emissions, excluding emissions from land-use change (LUC) and imported goods, 10% are from agriculture. The inclusion of imported goods would raise the contribution of the food system to 30% according to a WWF UK report (Audsley, et al., 2009). It is, therefore, expected that the food system will be directly and indirectly affected by mitigation strategies. While agriculture has thus far been largely exempted from climate change policies, this is not likely to last. The EU target to cut GHG emissions by 40% by 2030, for example, implies a reduction of 20% of emissions from agriculture by 2030 as compared to 2005. In the UK, the Committee on Climate Change[11] has recommended that a fifth of the agricultural land must shift to alternative uses that support emissions reduction, including afforestation, biomass production, and peatland restoration.

Although climate change will lead to major transformations in the food system, our focus in this report is on mitigation policies rather than adaptation strategies. Although the food system is likely to experience major transformations due to the global effects of climate change, this report will only investigate the direct and indirect effects of mitigation policies on the sustainability of the food system. While we recognise the importance of adaptation strategies and their implications for the food system, the literature in this area is vast and well developed. On the other hand, the linkages between mitigation strategies and food system sustainability are less explored, hence the intention of this report to draw attention to these linkages, which are particularly relevant for the design of future mitigation policies.

[11] *The Committee on Climate Change offers independent advice to the UK government on building a low-carbon economy. The report is entitled: "Net Zero The UK's contribution to stopping global warming"*

4.1. Linkages with the Food System

Achieving ambitious emissions targets, as those set out by the UK, requires the adoption of a proper price on carbon and a switch to alternative sources of energy. In this report, we focus on two main policy strategies to reduce GHG emissions: implementing carbon prices and supporting bioenergy. Choosing the appropriate policy tool to sustain sufficiently high carbon prices and encourage the adoption of alternative sources of energy, is a complex process that involves political and technical judgements. In this report, we abstract from this policy decision process and focus instead on the consequences of adopting efficient carbon prices and increasing bioenergy production.

4.1.1. Carbon Prices

A carbon price is a cost applied to carbon pollution to encourage polluters to reduce the amount of GHG emissions they emit into the atmosphere. There are two main approaches to establish a carbon price: a carbon tax or a cap-and-trade-system. Both aim at attributing a cost to GHG emissions and, ultimately, at affecting the behaviour of polluters. This is to emphasise the focus on changing behaviour rather than raising revenues, which is typical of other forms of taxation.

Carbon prices are expected to increasingly cover additional sectors of the economy. Carbon prices are currently applied to varying extents across different sectors of the economy, with some sectors being completely exempted. While agriculture does contribute to global GHG emissions, it has so far been largely excluded from the mitigation targets. Currently in the UK, carbon pricing is already applied more widely than what is required by the EU ETS[12], but agriculture remains under-regulated (Burke et al., 2019). The expansion (both at the extensive and intensive margin) of carbon pricing will have direct implications for the sustainability of the food system through the effect on agriculture and food prices but also indirectly through the effect on other emission-intensive products and services.

Carbon prices will affect the affordability of emission-intensive goods and services but the extent of their impact depends on how businesses respond to the new incentives. Evidence shows that mitigation costs affecting the production, processing, and distribution of goods and the provision of services, are not fully passed through to final consumers. Where firms can adopt more energy-efficient technology or switch to more efficient production and distribution processes, price impacts are substantially reduced. The commission on climate change estimates that if carbon prices were passed on to consumers this would add 6 pence to final consumption by 2030 (CCC, 2019).

Carbon prices, whether on food or on other emission-intensive goods and services, have implications for the sustainability of the food system. A carbon price on food and/or agricultural products can directly affect the affordability of emission-intensive products. As mentioned above, the extent of the effect depends on the rate of pass-through to final consumers. Price changes will induce a shift towards crop mix and diets that are low in emission intensity. A carbon price on non-food products would also exercise upward pressure on other costs of living. As described in the previous section, increasing costs of living have important implications for food security.

[12] *The EU ETS is the is the cornerstone of the EU's policy to combat climate change and is based on setting a cap on the total amount of emissions allowed (this refers only to sectors covered by the policy). Within the cap, companies receive or buy emission allowances which they can trade with one another as needed. After each year a company must surrender enough allowances to cover all its emissions, otherwise heavy fines are imposed.*

Carbon prices, whether on food products or on other emission-intensive goods and services, can have adverse distributional effects. A high fraction of low-income household budgets are spent on electricity, heating fuel, and transportation, which are emission-intensive sectors. Hence, the effects of carbon prices are in general found to be regressive. A similar argument can be applied to carbon prices on food and agricultural products. For the UK, Gough et al. (2011) provide a comprehensive analysis of the impact of carbon prices that consider the direct and indirect emission embodied in food products. They show that emissions per capita across households rise less than proportionately with per capita income, confirming the regressivity[13] of carbon taxation. The regressivity is found to be particularly acute for emissions associated with domestic energy usage, food, and housing.

There are trade-offs between the use of uniform and differentiated (income-sensitive) carbon prices. The negative distributional effects discussed above are often used in support of differentiated carbon prices. Indeed this has been the concern of most governments. In the UK, for example, households currently face lower carbon prices on electricity and gas use than businesses. Also, carbon prices on domestic use of gas are lower than those on electricity. Academic research tends to suggest that a uniform carbon price should form a central part of policy aimed at reducing emissions as it bears the lowest overall economic cost (Advani and Stoye, 2017). Differentiated carbon prices instead provide weak incentives to reduce emissions arising from domestic energy use.

Carbon prices can raise revenues that can be used to cushion against the adverse distributional impacts of mitigation policies. Growing research is devoted to investigating alternative compensatory schemes for the negative distributional effects of carbon prices (Bowen, 2015). Advani et al. (2017), for example, review a number of studies on potential compensatory packages that can accompany energy tax reforms. For the UK case, the review proposes that revenues raised from a uniform carbon tax could be returned to households through lump-sum transfers combined with an increase in the generosity of existing benefits and tax credits. Doro and Réquillart (2018) suggest that the use of revenues to subsidise the consumption of fruits and vegetables is likely to have positive effects on both dimensions. Support policies can also be embedded into emission reduction mechanisms. Some carbon pricing schemes, unlike the European Union Emissions Trading System, have explicitly incorporated elements designed to protect less well-off families. The Californian scheme, for example, requires at least 25% of the revenue to be spent on programmes that benefit disadvantaged communities.

Carbon prices are not the only available tools to achieve emission reduction in agriculture. Payment for Ecosystem Services (PES) can deliver improvements in farming and land efficiency and reduce emissions. Under this approach, farmers receive payments for providing public goods services such as enhancing watershed areas and protecting biodiversity (Lightfoot et al., 2017). PES exist in various forms with a large variety of arrangements (from publicly to privately financed), and are adopted across developed and developing countries. A vast literature exists that investigates their impact (Wunder et al., 2008) and reveals largely heterogeneous results. This suggests that their success largely depends on the design, implementation, and method of financing adopted.

Technological developments can reduce the impact of carbon prices and make low-emission products and services cheaper. While technological development has the potential to reduce the negative effects of a transition to a low carbon technology, the development of green technologies will be heavily influenced by government policy (Popp, 2010). Technology improvements are likely to occur and will lead to lower costs. According to the CCC (2018), the average increase in energy costs to support the roll-out of low-carbon power has been more than outweighed by savings from improved energy efficiency. Yet, an uncertain policy framework

[13] *A policy is regressive if it affects disproportionally those with lower income levels.*

can result in less innovation in climate-related technologies. Providing predictable and long-term policy signals is crucial to give potential innovators and adopters the confidence to undertake the necessary investments.

Carbon prices can affect food security depending on the synergies and conflicts between nutritional properties and the emission intensity of food products. Briggs et al. (2017) show that while there are synergies for certain food products that are healthier and have low GHG emissions, others, such as sugar, have the opposite relationship (e.g. low in GHG emissions but possibly detrimental to human health). While research in this area is still emerging, a study by Vieux et al. (2013) has found that diets of high nutritional quality tend to have higher GHG emissions. On the other hand, studies that specifically simulate the possible implications of population diets shifting towards the consumption of low emissions products, tend to find positive synergies with few exceptions (Briggs et al., 2017). This issue is particularly relevant for food security since a diet that is healthy for the planet may not necessarily be better for individuals' health, and a carbon tax could disproportionately penalise highly nutritional food products. More research is needed to investigate the consequences of mitigation policies on dietary choices. For the UK, current dietary guidance suggests strong complementarity between environmental and health objectives (CCC, 2018). The recommended levels of meat and dairy consumption contained in the UK Government's EatWell Guide are even below those recommended to achieve emission targets (Burke et al., 2019).

Carbon prices can have implications for the sustainability of the global food system by affecting the global distribution of agriculture and food production. Carbon prices on agricultural and food products can reduce the competitiveness of domestic production relative to that of countries without – or with a laxer – climate policy. This can shift consumption towards cheaper imported food and agricultural products, a phenomenon known as carbon leakage[14]. A similar argument applies to carbon prices applied to other sectors. Empirical studies, however, do not systematically confirm the existence of carbon leakages and show heterogeneity across sectors and countries (Cherniwchan, Copeland, Taylor, 2016). Under the EU Emissions Trading Scheme (ETS), the European Commission identifies sectors that are at high risk of carbon leakage, which include several food processing activities, and monitor their performance through impact assessments and stakeholder consultations[15]. For the UK, a study of Sato et al. (2014) suggests that compensation or anti-carbon leakage measures could be targeted specifically at the pig, poultry, dairy and fertiliser sub-sectors.

Case Study 1: Decarbonising the Food Sector

In the UK, approximately one-fifth of GHG emissions come from the consumption and production of food and drinks (Berners-Lee et al., 2012; Garnett, 2008). Within the food and drink sector, around 70% of total emissions come from animal-based products (meat and dairy) (Weidema et al., 2008). This requires cereal crops to be grown for animal feed (Steinfeld et al., 2006), and involves energy-intensive manufacturing and storing processes. For example, in the meat sector, 40-60% of energy consumption is used in further processing procedures (Ramirez et al., 2006).

Food waste is another major source of GHG emissions. In the UK, one-quarter of food and drinks produced is wasted, totalling 10 million tonnes per year (WRAP, 2019). Nearly three-quarters of this disposed of food could actually have been eaten. The largest contributor to

[14] Carbon leakage refers to a situation that may occur if, in relation to climate policies imposed on one country, businesses were to transfer production to other countries with laxer emission constraints. This could potentially lead to an increase in their total emissions.

[15] See this website for the official list of sectors at risk of carbon leakage: https://ec.europa.eu/clima/policies/ets/allowances/leakage_en

food waste is households (70%), followed by manufacturers (18%), hospitality and food service (10%), and retailers (2%) (WRAP, 2019). Food waste is also a global problem: if food loss and waste were a country, it would be the third biggest emitter of greenhouse gas emissions after the US and China (Hanson et al., 2015).

Lifestyle and dietary changes have made a significant impact on GHG emissions. Urbanization resulted in a loss of awareness of the seasonality of food products, with modern city dwellers expecting food to be available all year round. To meet the urban demand, the food industry resorts to carbon-intensive methods to supply food which is out of season, such as heated greenhouses or importing from abroad (de Laurentiis et al., 2016). As with other developed nations, the UK's economic development over the past century also resulted in greater consumption of carbon-intensive products, particularly animal-based and processed foods (Behrens et al., 2017).

In most cases, meat consumption requires a sub-optimal use of land, water, and energy resources that could have been used in agricultural production instead (Godfray et al., 2010; Garnett, 2011). Conversion of feedstock into animal matter is quite inefficient: approximately 7kg of grain is required to increase a cattle's weight by 1kg, 4kg of grain for a pig, and 2kg for a chicken (Rosegrant et al., 1999). It is thus unsurprising that GHG emissions from a meat-eating diet are approximately twice as high as those from a vegan diet (Scarborough et al., 2014).

Policies to address food sustainability

1. Promoting efficient energy use

Energy constitutes a small proportion of total production costs in the food and drinks sector (ranging from 2-10%), so manufacturers have little financial incentive to prioritise decarbonisation. New technologies also require large upfront costs and long lifecycles (20-40 years), which discourages regular investment, especially among small and medium enterprises (SMEs).

The Department for Business, Energy, and Industrial Strategy (BEIS) outlines a number of ongoing (as of November 2019) and proposed policies to promote the development and adoption of new technologies across the sector, including:

- Providing £9.2 million worth of funding for an Industrial Energy Efficiency Accelerator (IEEA) programme, to finance the roll-out of close-to-market energy efficiency innovations across the sector. (In effect from 2017-2022)
- Establishing an energy efficiency scheme to help companies install energy-efficient and cost-saving measures. (In effect from 2017-2022)
- Introducing a financial support programme to subsidise onsite feasibility studies for energy-efficient technology adoption, and subsidise investments in these technologies. (In effect from 2017-2021)

It is worth noting that these policies are in effect under the current Government, but may change in the future.

2. Promoting sustainable diets

Although new technologies and changes in farming practices can help reduce GHG emissions, substantial reductions can only be achieved by changing consumption patterns (Stehfest et al., 2009). In a recent report, the Intergovernmental Panel on Climate Change (IPCC) identified plant-based diets as a major opportunity for reducing GHG emissions and recommended a global reduction in meat consumption (IPCC, 2019).

Researchers estimate that for the average daily energy intake in the UK, moving from a high meat diet (100g or more per day) to a low meat diet (50g or less per day) would reduce an individual's carbon footprint by 920kg of CO2 per year – a similar amount to the emissions from a medium-haul return flight (Scarborough et al., 2014)[16]. Switching to a vegetarian or vegan diet has an even larger impact (reductions of 1,230kg and 1,560kg of CO2 per year respectively), enough to offset the emissions from driving a family car for 3,000 miles. Besides mitigating climate change, reducing consumption of animal-based foods can improve global food security (Foley et al., 2011; Godfray et al., 2010; Ray et al., 2013), and reduce water stress and biodiversity loss (Steinfeld et al., 2006).

There are a number of other proposed dietary shifts that would reduce our environmental impact, including increased consumption of seasonal products (Foster et al., 2014), and decreased consumption of products that have a high environmental burden but are low in nutritional content, such as coffee, tea, cocoa, and alcohol (Saxe et al., 2012).

Nationally recommended diets (NRDs) are important policy tools for guiding individuals towards diets that are both healthier and environmentally sustainable (Story et al., 2008). While NRDs differ across countries according to the health challenges faced by particular nations, one common feature is their recommendation to substantially reduce consumption of sugars, oils, meat, and dairy, and increase consumption of fruit, vegetables, and nuts. Switching from the average diet to an NRD is estimated to reduce GHG emissions by 13-25%, eutrophication by 10-21%, and land use by 6-18%, depending on the specific NRD chosen (Behrens et al., 2017).

3. Reducing food waste

Food waste reduction is expected to have a greater impact on carbon footprints than dietary changes (Behrens et al., 2017). The average UK resident wastes £200 worth of food per year, but most consumers are unaware of how much food they waste (EFRA, 2017). Besides a lack of awareness of their own wastage, studies have found numerous other reasons why, including:

- **Consumers are unaware of food waste's environmental impact** (Neff et al., 2015).
- **Consumers can afford to waste:** a common finding among studies of food waste is that richer households waste more food than poorer households because the marginal cost of doing so is much lower (Pearson et al., 2013).
- **High-quality standards and sensitivity to food safety** place unnecessarily strict restrictions on what consumers are willing to eat. For example, consumers are often unsure of what to do with leftover food and edible leftovers are often thrown out for fear of contamination (Cappellini and Parsons, 2012; Rozin, 2014; Porpino, 2016).
- **Over-purchasing because of insufficient planning.** Many shoppers fail to check what food is already available at home, or end up purchasing more than planned because of marketing practices such as buy-one-get-one deals or sales (Farr-Wharton et al., 2014). This surplus food has a high probability of ending up as waste.

The Environment, Food and Rural Affairs Committee (EFRA) identified a number of policies that could substantially reduce food waste, including:

[16] *This analysis accounts for the location in which raw materials are sourced throughout all stages of the production process (in the UK, the EU, and outside the EU), and the relative proportion that imported and locally-produced foods are consumed within the UK.*

- **A mandatory target for food waste reduction.** The Courtauld Initiative, launched in March 2016, is a voluntary agreement that aims to reduce UK food waste by 20% per person over a 10-year period (2015-2025). Major UK retailers and global food manufacturers, who represent more than 93% of the food retail market, have signed up for this initiative (EFRA, 2016). The Government will consult in 2019 and 2020 on introducing regulations to make food waste reporting mandatory for major retailers, as well as mandatory food waste prevention targets and surplus food redistribution obligations (DEFRA, 2018).
- **Improved household access to food waste collection points.** Food waste management is decentralised - each local authority differs in its specific targets and availability of food collection facilities. Government collaboration with local authorities is needed to ensure more households have access to food waste collection points, and that waste contracts include separate food waste collection.
- **Stronger tax incentives for food surplus redistribution.** Currently, it is cheaper for firms to send food waste for anaerobic digestion (AD) instead of for redistribution to people in need, which has additional storage and handling costs. Based on the current level of redistribution, an estimated £1 million of government funding is needed to cover these costs (EFRA, 2017). In 2018, the Government announced a £15 million scheme dedicated to addressing surplus food from the retail and manufacturing sectors, and dedicated the first £5 million to help food redistribution organisations overcome financial barriers to redistributing surplus food (DEFRA, 2019).
- **Influencing household behaviour.** Government funding of charities such as WRAP would enable them to maintain their food waste reduction programmes. In the long term, the government could aim to incorporate lessons on food and food waste into the school curriculum, to raise awareness at an early age. In December 2018, the Government appointed Ben Elliott as the first Food Surplus and Waste Champion, with the aim of promoting public awareness of the issue of food waste (DEFRA, 2018).

4.1.2. Bioenergy

Bioenergy is expected to be a fundamental component of the future provision of energy. Integrated Assessment Models (IAM), which are interdisciplinary efforts that try to link the main features of society and economy to the natural environment, have shown that meeting ambitious greenhouse gas mitigation targets will require substantial amounts of bioenergy as part of the future energy mix (Calvin et al., 2012; Popp et al., 2011). In the UK, the Committee on Climate Change has concluded that bioenergy could provide up to 15% of the UK energy demand in a low carbon economy by 2050.

The relationship between biofuels and food security is complex and depends on several factors. Among others, key determinants of the competition between food and biofuel production are: the choice of feedstock, the available natural resources, the relative efficiency (GHG emissions, yields, costs) of different feedstocks; and the available processing technologies (HPEL, 2013).

A major concern for food security is the use of food and feed crops for energy production. The diversion of land from food to energy uses can have negative consequences on food supply and prices. The area of crops grown for bioenergy equated to just over 2% of all arable land in 2017 in the UK; 48% of land used for bioenergy was for biofuel (biodiesel and bioethanol) for road transport (DEFRA, 2017). In the UK, biodiesel is more central to biofuel policy given that half of the cars are equipped with diesel engines, giving greater weight to oil crops, such as soybean or oilseed rape over cereals and sugar beet for the production of

biofuels[17]. Yet, a trend is emerging towards the increase use of waste instead of crop for biodiesel[18].

There is a general consensus that biofuel production induces an increase in food prices but controversy exists on the extent of the impact. In less than one decade, world biofuel production has increased fivefold alongside with a sharp rise in food commodity prices (HLPE, 2011a). While biofuels have played a major role in pushing up food prices, a range of other factors have contributed including, among others, a rise in food demand, a shift to animal protein in emerging economies and weather events. While there is a general consensus on the fact that biofuels have a role in driving price volatility, controversies still persist on the extent of their impact (Abbott, 2012).

When deciding how to allocate farmland, including for the production of energy crops, farmer considers not only future returns, and the related uncertainty but also the sunk costs of conversion. With the right incentives in place, farmers can switch to alternative uses of land beyond food production. Conversion policies, however, should be carefully designed to take into account broader and indirect effects. Song et al. (2011) show that while conversion subsidies do encourage conversion, they do also have an indirect effect on those already cultivating energy crops who do not directly benefit from the conversion subsidy and might have the opposite effect of encouraging a switch in the opposite direction. Under the European Common Agricultural Policy (CAP), food production has been rewarded over other services that the land can provide. Currently, farmers receive subsidies that are not linked to GHG emissions reduction (CCC, 2018). Greater emphasis could be devoted to the role of land as a natural store for carbon or a regulator of natural hazards such as flooding.

Second-generation bioenergy is expected to have a limited impact on food security. The types of bioenergy used to replace fossil fuels have different implications for food security (Blandford et al., 2018). The use of first-generation biofuels (i.e. food crops such as maize, sugarcane, and sugar beet) could potentially put pressure on food security. The overall effect on mitigation is also questionable since the production of these biofuels generates emissions (Wagstrom and Hill, 2012). On the other hand, second-generation biofuels make use of non-food biomass such as woody crops or agricultural waste or can be cultivated on marginal farmland. Non-food feedstocks do not compete directly with food crops for the use of land and water and are hence more consistent with food security goals[19]. Indeed, Lotze-Campen et al. (2014) find that the overall impact of second-generation bioenergy on global food prices is estimated to be modest as the feedstock, for example from forests, does not directly compete for agricultural land.

UK emission reduction targets require an increase in bioenergy and targets cannot be fully met using only domestic biomass. In the UK, estimates indicate that over 60% of the crop-derived bioethanol for road transport originated from crops grown outside of the UK (DEFRA, 2017). Top suppliers are European countries while little is imported from non-European countries. Recent studies show that local GHG emission offsets from the use of bioenergy may

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[17] Bioethanol is obtained from corn, wheat, sugar cane, and biomass and can be blended with petrol or used on its own. Biodiesel instead is derived from natural oils such as soybean oil or animal fats. It can be used in diesel engines but cannot be used on its own and needs to be blended with tranditional petroleum fuel.

[18] Provisional data indicates, for example, that no oilseed rape grown in the UK was used to produce biodiesel in 2017/18. This reflects a longer term shift towards the use of wastes compared to the early years. Indeed, the most widely reported UK sourced feedstock for biodiesel was used cooking oil.

[19] Second-generation biofuel feedstock is the nonedible by product of food crops. This means that no additional fertilizer, water, or land are required to grow this feedstock. Third generation biofuel has refers to biofuel derived from algae.

be compromised by increasing emissions elsewhere due to the intensification of agriculture and deforestation in other parts of the world (Fargione et al., 2008; Searchinger et al., 2008).

Case Study 2: The Energy-Water-Food Nexus

The energy-water-food nexus (EWFN) represents the interactions between these three resources, and the trade-offs in resource use brought about by societal pressures such as the growing population, urbanization, and shifts in dietary patterns (de Laurentiis et al. 2016). These pressures are expected to increase in future decades, since by 2050 researchers expect the global population to reach nine billion and the urban population to double – changes that will increase the demand for water and energy by more than 40% (Defra 2012, FAO 2013). Although food production has grown at a faster rate than the world's population for the past two decades (56% compared to 30%), the natural resource depletion and ecosystem pollution caused by current production systems is unsustainable, making food security one of the biggest challenges of this century.

Climate change adds further pressure on the nexus, by changing normal weather patterns and making extreme weather events such as droughts and floods more frequent. Land-intensive climate change mitigation measures such as biofuel cultivation can also strain the nexus, resulting in policy debates on the best allocation of limited resources between energy and food provision (Hoff 2011). This case study investigates the use of bioenergy (anaerobic digestion and biofuels) in the UK, its current and expected effect on the EWFN, and policies that could promote sustainable bioenergy supply.

1. Anaerobic digestion (AD) and biofuels in the UK

Anaerobic digestion converts organic matter into biogas, a renewable energy source that can be used for heat and power. While AD plants have been operating within the UK for decades, the number of plants has only increased dramatically recently due to government subsidies. For example, the Feed-in Tariff (FiT) and the Renewable Heat Incentive (RHI) provide financial support for the installation of small-scale renewable energy systems and renewable heating technologies respectively, and the Renewables Obligation (RO) requires UK electricity suppliers to increase the proportion of energy derived from renewable sources (Ofgem, 2019).

In 2017, there were 401 operational AD plants and a further 420 projects under development, which are expected to double the current capacity of AD energy production (from 363 MWe to 689 MWe) (DEFRA 2019). In the UK, AD production uses a fairly equal mixture of food/crop waste and specially-grown crops (the vast majority being maize). Crops are also grown for biofuel production, with wheat being the dominant input, followed by sugar beet. These crops can be combined with food waste or used cooking oil to produce biodiesel and bioethanol. Biofuel supply is divided roughly equally between these two types (49% and 46% respectively, with bio-methanol making up the remaining percentage). In 2017, biofuels constituted 3.1% of total road and non-road mobile machinery fuel, of which 99.4% met EU sustainability requirements[5] (DEFRA 2019).

2. Bioenergy and the energy-water-food nexus

While bioenergy contributes to the UK's energy and climate change targets, there are concerns that feedstock production competes with food production for land use (ADBA 2012, DEFRA 2015). The experiences of other European countries such as Germany and Italy have shown that the bioenergy sector can significantly change land-use patterns because of the need for purpose-grown crops, resulting in negative environmental and economic impacts such as soil erosion and nutrient loss (ADAS 2016, Britz and Delzeit 2013, Delzeit et al. 2013, Steinhausser et al. 2015).

However, the UK's AD industry is relatively small, both in absolute terms and relative to that of Germany and Italy, so its current scale is unlikely to affect food production (Röder 2016). In 2017, only 2% of the UK's arable area was used to produce crops specifically for bioenergy (either AD or biofuels) (2016 report), less than that used for golf courses (More, 2017). Studies on the impact of AD find that bioenergy crop production has not significantly affected land rental values or changed agricultural practices and land-use patterns in the UK (ADAS 2016, ADBA 2012, DEFRA 2011). Even if the AD industry grows to its target size of 1,000 plants, the resulting increase in land use is projected to be quite small (less than 1% of UK's total agricultural land).

Rather than place additional stress on the EWFN, bioenergy production can actually help mitigate challenges to the nexus. AD and biofuels help "close the loop" between supply and waste disposal, providing a sustainable alternative to extracting new resources (Voulvoulis 2015). Aside from transforming waste into an energy source, AD also produces digestate, a valuable organic fertilizer and soil conditioner, which can change farming practices by reducing reliance on fossil-based fertilizers (Iacovidou et al. 2013). Compared to annual crops grown for consumption, energy crops also require fewer inputs (fertilizer and agrochemicals), can grow on lower-quality land (including land that is no longer suitable for food production), and are more resilient to extreme weather (Whitaker 2018). Thus, AD crops can help reduce carbon emissions in the energy market while simultaneously improving the security and sustainability of food production.

Energy crops also provide many socio-economic benefits for the rural economy, including diversification of farm income, as some parts of the UK offer relatively secure long-term contracts to farmers who can dedicate a proportion of farmed land to feedstock production. The development of bioenergy supply chains can increase non-farm employment, providing opportunities for new skills and business.

Even in countries with a much larger bioenergy industry, appropriate policies can help manage the trade-off between crops for energy and crops for food, ensuring food security. For example, price volatility in the grain market is expected to increase due to greater climate variability, which affects crop yields. A flexible biofuels mandate, which allows energy crops to be diverted to the food market during supply shortages, can reduce price volatility in these markets. A study conducted by the UK Department for Environment, Food and Rural Affairs (DEFRA) finds that this flexible mandate could reduce the magnitude of a hypothetical spike in the price of coarse grains by up to 15% in the EU, and by more than 40% in the US (Durham et al. 2012). Instead of being a major driver of price spikes, biofuels can instead be part of the solution.

3. Policies for sustainable bioenergy supply

The UK's bioenergy industry is still relatively young and immature, but has great potential to scale up production. Although the industry has grown rapidly over the past decade, this trend is not expected to continue due to reductions in subsidies for energy generation (the Feed-in-Tariff and Renewable Heat Incentive) (Haltas et al. 2017). While these changes do not affect existing plants and installations, they weaken the incentives for new investment or development. Also, land use decisions involve a range of government departments and agencies, and the current lack of coordination between these parties has resulted in a non-integrated approach to policy-making and a lack of long-term policy certainty (Whitaker 2018).

There are also perceived economic barriers to bioenergy adoption. Energy crop production involves high establishment costs and delayed revenues from harvestable biomass, which discourage uptake, even though banks account for these factors when offering financial support to farmers. Also, despite evidence to the contrary, there are also widely held views

that energy crops can negatively affect land values because land cannot be converted back to arable farmland (Whitaker 2018). The government could adopt a number of policies to overcome these barriers and support the scaling up of sustainable bioenergy supply, including:

- A long-term government commitment to bioenergy, building on statements of support made in the 25-Year Environment Plan and the Clean Growth Strategy. Providing financial support for UK-produced feedstocks and for scaling up bioenergy crop production (including R&D) would encourage adoption and create a safer investment environment.
- The development of an integrated land use strategy that connects the relevant policy objectives (including agriculture, food, energy, land use planning, infrastructure, and transport), in order to better manage the conflicting demands on land use. Multiple departments and agencies will need to coordinate to unify and streamline processes for land use planning and permissions, to reduce the time delay in planting crops.
- The creation of an advisory service that provides farmers and landowners with up-to-date advice on bioenergy planting. This service involves collaboration with relevant agencies (such as Natural England) and industry stakeholders.

4.2. Summary

Climate policy is expected to increasingly influence the policy agenda of future governments. Our review has highlighted strong links between climate policy and the sustainability of the food system. It reveals that a portfolio of policies is needed to implement efficient climate policies without threatening the sustainability of the food system. We can summarise the effects of climate policy on the food system through the following mechanisms that are relevant for the socio-economic and environmental dimensions of food system sustainability:

1) **Food prices**: climate policies are expected to increase the price of emission-intensive food and agricultural products. A shift towards bioenergy has also been linked to higher food prices. In addition, the effect of carbon prices on real incomes via higher consumer prices appears to be regressive. These price and distributional effects have implications for food affordability and security. On the other hand, appropriate compensatory packages can be put in place to cushion against these negative effects. In addition, second-generation bioenergy does not compete with food and has the potential to lead to greater emission reduction. Higher food prices matter also for the environmental sustainability of the food system. If carbon prices are not implemented globally they can induce a relocation of production towards countries with laxer environmental and climate policy. Monitoring and preventive measures, however, can substantially reduce carbon leakage.
2) **Consumption choices**: carbon prices will affect dietary choices by altering the relative prices of emission-intensive foods and agricultural products. Their effect on food security through nutrition depends on the synergies and conflicts between emission intensity and nutritional properties of food products. Carbon prices on non-food products and services can also indirectly affect food security by increasing living costs and exercise downward pressure on food expenditures. Such effects are also generally found to be regressive. On the other hand, although more research is still needed, current dietary guidelines suggest a strong complementary between low emission food products and healthy eating. Compensatory schemes can substantially limit the negative distributional effects and technological developments, (e.g. greater energy efficiency) can limit the transmission of carbon prices into higher household expenditure.

3) **Land use and agricultural practices:** With the right incentives in place, farmers can switch to the production of bioenergy and environmental services. While first-generation bioenergy tends to intensively use inputs and natural resources such as water, second-generation bioenergy induces agricultural practices that are not detrimental for the environment as they encourage the use of marginal land and agricultural residues for the production of energy.
4) **Institutions**: Coordination between climate, energy and food policies has emerged to be key in ensuring that negative distributional effects are reduced and conflicts between environmental and nutritional objectives are taken into account. International cooperation and coordination have also emerged to be key to reduce the undesired effects of carbon prices and the increased worldwide production of bioenergy. Monitoring, as done within the EU ETS, is also important to reduce carbon leakages.
5) **Innovation:** With the right incentives in place, technological change is likely to drive the development of cheaper low-emission alternatives to products and services and of sources of bioenergy that compete less with food production (e.g. second and third-generation bioenergy). Improvements in energy efficiency can also help reduce the transfer of carbon prices to final consumers.

5. International Trade and Preferential Trade Agreements

The last 50 years have witnessed substantial growth in international trade. The global trend in tariff reduction[20], declining transportation costs, and bilateral and regional trade agreements, combined with economic growth in emerging economies, have contributed to the expansion of international trade. Yet, in comparison to the manufacturing sector, trade in agricultural products has seen a smaller increase given the higher tariffs, as well as, the presence of domestic support measures for manufacturing. Non-tariff measures are typically applied to the agricultural sector, but are also expected to be gradually removed (FAO, 2018). Recent trade tensions, in particular between the US and China, are concerned mostly with the manufacturing sector (UNCTAD, 2018).

Agriculture trade patterns differ across countries and income levels. While emerging economies are gaining a prominent position in the international trade sphere, growth in agriculture exports from least developed countries has been held back by low productivity and weak institutions (FAO, 2018). Least developed countries are projected to become significant net importers of agricultural products in spite of agriculture having a key role in providing employment and livelihood opportunities.

The EU is a major source and destination of trade in food and agricultural products. The EU represents about 39% of global agricultural imports followed by the US, China and Japan (UN Comtrade database). Emerging economies such as China, India, and Indonesia are increasing their share of agricultural imports. In the UK, less than 50% of the food consumed is supplied domestically. About 30% of food consumed in the UK originates in the EU, while Africa, Asia, North and South America each provide about 4% (DEFRA, 2017). The EU is also a major exporter of agricultural and food products, contributing to 41% of global exports, followed by the US, Brazil, and China (UN Comtrade database). In the UK, exports are dominated by the beverages sector, followed by the cereal sector (DEFRA, 2017).

[20] *Tariffs have remained mostly stable since 2008 but have declined on a multilateral and preferential basis through bilateral and regional trade agreements (UNCTAD, 2018).*

Agricultural commodity prices are determined by the global supply and demand for food, feeds, and energy. In the recent past, agricultural commodities have experienced significant spikes in prices, which were the result of a combination of factors including an increase in the demand for food and feed, the expansion of biofuels, and weather events. Since 2008, agricultural prices have been declining, although they are still higher than in 2007. Restrictions to food exports have been popular responses to food price spikes in several countries to insulate the domestic market from the international price rise (Anderson and Nelgen, 2012). Evidence suggests that trade restrictions have added substantially to the spike in international prices. Anderson et al. (2013) find that while domestic prices rose less than they would have without protection in some countries, in many other countries they rose more than had there been no such insulation.

The number of preferential trade agreements[21] (PTA) has been increasing rapidly over the last decades. The rapid increase in the number of Preferential Trade Agreements, both under negotiation and implemented, has been a prominent feature of international trade in the last couple of decades (WTO, 2011). Recent figures show that currently about half of world trade has occurred under some form of PTA (UNCTAD, 2018).

This section focuses on links between Preferential Trade Agreements and the sustainability of the food system. While international trade more generally has important implications for the food system in terms of environmental, and socio-economic effects, this is a very vast and complex area of analysis. Hence, while current and expected trends in trade and agricultural products serve as a necessary background, we have narrowed the focus of this study to investigate the role of PTAs given their relevance in shaping future patterns of international trade.

5.1. Linkages with the Food System

The role of trade in meeting global food demand is expected to increase over the next 30 years. Over the past decades, food production has expanded, largely driven by increasing demand from the growing emerging economies. As a consequence, world agricultural trade has increased more than threefold since 2000. In the coming decades, however, climate change is expected to induce a significant shift in production across regions and a reconfiguration of international trade patterns. Indeed, most Integrated Assessment models (IAMs) predict declining agricultural production, increasing food prices, and increasing trade as a result of climate change (FAO, 2018).

Preferential trade agreements have been found to deliver greater openness in agricultural markets. A review of 54 recent PTAs by Thompson-Lipponen and Greenville (2019) has found that agriculture is increasingly treated as other good sectors in bilateral and multilateral trade agreements. Hence, modern PTAs are expected to increasingly promote international trade in agricultural commodities. Yet, while PTAs have achieved tariff reductions and reduced regulatory differences for agricultural and food products, the lack of consistency in terms of rules of origin applied to agriculture across agreements still imposes high compliance costs for exporters. The impact of increased trade in agriculture and food products on the sustainability of the food system largely depends on the conditions under which these products are produced and distributed.

[21] *A preferential trade agreement is a trade pact between countries that reduces tariffs for certain products to the countries who sign the agreement. While the tariffs are not necessarily eliminated, they are lower than countries not party to the agreement.*

Preferential trade agreements stimulate trade and the economic impact on the food sector can be summarised under three main effects. A typical analysis of the impact of trade liberalisation on the economy covers three main mechanisms that are also relevant when considering the aggregated effect on the food sector. A scale effect represents the increase in production driven by an increase in exports and is often associated with an increase in resource use and in by-products of the production process. A composition effect is the result of shifts towards the production of certain products due to differences in comparative advantages. Finally, international trade can stimulate innovation through competitive pressure and/or the transfer of technology (Grossman and Krueger, 1991). A technique effect captures such transformations and is often associated with a more efficient and environmentally friendly use of resources.

Case Study 3: Deforestation and Trade

Deforestation is one of the most pressing environmental challenges of the modern era. It plays a critical role in global climate change through associated greenhouse gas emissions, and threatens biodiversity through the destruction of sensitive habitats. Over the last 20 years, agricultural expansion has been one of the primary drivers of deforestation in many areas around the world, and at the same time, global agricultural trade has been steadily increasing. This relationship has led many researchers to study the role that trade plays in deforestation.

What are the channels through which trade affects deforestation? First, and foremost, the amount of deforestation is affected by agricultural output prices, which in turn are affected by trade. Therefore, when trade affects those prices, it will affect deforestation. If trade liberalisation is associated with an increase in local agricultural prices, then deforestation will increase as a result. In contrast, if trade liberalisation leads to a decrease in local agricultural prices, then deforestation will decrease. Empirical evidence suggests that increases in agricultural prices have led to increases in the amount of deforestation in Mexico, Tanzania, Brazil, Thailand, Costa Rica, and Australia (Robalino and Herrera 2010).

Trade can also affect deforestation indirectly through changes in input prices, or by contributing to broader economic development. However, the anticipated effects of lower agricultural input prices (such as the prices of fertilizer or agricultural machinery) and greater local economic development on deforestation are largely unclear: agricultural intensification may lead to less land used in agriculture and thus more forest area being conserved (Angelsen and Kaimowitz 2001), or intensification may increase the returns per unit of land at the forest frontier, resulting in a faster rate of deforestation (McNally 2015).

There are clearly many other confounding factors that affect the trade-deforestation relationship, including trends in governance, productivity, changes in regulatory frameworks and the associated changes in property rights. For instance, political corruption in Latin America explains land-based agricultural subsidies at the national level, which encourage producers to convert additional land to agriculture (Bulte et al 2007). There is also strong cross-country evidence on the link between institutional quality, governance, and deforestation (Deacon 1994, Bohn and Deacon 2000, Marchand 2016).

Regional trade agreements (RTAs) represent an important policy tool in trade liberalisation, and thus can affect deforestation. Regional trade agreements (RTAs), under the current WTO definition, include free trade agreements, customs unions, partial scope agreements, and economic integration agreements. Although RTAs typically cover a broad range of goods and services, they are especially relevant in the liberalisation of agricultural trade. Agriculture remains one of the most protected categories of goods, with tariff rates substantially higher than those for manufacturing goods (Trebilcock and Pue 2015). Because of this, agricultural markets are more likely to experience larger price shocks relative to other sectors after an RTA has been established. Another important trend is that the growth in agricultural trade

between RTA signatories has outpaced the growth in manufacturing trade among RTA signatories over the period 1998 to 2009, with the global share of agricultural trade increasing from 20% to 40% over the same period. In addition, the agricultural sector is more strongly protected in developed countries compared to developing countries. For instance, Bureau and Jean (2013) find that across 78 RTAs signed between 1998 and 2009, the average preferential margin[22] for agricultural imports in developing countries was more than three times that in developed countries 8 years after enactment. This discrepancy between developed and developing countries in existing agricultural tariffs implies that an RTA between a developed and developing country would, by eliminating tariffs, lead to a greater price effect on the agricultural exports of the developing country compared to that in the developed country. Given this asymmetry in response to an RTA agreement and the importance of agricultural expansion in affecting deforestation, it is not surprising that Abman and Lundberg (2020) found that deforestation increases after the enactment of regional RTAs. Although some of these RTAs include environmental provisions, which have helped to mitigate pollution (Baghdadi et al 2013), these provisions largely focus on timber trade rather than preventing the expansion of agricultural production into forests.

The recent acceleration of deforestation in the Brazilian Amazon has returned issues related to trade liberalisation and deforestation to the global spotlight. The debate focuses on whether the EU-Mercosur free trade agreement (which both parties have agreed to in principle in 2019) should be used as a "carrot and stick" to reinforce conservation policies in Mercosur countries, particularly in Brazil (Harstad, 2019). This illustrates that the environmental provisions incorporated into RTAs are not necessarily sufficient to guarantee environmental conservation if countries have weak governance and institutions, so RTAs should incorporate provisions that encourage specific conservation efforts and prevent the expansion of agricultural land into forests and sensitive habitat areas.

5.1.1. Environmental Concerns and WTO Rules

International trade under WTO[23] rules is governed by the principle of trade without discrimination. WTO rules are meant to ensure that countries cannot discriminate between trading partners (also known as most-favoured-nation (MFN) treatment) and that imported and locally produced goods should be treated equally (also known as the principle of national treatment). The system does allow tariffs and, in limited circumstances, some forms of protection.

There are two general exceptions to WTO obligations based on environmental grounds. Under WTO rules members can adopt policy measures that are inconsistent with the General Agreement on Tariffs and Trade (GATT) if they 1) are necessary to protect human, animal or plant life or health or 2) relate to the conservation of exhaustible natural resources. The main concern remains that of avoiding the misuse of environmental measures for protectionist ends.

Countries have undertaken a number of initiatives to incorporate environment-related concerns under the World Trade Organization (WTO) framework. The WTO's Committee on Trade and Environment (CTE) offers the institutional setting to discuss the relationship between trade and environmental measures. Measures that have been discussed include tariff reductions in environmental goods and services, clarity on the role of obligations in multilateral environmental agreements, and the removal of environmentally unfriendly subsidies, such as

[22] *The absolute difference between the tariff applied to countries not part of the trade agreement (under the principle of equal treatment) and the reduced tariff rates applied to countries that are part of the trade agreement.*
[23] *The World Trade Organization (WTO) is an international organization dealing with the rules of trade between countries. It is governed by agreements that are negotiated and signed by the bulk of the world's trading nations and ratified in their parliaments. Its goal is to ensure that trade flows as smoothly, predictably and freely as possible.*

those on fisheries. Yet, the majority of WTO members are developing countries with strong concerns about green protectionism (Johnson 2015).

WTO rules do not explicitly promote environmental goals and the WTO has no specific agreement dealing with the environment. While conversations are ongoing on environmental-related concerns, negotiations have not been concluded and the WTO official position remains that of dealing exclusively with trade-related issues, hence environmental concerns only emerge as far as environmental policies have a significant impact on trade. MEAs are international agreements between nations that, once ratified, are binding under international law. They cover environmental issues such as climate change, hazardous waste, and the marine environment. Among the 200 MEAs currently, about 20 deal specifically with issues of international trade, and hence intersect with WTO objectives.

Domestic Environment-related measures can be the subject of disputes under WTO rules if they are considered to go against the principle of non-discrimination. The WTO system has a dispute resolution mechanism that covers all agreements under the WTO umbrella. The dispute settlement system has seen an increase in the number of cases that relate to the environmental and, in particular, to national climate policies, that have trade implications. While cases confirm that governments have been able to adopt measures to address environmental concerns without going against the non-discrimination rules, disputes are still addressed by a case-by-case nature (Droege et al., 2016). A more authoritative interpretation of existing environmental exceptions to trade rules would provide a less uncertain regulatory setting for the implementation of domestic environmental policies (OECD, 2017).

5.1.2. Environmental Provisions and Free Trade Agreements

Trade agreements can be used to promote environmentally friendly behaviours on trade patterns. International cooperation towards sustainable goals has usually been achieved through the use of multilateral environmental agreements (MEAs), such as the Basel Convention on hazardous wastes. A growing consensus is emerging around the use of PTAs to pursue sustainable goals. Indeed, in the context of climate change, for example, the Paris Agreement states that a regional economic integration organisation (i.e. a PTA) may become a party to the UNFCCC and act jointly to implement its objectives. The use of PTAs to pursue the double outcome of increased trade and environmental sustainability stems from the premise that because gains from trade (and losses from reverting to a highly restricted regime) are large, unpleasant components can be inserted into trade agreement (Nordhaus, 1999). In particular, because PTAs are based on direct reciprocity, retaliation through sanctions can be effective in pursuing the implementation of environmental provisions. Another important advantage of PTAs is that trade negotiations involve a limited number of partners in comparison to MEAs and can, therefore, be achieved at a faster pace (Morin et al. 2018).

Environmental issues are increasingly regulated in PTAs. Environmental issues addressed in PTAs include conservation of fisheries, endangered species, forest governance, and trade in environmental goods. A study by Morin et al. (2018) shows that starting in the 1990s, environmental provisions begin to feature prominently in trade agreements. Since then, the number of environmental provisions included in trade agreements has increased considerably. This trend seems stronger in agreements between developed and developing countries (North-South FTAs). The study also highlights that environmental provisions cover a large variety of environmental concerns (the study identifies 14 categories). The most common are exceptions for the conservation of natural resources and to protect plants or animals. References to MEAs have also become increasingly common in free trade agreements. Data from the Trade and

Environment Database (TREND[24]) shows that the EU is the most important proponent of environmental protection in trade agreements with 3005 provisions over 202 agreements followed by the USA with 1325 (over 22 agreements) and Canada with 927 (over 16 agreements).

FTAs can stimulate trade in environmental goods and services (EGS). Environmental goods and services encompass environmental activities that are aimed at environmental protection and resource management. International trade has the potential to provide access to cheaper or more advanced equipment and technologies for preventing or mitigating environmental harm. While the Environmental Goods Agreement at the WTO level has seen little progress since its launch in 2014, trade barriers on EGS can be removed on a bilateral basis through the use of PTAs. Because PTAs involve negotiations among fewer parties than WTO negotiations, agreements are achieved faster.

FTAs with environmental provisions have been shown to lead to improvements in environmental quality. Only a few studies are known to address the relationship between RTAs and environmental quality to date. A study by Martinez-Zarzoso finds a positive relationship between membership in RTAs, either with or without environmental provisions, and improved environmental quality for two out of three pollutants investigated. While the study could not conclude to what extent RTAs with environmental provisions make a difference, a paper by Baghdadi et al. (2013) finds consistent evidence that only PTAs with environmental harmonization policies affect relative and absolute pollution levels.

FTAs with environmental provisions are likely to induce regulatory convergence among the signatory countries. The inclusion of environmental provisions in preferential trade agreements has been shown to help harmonise environmental regulations, in particular between developed and developing countries. Because environmental clauses have become a regular feature of European and American PTAs (Jinnah and Morgera 2013, Rose 2016), adopting and maintaining an adequate level of environmental protection is of critical importance for developing countries willing to enter into a preferential trade relationship with the EU or US. Evidence suggests also that environmental provisions diffuse faster when they are introduced through intercontinental agreements that involve more diverse country partners as the consensus makes it more likely for the provision to be widely accepted in the future (Morin et al. 2019).

Monitoring and assessment are crucial to achieving environmental goals through PTAs. Whether an environmental clause is legally enforceable is not a necessary or sufficient condition to determine whether the agreement has affected the relevant issue. The effectiveness depends on adequate procedures for monitoring, reporting, and review, and most RTAs do not provide for such procedures (Limão, 2016). On the other hand, more recent trade agreements established intergovernmental committees and stakeholder committees. The EU and US tend to have a different approach to environmental provisions. While US PTAs punish countries for non-compliance with environmental commitments, EU PTAs are characterised by soft measures of dialogue between civil society actors and governments. A study by Bastiaens et al. (2017) shows that, in both cases, environmental provisions are a channel of environmental policy diffusion. On one side, fear of possible sanctions induces ex-ante environmental policy improvements, on the other, policy learning spurred by the dialogue with EU institutions manifested into ex-post adjustments. Yet, given the increasing importance of non-economic provisions, more research is needed to evaluate the effectiveness of environmental provisions in PTAs.

[24] *The database on environmental provisions in PTAs can be found here: http://www.chaire-epi.ulaval.ca/en/trend*

Case Study 4: EU Approach to Sustainable Trade

The European Union has long shown commitment to environmental protection. In the international trade sphere this has been achieved both at unilateral (non-reciprocal) and multilateral levels. At the unilateral level, for example, the EU requires the use of sustainable management policies to obtain access to a generalised system of preferences (GSP). GSPs allow developing countries to access additional preferential tariff reduction if they satisfy certain environmental criteria.

At the multilateral level, besides contributing to WTO activities in terms of promoting initiatives to incorporate environment-related concerns under World Trade Organization (WTO) rules, the EU has increasingly incorporated environmental provisions into preferential trade agreements. Considerations for trade-environment linkages are an integral part of the trade negotiation process and consensus is sought through the engagement with stakeholders at different stages of the negotiation process. All preferential trade agreements are subject to impact assessments (IAs) before negotiations are undertaken, which cover aspects of social and environmental impacts.

A Trade and Sustainable Development (TSD) chapter was first introduced within the EU-Korea Free Trade Agreement and aimed at explicitly considering social and environmental issues in EU FTAs by considering the potential impact of trade on environmental protection and obligations under Multilateral Environmental Agreements (MEAs). The chapter also provides specific provisions that encourage trade practices compatible with sustainable development goals and the sustainable management and use of natural resources.

The EU-Japan FTA and EIA is another interesting example. The preferential agreement ratified in February 2019 explicitly addresses the issue of whaling and illegal logging – The EU has banned all imports of whale products for more than 35 years, and this will not change with the Economic Partnership Agreement.[25] Whales receive special protection under EU law and the EU strictly enforces the ban on trade under the Convention on Trade in Endangered Species. The sustainable development chapter of the EU-Japan economic partnership agreement provides a platform to foster dialogue and joint work between the EU and Japan on environmental issues of relevance in a trade context.

Similarly, trade policies are part of environmental instruments adopted by the EU such as the Timber Regulation and related FLEGT (Forest Law Enforcement, Governance and Trade). These are voluntary agreements addressing trade in illegal timber, which are devised to be compliant with WTO rules and to achieve desired environmental objectives.

While the EU follows the implementation of environmental provisions mainly through a civil society dialogue, effective monitoring remains a challenge, more generally for all PTAs that involve environmental provisions through rigorous ex-post evaluations.

5.2. Summary

Our review has documented the growing use of environmental provisions embedded into PTAs as tools to foster international cooperation towards a transition to a sustainable food system. In particular, we have identified two main mechanisms through which PTAs interact with food system sustainability:

[25] https://trade.ec.europa.eu/doclib/press/index.cfm?id=1955

1) **Institutions:** Modern PTAs, which very often include environmental provisions, have been found to constitute motives for international dialogue over environmental issues and multilateral environmental agreements. Recent trade agreements also aim at establishing intergovernmental and stakeholder committees. Evidence suggests that PTAs can be effective in facilitating the convergence in environmental regulatory regimes. Their effectiveness stems from the fact that PTAs involve negotiations among fewer parties than multilateral environmental agreements, combines costly environmental provisions with economic gains from trade and are based on the principle of reciprocity. Yet, our review has also highlighted the need for further research and greater institutional effort in monitoring and evaluating the effectiveness of such provisions.
2) **Innovation:** International trade has the potential to provide access to cheaper and more advanced equipment and technologies for preventing or mitigating environmental harm. FTAs have shown to be effective in reducing tariffs and non-tariff barriers on goods and services aimed at environmental protection and resource management.

6. Diet and Lifestyle

Peoples' dietary choices are a response to the broader daily living conditions in which they are born, live, learn, work and age. According to Friel and Ford (2015) influences operate both directly through the food system and indirectly through political, economic, social, and cultural pathways - peoples' dietary behaviours are a response to the broader daily living conditions in which they are born, live, learn, work and age.

Consumption patterns are increasingly shifting towards sustainable and healthy products. An increasing trend—most commonly among affluent millennials in developed countries—has been the adoption of a 'sustainable identity', which characterises itself by consuming environmentally-friendly goods. Consumers—particularly millennials—increasingly communicate their desire for sustainable brands. A recent report demonstrated that certain products with sustainability claims showed twice the growth of their traditional counterparts (White et al., 2019). Forbes recently named products that claim to be sustainable on the package as one of the six most important consumer trends for millennials. Researchers at Clemson University found that packaging characteristics are strongly tied to how consumers perceive the contents. Minimal and eco-friendly packaging is a crucial component of communicating that a product is good for the environment (Thackston, 2013). Nielsen Research has found that marketing goods as sustainable can lead millennials to significantly increase their purchase of certain goods including tea, coffee, and snacks (2018). Indeed, recent research indicates the increasing adoption of a sustainable lifestyle among millennials (Kocchar, 2017). While less than a third identify directly as environmentalists, the report argues that millennials are the most sustainable generation through their willingness to pay for more eco-friendly products.

A movement towards purchasing locally-sourced goods has risen among certain groups. An IRI report has highlighted the growing importance of location for shopping where 70% of EU shoppers identify strongly with ethical purchasing practices with a clear preference for consuming locally sourced products**.** The study surveyed over 3,000 EU consumers across seven EU member states—including the UK (Whelan, 2019). Trends demonstrate increased engagement with small-scale people-initiated community gardening and increased demand for locally sourced foods which can contribute to enhanced environmental, cultural and social values. Community initiatives increasingly transform urban spaces, such as farmers' markets which some argue are preferred to supermarkets. If fresh and local foods reach consumers of ready-made meals in an equally convenient manner, increased access could likewise decrease consumption of ready-made meals, which have a higher environmental impact than home-made meals because of the energy spent while re-heating and packaging. The UK Government has called on food producers to provide further labelling information for consumers to know where

in Britain their food comes from, as new research shows that almost 80% of people see buying local food as a top priority (DEFRA, 2015). However, several studies outline accessibility barriers to such markets for low-income communities. Some suggest that such markets in low-income and non-white communities are smaller and provide fewer fresh fruits and vegetables than markets situated in more affluent communities because of factors such as competition, farmer recruitment, and retention (Lowery et al., 2016). Others demonstrate that those in low-income households do not shop at farmer's markets due to lack of convenience and higher prices (Ritter et al., 2019). As such while demand for locally-sourced goods has risen, the effect of such a trend might be dependent on further external factors including socioeconomic status and purchasing power.

Work stress is a serious problem in parts of the UK. While trends demonstrate a decrease in average working time in the UK as a whole, regional differences are comparable[26]. For example, while average working hours decreased between 2008 and 2016 in Scotland, they slightly increased in London (albeit not by a significant amount) (Francis, 2017). Furthermore, studies have found that workload continues to be a challenge irrespective of working hours. The 2019 CIPD Working Lives Report demonstrates that a third of UK workers feel they have too much work, 20% cannot complete their task list within their allocated hours, and one in twenty feel completely overloaded. Regarding working hours, the survey reveals that 60% of respondents work longer hours than desired and that overwork is most often experienced amongst manager-level workers. The implications of work stress levels for consumption patterns are investigated below.

Flexible working has been noted to be a common solution to manage work stress and healthy lifestyles. This includes both formal and informal arrangements to benefit from flexi-time, reduced hours, and the possibility to work from home. According to CIPD, the largest motivators for flexible working arrangements are caring responsibilities and leisure time. However, while the study finds that 'costs' of flexible working to a career are uncommon, the demand for flexible working options is unmet. The report finds that about 20% of respondents had no flexible working arrangements available while two-thirds of UK employees lack their preferred option of a flexible working arrangement.

6.1. Linkages with the Food System

This study recognises two key mechanisms via which lifestyle changes have an effect on food system sustainability, namely 1) trends in consumer preferences; and 2) trends in working environments. Consumers have the power to shift the structure of the system entirely and in the past two decades have begun demonstrating preferences to do so.

6.1.1. Trends in consumer preferences

As outlined above, peoples' consumption patterns are context-specific responses to their broader daily living conditions, inclusive of socioeconomic status. While the literature in this section reflects trends towards a *willingness* to adopt sustainable habits, the literature further explained below outlines that the size of these effects does not directly translate to equal effects on *actual* consumption, which is argued to be context-specific and dependent on financial ability. Determinants of food choice depend on the conditions in which people are born, live, learn, work and age, driven by economic and social influences (Friel and Ford, 2015).

[26] https://clockify.me/working-hours

Increasing demand towards the consumption of sustainable goods has been shown to incentivise sustainable company behaviour/production. For example, according to Tetra Pak, declines in prepared soup consumption were suddenly reversed due to the increasing availability of biodegradable packaging, including paper cartons of soup, as it was found that three-fourths of millennials prefer soup in paper cartons to cans. While the trends are more significant within this age group, the visible sustainability of millennial-targeted soup packaging is argued to increase larger consumer knowledge that paper cartons are 70% more environmentally friendly than cans.

Consumption patterns towards locally-sourced goods have increased the visibility of, and access to, sustainable sourcing information. According to research conducted on behalf of the East of England Co-op, vegetables were at the top of the list for consumers in the UK of products that consumers would buy if a local option was available (DEFRA, 2015). Consumers' demand for information on the sources of their food has begun leading to innovative developments such as Tesco's online tool to allow consumers to identify products sourced within 10 miles of their local area. In an effort to further nudge consumers towards sustainable behaviour, recent research has highlighted drivers of the current increase in trends towards sustainable consumption - one central to the millennial generation being the rise of social media. The social exposure of consumers' purchasing habits to one another has amplified their desire to consume sustainably by holding each other accountable and simultaneously increasing the spread of information regarding environmental impacts (White, 2019).

Consumers' hierarchy of needs establishes a distinction between actual consumption and intended consumption of sustainable food products. Studies have sought to investigate the link between Maslow's hierarchy of needs[27] and consumer behaviour, with the common acceptance that even when consumers communicate a willingness to prioritise sustainability and other emotional values, price, quality, and convenience, under the umbrella of physiological needs, are often determinants of *actual* consumption (Mcleod, 2018; Harper, 2018). Consumers are more likely to report the *intention* of purchasing sustainable products, but less likely to actually follow through with the selection. Results from a recent survey demonstrated that while 65% communicated the desire to purchase from brands that advocate sustainability, only about 26% actually followed through (White et al., 2019). On the other hand, others argue that the discrepancy between intended consumption and actual consumption has been abused by brands as a justification for not making their products more sustainable. NYU Stern's Centre for Sustainable Business recently (2019) completed extensive research into U.S. consumers' actual purchasing of consumer packaged goods (CPG), using data contributed by IRI. Results demonstrated that more than half of the growth in packaged goods between 2013-2018 was derived from products marketed as sustainable (Whelan, 2019). With the aim of measuring actual purchases rather than intentions, data was collected from bar scan codes at checkouts across food, drug, dollar, and mass merchandisers. Consumption of sustainable products grew 2.3% between 2013 to 2018, which is notably almost six times faster in comparison to non-sustainable products. Finally, across almost all of the categories investigated, sustainable products grew faster than their non-sustainable counterparts. However, food prices remain to be a primary determinant of consumption patterns, and high food prices may have important negative effects, especially among poorer households (Green et al, 2013; Van Lenthe, 2015).

[27] *Maslow's hierarchy of needs is a motivational theory in psychology comprising a five-tier model of human needs, often depicted as hierarchical levels within a pyramid. Needs lower down in the hierarchy must be satisfied before individuals can attend to needs higher up. From the bottom of the hierarchy upwards, the needs are: physiological, safety, love and belonging, esteem, and self-actualization*.

Resistance to novel food products may impede the catalysation of technological innovations for sustainability opportunities. While Taufik (2018) finds that there are higher intentions to reduce meat consumption via curtailment, rather than with the intention to consume (more) meat substitutes, others argue the increasing supply of alternative meat sources such as Impossible Foods and Beyond Meat, reflects the fast-paced growth of its demand. Furthermore, informed adoption of agricultural biotechnology has been argued to provide necessary tools to enhance sustainable production, sustainably meet increasing demand and food security needs, improve crops, and mitigate climate change risks to a sustainable food system (Lakhan Sing & Mondal, 2018).

Trends towards "sustainable" foods such as organic produce are argued to be correlated with increased resistance to genetically modified foods. According to the Food Standards Agency (FSA) attitudes tracker, concern over GM foods in the UK seems to have increased between May 2015 and May 2016, peaking at 27% of respondents communicating concerns over GM foods (FSA, 2015-2016). However, while concerns decreased the following year to reflect 22% of respondents in November 2017, trends demonstrate that concerns are back on the rise with 25% of UK respondents communicating concerns over GM foods in May 2019 (FSA, 2016-2019). While understanding causes for concern is complex, many studies attempt to investigate possible drivers of public perception towards innovative foods. A University of Manchester study found that attitudes towards organic foods are a useful indicator of attitudes towards biotechnology as they are seemingly inversely correlated. The preference structure that underlies attitudes towards organic foods additionally seems to inform preferences towards genetically modified foods (Burton et al., 2001). Mistrust regarding agricultural biotechnology exists among consumers for a plethora of reasons—influential factors identified by several studies on public acceptance of plant GMOs included perceptions of risks and benefits, knowledge and trust, and personal values. These are argued to be exacerbated by large-scale dissemination of misinformation via social media. The recent EU Court of Justice Decision in 2018 to restrict the adoption of gene-edited products under the same restriction of genetically engineered products reflect continued resistance among public attitudes (Bonny, 2003; Lucht, 2015). However, there is a wide gap in perceptions between public consumer resistance and the rapid acceptance of GM crops for cultivation by farmers. The United Voice of Farmers and the United Voice for Agri-Cooperatives in the EU published a joint statement recognizing that "new technological, biotechnical and agronomical solutions are emerging on a global scale". The statement urges the EU to facilitate the breeding of novel crop varieties to help farmers meet challenges regarding climate change, the environment, biodiversity, and the production of sufficient, high-quality food and feed with increasing demand. Attitudes are likewise fragmented across the EU. While the percentage of consumers with concerns regarding GM foods in the UK is below the EU average (27%), many countries such as France and Germany reflect populations with above-average concerns (EFSA (a)-(c), 2019). Considering the cohesive EU regulatory framework restricting the use of agricultural biotech, regional consumer attitude trends may play particularly important roles for food system sustainability. However, with the uncertainty of regulatory reform under Brexit, attitudes towards innovative foods in the UK are argued to be an important future research area with significant policy implications for food system sustainability.

Popular alternative food products perceived as environmentally friendly and healthy might not actually be good for the environment. Finally, where consumer support does exist, evidence demonstrates information gaps and issues regarding perceptions of unsustainable products as environmentally friendly. For example, although almond milk seems like a great milk alternative, its environmental impact is fairly high. The biggest problem with almonds is that they require a lot of water to produce. On average, it takes a little over a gallon of water to grow a single almond, and many almond growers are located in California, which suffers from extreme droughts. Soy likewise requires massive chunks of land and pesticides to produce. There are large areas of the Amazon rainforest that are being destroyed in order to grow soy, and it is argued that soy is, in fact, more environmentally impactful than consuming traditional milk, depending on the source of production. Another example regards the significant

and abrupt jump in the consumption of avocados in the UK as well as across the EU (Martindale, 2017). While avocados are indeed healthy fats and marketed as super fruits, the environmental impacts and social consequences for avocado farmers have been found to be increasingly concerning. The increases in imports have direct effects for water shortages in rural Chile, as well as effects for deforestation and violence among cartel-like structures of avocado farming in Mexico (Mills, 2016; Facchini & Laville, 2017). Future interventions and policies aimed at reducing meat and dairy consumption, including labelling, provision of more information, educational campaigns and new product development will be more effective if they are holistic and better inform specific consumer segments (Apostolidis & McLeay, 2016).

6.1.2. Trends in working environments

The evidence on the effects of working environments on healthy eating is mixed. On one side, longer working hours limit the amount of time individuals spend on healthy activities such as food preparation. On the other hand, increased working hours, if associated with raising income, can lead to greater consumption of healthy products or healthy activities. Yet, there seems to be a gap in the literature regarding links between working arrangements and food system sustainability.

Work-related stress is a driver of unsustainable eating habits. Multiple studies have found a direct relationship between stress in the workplace and consumption of unhealthy foods. A 2011 study found that more unhealthy eating patterns were observed in employees characterised by a higher level of stress. Work overload, lack of control over work, and inappropriate work communication were particularly strong predictors of poor eating patterns. It was found that those with medium levels of work-related stress were less likely to build a tendency to unhealthy habitual and emotional eating (Potocka & Moscicka, 2011). Another study found that the effects of stress in the workplace continue beyond eating at work and drive dinner-time consumption after work hours. A 2017 study by the University of Michigan found that those who experience high levels of work-related stress have a higher tendency of consuming junk food instead of healthy food for dinner as an effect of experiencing negative moods throughout the day (Liu et al., 2017). This is argued to be driven by the desire to relieve one's negative mood as well as diminished self-control under feelings of stress (Liu et al., 2017)

Long and irregular hours are likely to encourage consumption of energy-intensive goods but results are not conclusive and more research is needed. Some evidence suggests that employees compensate excessive working time with higher consumption of fat and sugars and by reducing physical exercise (Oliver and Wardle 2000). In addition, a 2011 study conducted an analysis of the relationships between consumption and working hours. Employing surveys on French household expenses to highlight the environmental consequences of long hours, the study finds a direct relationship between working long hours and consuming energy-intensive goods (Devetter, 2011). Gerdtham and Ruhm (2006) find that a reduction in the number of hours worked has a positive impact on health. Similarly, a study by Hammermesh (2010) finds that the amount of time spent eating and its distribution over the day influences bodyweight and self-reported health. On the other hand, a more recent paper by Costa-i-Font and Sáenz de Miera Juárez (2018) find that reducing working hours have different impacts for white- and blue-collar workers in France. Blue-collar workers, for example, experienced higher chances of being overweight after the introduction of a reform to reduce working time partly because job-related physical activity was their primary form of exercise.

Workplace provision of healthy food options is particularly important for those working irregular hours. Furthermore, a 2019 systematic review investigating irregular working hours and consumption patterns, found that while most foods were sourced from canteens or cafeterias, such hours likewise caused vending machines to seem more convenient. The lack of healthy vending machine options is a concern among workers, with studies reporting perceived lack of healthiness and attractiveness of the foods available in vending machines. To

improve healthy eating habits at work, nurses in the UK have asked for vending machines to be stocked with healthy options, such as nuts, fruit, and low-sugar drinks. When healthy options, such as nuts, fruits, and low-sugar drinks, have been included in vending machines in work environments, it was found that purchases increased. However, this pattern is context-specific as satisfaction and willingness to pay for healthier options varied among different worksites. The availability of only smaller unhealthy snack foods in vending machines may account for the frequency of snacking behaviour during nightshifts. Indeed, the results of investigating eating habits during irregular working hours demonstrated that night workers did not eat more than day workers, but ate snacks over a longer time period. Additionally, in comparison to those working regular hours, night-shift workers lacked routine by adopting different consumption patterns on work and rest days. Considering that there is typically a lack of good food facilities available near work environments at night, it is suggested that irregular working hours may drive unhealthy and unsustainable consumption patterns (Reeves et al., 2004).

Regarding female employment specifically, there is mixed evidence on the relationship between working hours and food behaviour within the home. Earlier studies have found that the lack of time, irregular working hours, and busy lifestyles are barriers to adopting a healthier diet (Lappalainen et al., 1998). On the other hand, a study by Hambly et al. (2002) finds no direct association between the number of hours worked and household food behaviour; although working hours were associated with greater shared responsibility for food-related tasks. This suggests that work commitments do not automatically lead to unhealthy food choices.

6.2. Summary

Perhaps the most central theme of food system transformation revolves around dietary and lifestyle patterns. This study recognises two key mechanisms via which lifestyle changes have an effect on food system sustainability, namely, links among 1) trends in consumer preferences; and 2) trends in working environments. The following channels have been identified:

- **Consumption choices:** Lifestyle changes affect consumption choices and have implications for both the socio-economic and environmental dimensions of food system sustainability. Observed trends towards the consumption of sustainable and locally sourced goods, mostly among young adults, have been found to affect the food sector by influencing packaging choices and the information that retailers provide to consumers. Yet, there is some resistance to the adoption of innovative food substitutes, which might hold back potential sustainable developments in the food sector. In addition, contradictions are sometimes found between intended consumption and actual consumption of sustainable food products. These are partly the consequence of information gaps and misconceptions, which can be addressed with appropriate labelling and information campaigns. However, it is likewise argued they are largely attributed to discrepancies among purchasing power and the hierarchical prioritisation of price and convenience. Work-related stress and long working hours have been found to encourage unhealthy eating habits. The study also identifies the provision of food options in the workplace to be of particular importance, in particular for those working irregular hours. Yet, the evidence on work-related arrangements and healthy eating, including food behaviour within the home, is mixed and further research is needed in this area.
- **Innovation**: There is conflicting evidence on the willingness to consume innovative food products and resistance among the public to new products. This may act as a barrier to catalysing the opportunities of agricultural biotechnology, which have the potential to enhance the sustainability of the food system. On one side there is an increasing appetite for alternative food products, but on the other, food-related innovations are sometimes met with mistrust, which is often the by-product of positive attitudes towards organic food or locally sourced foods.

7. Conclusions

This study has explored how wider economic and societal transformations can impact the food system and affect its sustainability. We have focused on four main external forces, i.e. trends in societal and economic transformations occurring outside the core food system: poverty, inequality, and social security measures; climate change mitigation policies, preferential trade agreements, and lifestyle changes. Our conceptual framework has highlighted five main mechanisms: changes in food prices, changes in consumption levels and choices, and institutional and technological changes. This framework has proven to be useful in condensing scattered pieces of independent evidence within sufficiently narrow mechanisms through which external forces can impact the food system. Some of these mechanisms, in particular food prices and consumption choices, have also the advantage of being observable and measurable using commonly available data. Hence, they can offer possibilities to monitor the impact of external forces on the sustainability of the food system.

While the conceptual model has proven to be an informative tool in broadening the scope of common food system analyses to highlight important systematic influences driven by wider socio-economic changes, the report refrains from providing specific and actionable policy recommendations. Rather, the study outlines below key findings to inform policy and prioritise innovate policy design to include wider structural effects. The rationality behind the lack of direct policy recommendations derives from the recognition that there are substantial gaps in the existing literature—and consequentially insufficient for robust recommendations.

However, while this study comes to important conclusions, the identified gaps in the literature are equally informative for areas for necessary focus in the future. Certain themes reflected larger and stronger pools of literature, while some were presented with less-extensive evidence. Specifically, this study identifies three areas with particularly large gaps in the literature. First, while the literature on climate change adaptation strategies and their implications for the food system is well developed, significant gaps exist when investigating the linkages between mitigation policies and their effects on food system sustainability. Additionally, there is insufficient evidence on the effects of working environments on sustainable food systems. While some suggest longer working hours limit time for fresh food preparation, others argue that increased working hours associated with raising incomes can lead to the affordability of more sustainable products. Yet, as there seems to be a gap in the literature this area would benefit from further investigation.

Perhaps most evident is the sparse evidence on the direct linkages between poverty and income inequality on food system sustainability. To mitigate for the gaps, this study relies on a larger literature on the indirect effects. However, it is important to highlight where further research could contribute. The relationship between food-related support measures and environmental sustainability has not been sufficiently explored. While research findings suggest linkages between poverty-related policies and the food sector and specifically for excluding certain food products, understanding how such policy changes affect spending, however, requires further empirical and theoretical research. While some evidence is available on whether food assistance programs—including food banks, food stamps, and cash transfers—lead to the consumption of nutritious food, the literature fails to capture arguments on the environmental sustainability of consumption. Lack of rigorous empirical evidence in this area likewise prevents us from identifying the overall impact of such initiatives on food waste. While discussing the effectiveness of foodbanks is beyond the scope of this report, we have identified a vast gap in the literature regarding the effectiveness of food banks and their relationship with consumer preferences, and ultimately healthy food choices.

While gaps evidently exist, this study undertook an extensive review of the available literature, particularly employing innovative methods to mitigate for existing gaps. Our key findings from this review are listed below:

Poverty, inequality and social security:

- Income inequality, poverty, and social security measures are closely linked to the sustainability of the food system through their effects on food prices, consumption levels, and dietary choices.
- Rising living costs, unexpected income shocks (such as temporary increases in fuel expenditure associated with cold weather shocks) and declining working-age benefits are found to negatively affect consumption levels and the food choices of lower-income households.
- Healthy food products are more expensive than less healthy ones and the gap is increasing over time. Income inequality has partially contributed to widening the gap.
- In designing poverty-related policies, attention needs to be paid to limit the possible stigmatizing effect of food-related aid, and to how different policy tools induce can behavioural changes.
- Well-designed social security policies can tackle poverty and favour sustainable food consumption but can also incur the risk of tying agriculture and the food industry to poverty-related policies.

Climate change mitigation policies:

- The relationship between climate policy and the sustainability of the food sector is complex and demands monitoring. Climate change policy is expected to affect the sustainability of the food system through its effect on food and non-food prices and on consumption levels and dietary choices. The effects are strongly dependent on technological discoveries and adoption.
- There are important synergies and conflicts between emission reduction and nutritional outcomes, and a portfolio of policies is needed to implement efficient climate policies without threatening the sustainability of the food system.
- Appropriate economic incentives, e.g. stable prices and long-term contracts, can favour the transition to emission-reducing activities, such as switching from food production to bioenergy and/or environmental services. Technological developments are increasingly shifting bioenergy production towards sources that compete less with food production.
- Anaerobic digestion and biofuels can help "close the loop" between supply and waste disposal, providing a sustainable alternative to extracting new resources. Closing the resource loops could deliver economic benefits from the additional renewable energy generated, and savings on costs for the infrastructure required for the exclusive digestion of food waste.

Preferential trade agreements:

- Preferential trade agreements with environmental provisions can support the transition to a sustainable food system. Regular monitoring and evaluation can improve the effectiveness of such provisions.
- Modern PTAs have been found to be associated with improvements in environmental outcomes and to be effective in facilitating the convergence in environmental regulatory regimes. PTAs can also favour the international transfer of cheaper and/or more advanced technologies for preventing or mitigating environmental harm.
- Trade agreements between developed and developing countries should also include provisions for specific conservation efforts (such as payments for ecosystem services or creation of protected areas), with reliable and transparent monitoring, to prevent the expansion of agricultural lands into forests and sensitive habitat regions in tropical

developing countries.

- International cooperation and coordination, both in the form of multilateral environmental agreements and preferential trade agreements, can help to limit the undesired international effects of carbon policy and favour the transfer of green technology across countries.

Lifestyle changes:

- Lifestyle changes are leading to changes in the types of foods, packaging and information demanded both in the UK and globally. Trends towards sustainable and locally sourced products can help decrease food system-related environmental food prints. However, difficulties in public acceptance of food-related innovations may block sustainability opportunities of innovative technologies.
- Lifestyle and dietary changes have made a significant impact on GHG emissions. Urbanization has resulted in a loss of awareness of the seasonality of food products, with modern city dwellers expecting food to be available all year round.
- Reducing work-related stressors and work-related time constraints along with improving the quality of food provision at work can improve health by allowing for the adoption of healthier eating habits both at home and in the workplace.

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