

Plausible future scenarios for the UK food and feed system - 2015 & 2035

Final Report



Plausible Future Scenarios for the UK Food and Feed System – 2015 & 2035

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About the Defra Futures Partnership

Cranfield University was contracted by Defra and nine partners to deliver a package of pan-government futures research activities including regular horizon scanning, risk prioritisation/analysis, medium to large scale foresight studies and end-user capacity building. This futures research programme is designed to enable Defra and its partners to look ahead, to analyse what is seen, react to it and use that insight to strengthen strategic, policy and operational goals and approaches.

As part of the futures research programme at Cranfield University, medium-and-large-scale futures research projects are undertaken to assess the implications of future change to high priority areas of policy, strategy and/or delivery. This research takes a long-term strategic approach to investigating plausible changes, developments, challenges and opportunities within complex, interconnected, socio-technical systems such as the production and supply of food. It aims to identify what opportunities and challenges exist, which these systems might face in the future. The research, developed in close collaboration with the project's partners, provides organisations with the tools needed to assess the skills, resources, institutions and policies required to deal with a range of plausible futures. Research outputs establish a context for dialogue and encourage foresight in decision-making, by providing a framework for assessing the robustness of strategies and policy approaches in different situations.

Using this document

This report draws on evidence from the academic literature, published reports and the knowledge of experts, gathered through workshops and interviews, to produce a range of future scenarios for the UK food and feed system. Futures thinking has been applied to interpret information as the basis for creating three plausible scenarios, with an emphasis on implications for consumer behaviour. These scenarios have been shaped by experts within Cranfield University and the Food Standards Agency (FSA), and through stakeholder workshops and interviews, to establish the implications for the UK food and feed system. It should be noted that with a different group of stakeholders the scenarios (and indeed their implications) may emphasise different insights or priorities (e.g. a greater focus on nutrition and health as opposed to food safety). The scenarios do not represent UK Government policy nor the policy or position of the FSA and Cranfield University. Their utility is to provide a strategic tool to facilitate discussion and decision-making.

In reading the report, it is important to note that plausible futures were developed through the use of qualitative scenarios, which are not intended to predict the future, but do include explicit 'storytelling' pieces that illustrate a progression from current state of affairs to the future created in the scenarios. These provide plausible 'views' on the future based on past trends and knowledge, assumptions about the future, and insights garnered from a wide range of experts and the pervasive literature. The 'real' future is unlikely to be identical to any of these futures; however, it may be contained somewhere within this 'envelope' of future scenarios. The scenarios themselves are think pieces, designed to fuel discussion and debate, aiming to consolidate reflections about future developments into coherent depictions of potential courses of events leading up to 2015 and 2035. Seen from this perspective, they aim to better understand shocks and uncertainties and, in turn, help reveal more innovative and resilient strategies for the future.

Executive summary

Investigating the likely consequences of future changes in the food system and the risks associated with food processing and preparation is important to protect consumers, ensuring food is safe for human consumption. A wide range of futures research tools are used by regulators and businesses to understand the social, economic and environmental impacts on food systems, using this knowledge to determine where future intervention is best directed. Scenario planning is a tool often used for considering a number of alternative futures. In this case, scenarios ranged from an abundant supply of food during economic prosperity, to food shortages, food security issues and environmental destruction during an extended period of global economic hardship. Exploring these alternative futures, looking at short-to-medium and long term influences, is an important step in developing a clear context for future strategies and policies for the UK's food and feed system.

It is with this objective that Cranfield University, contracted by Defra and nine partner organisations to deliver a futures research programme, worked in partnership with the Food Standards Agency (FSA) and its stakeholders to consider three possible states of the UK food and feed system between 2015 and 2035. The project was implemented between April 2012 and March 2013 and involved more than 60 experts and stakeholders from government agencies, academic institutions, industry and other relevant organisations in the UK. The scenario process began with an environmental scanning exercise that took stock of existing information and knowledge related to the UK food and feed system. The intention was to assess the long-term challenges, identifying key trends and drivers of change for the UK food and feed system. Involving stakeholders with expertise in a range of disciplines including economics, social science, food preparation and retail, and risk management, provided a basis for varying assumptions about drivers and trends in the food system in order to reveal areas of uncertainty. Future projections of key drivers deemed plausible and consistent, formed the basis of the scenarios, supplemented by 'explicit story-lines' that illustrate alternative futures. The scenarios are designed to provoke thought about possibilities, and may be used as a tool to better understand the inherent shocks and uncertainties about the future and, in turn, help reveal more resilient responses for adapting to change.

Scenarios overview

The scenarios paint an integrated picture of plausible futures, drawing on an analysis of possible developments in a wide range of global change indicators, associated with the UK food and feed system. They are intended to be used by the FSA as part of a number of assessment methods to inform future policy development. Specifically, they will be used to consider how the FSA's control measures may be changed or adapted to achieve more robustness towards 2035. The following sections describe the scenario environment and the tables provide an overview of the key implications for the different sectors within the food chain (i.e. from production to consumption).

Reference

The Reference scenario is based on the way in which today's policies, strategies and agreements continue to develop and influence the food and feed system into the future.

Modest growth means the UK economy experiences a growing trade deficit and struggles to maintain its share in the global market. The UK's buying power diminishes as emerging economies, in a more liberalised international market, control the price and availability of goods. Rising food prices continue as energy and agricultural production costs increase. These pressures drive consolidation throughout the food supply chain, and a greater reliance on production and processing within Europe and the UK. More frequent extreme weather events impact on food supply and availability, making prices more volatile. Population growth and urbanisation reflect a shift in lifestyles and food consumption patterns. A prevalence of supermarkets and fast-food outlets increases the availability of cheaper, sometimes less healthy, food choices.

Consumers	Food and non-food retailers	Catering	Processing, production and supply
Economic constraints and busier lifestyles drive demand for convenient and affordable food	Fluctuation in food prices, consumer demand for convenience and affordability drive 'discounted' or 'value-based' retailing	The 'budget' consumer sets the trend for consumption	UK domestic self-sufficiency is promoted to combat volatility in commodity markets

Global trading

The Global trading scenario reflects developments that tend to be more open, co-operative and coherent. The UK experiences strong economic growth, having fully recovered from the global economic downturn. Global trade agreements lead to a stable increase in commodity prices, which is associated with a lower rate of inflation that takes the pressure off household spending (i.e. increases disposable income). Advances in food processing and modern technology drive innovation in the food system, changing food production and consumption patterns. Consumer interest in environmental and social issues increases and this is reflected in a more responsible (and sometimes healthier) diet, largely among those of higher socio-economic status. The structure of households is changing and suppliers respond by offering goods and services tailored to those changing demographic needs.

Consumers	Food and non-food retailers	Catering	Processing, production and supply
Choice for consumers is seemingly limitless in a technologically advanced food sector	High levels of innovation, investment in new technology and integration of ICT in the supply chain drive personalisation, diversification and specialisation in retailing	Hi-tech operations are adopted to provide a 'gastronomic' experience that meets expectations for quality, taste and nutrition	Environmental and economic sustainability drive technological innovation in processing, production and supply

Resource tensions

The Resource tensions scenario reflects developments that tend to be more fragmented, unstable and less coordinated at national and global levels. The UK economy experiences long-term economic difficulties with no real growth. International markets work largely on bilateral agreements driven by industry. This leads to protectionist measures such as embargoes and trade restrictions, resulting in market volatility and an increase in commodity prices. Volatile climate change adds to other resource pressures. The consumer is challenged by increasing food prices; choice is mainly based on cost with an increase in stockpiling practices, reflected in a preference for foods with a long shelf life. The prevailing economic climate increases consumers' tolerance of risk prompting a regulatory change including a reduction in safety standards (e.g. higher mycotoxin levels) and ready implementation of food technology (e.g. GMO and nanotechnology).

Consumers	Food and non-food retailers	Catering	Processing, production and supply
Widespread food poverty means 'value for money' is the 'mantra' as the recession drives price-based consumption	Retailing is shaped by fragmented supply chains and increasing diversity in the range of organisations that supply food	Poverty stricken consumers seek out 'big-society' initiatives to meet dietary requirements	A 'resource-grab' mind-set prompts business-led trade agreements

Scenarios description and analysis

While each scenario reflects different types and directions of development, from more or less coordination and disruption, all scenarios involve significant change, disruption and uncertainty along the way. The scenarios provide a tool to analyse insights about the future and consider how different strategies and controls might perform across a range of futures. While it is understood that some strategies or controls may be effective and resilient despite the futures depicted in these scenarios, the consensus is that the more robust actions are those taken in response to conditions highlighted in multiple scenarios.

A more comprehensive description of the scenarios and an analysis of the implications along the entire food chain (from production to consumption) are presented in Section 2.2. Further analysis of the scenarios was undertaken. This utilised case studies of three different foods types to illustrate how the scenarios may be used to assess policy implications for the range of sectors along the food chain. The case studies explore what the triggers for change in food production and supply might be in the next twenty years, and what the emerging food safety implications might be under each scenario.

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1.0 Introduction

This section of the report outlines the project aims and outcomes, and discusses the role of scenarios in helping organisations develop flexible long-term plans.

1.1 Project outline and outcomes

Cranfield University worked in partnership with the Food Standards Agency to support the development of scenarios for the UK Food and Feed System.

The work took account of all relevant sectors and stakeholders in the UK food and feed system, and is intended to be used by the FSA as part of a number of assessment methods to inform future policy development. The questions underpinning this research project were: *“What are the plausible futures scenarios for the food and feed system in 2015 and 2035 for the UK? What are the strategic risks these futures pose to the food and feed system?”* The research questions, set out in the project specification document, were approved by the FSA and the Futures Partnership.

The project was implemented between April 2012 and March 2013 and involved more than 60 experts and stakeholders from government agencies, academic institutions, industry and other relevant organisations in the UK (Appendix A). It drew upon a number of key research reports and evidence from organisations with relevant expertise and knowledge of the UK food and feed sector. This allowed:

- A long-term, strategic approach to assess plausible changes to the UK food and feed system over a twenty-year period. Futures research, specifically scenario analysis, was adopted to investigate possible developments within the UK food and feed system, thus providing the FSA with the information needed to assess the skills, resources, institutions, and policies required to deal with the range of plausible outcomes.
- An analytical framework that took a broad view of the UK food and feed system and the wide context in which it operates. The analysis carried out considered key aspects of the food/feed chain, ranging from production and supply to retail and consumption.
- Involving stakeholders with expertise in a wide range of disciplines (e.g. economics, social science, food preparation and retail, and risk management) to capture the issues affecting the UK food and feed system, and adopting a participatory approach to gain consensus across disparate notions of plausible alternative futures.

The project was completed in five phases (Figure 1). The scenario process detailed in Appendix B) began with an environmental scanning exercise that took stock of existing information and knowledge related to the UK's food system. Recognising that the food and feed system exists in a rather turbulent environment, beyond what was originally conceptualised, the intention was to assess the long-term challenges, identifying key trends and drivers of change. Building on a list of influential drivers of change identified by the FSA and the Agency's stakeholders, this stage of the project involved outlining the key drivers – described here as key factors - that are crucial influences on the development of the UK's food and feed system. During the next

phase, the possible, relevant states or conditions each key factor may assume were explored, relying on expert judgement to establish projections of plausible change in each key factor. A detailed breakdown of the key factor projections are provided in Appendix C. In the third phase, raw scenarios were selected using a cross-impact analysis and consistency analysis as a base. Modelling how these projections influence each other, and in turn the system, revealed logical relationships (i.e. projections that are consistent or plausibly co-exist in the future). A high order of internally consistent projections (distinct to clustered configurations) is the premise for defining ‘alternative futures’ subject to expert review of how well each alternative future sits within a complex policy space. Stakeholders with expertise in a range of disciplines, such as economics, social science, food preparation and retail, and risk management provided a basis for developing the scenarios, varying assumptions about the development of the food system in order to reveal areas of uncertainty. In the fourth phase, the raw scenarios were elaborated to produce a series of draft scenarios supplemented by ‘explicit story-lines’ that illustrate alternative futures. The description and analysis of the scenarios are accompanied by case studies of three foods illustrative of broad groups (processed product, raw food/ingredient and feed/ingredient) to assess policy implications for different sectors along the food chain (i.e. from production to consumption). In the final stage, feedback from a stakeholder workshop was integrated to produce the final reports. A detailed description of the methodology is provided in Appendix B.

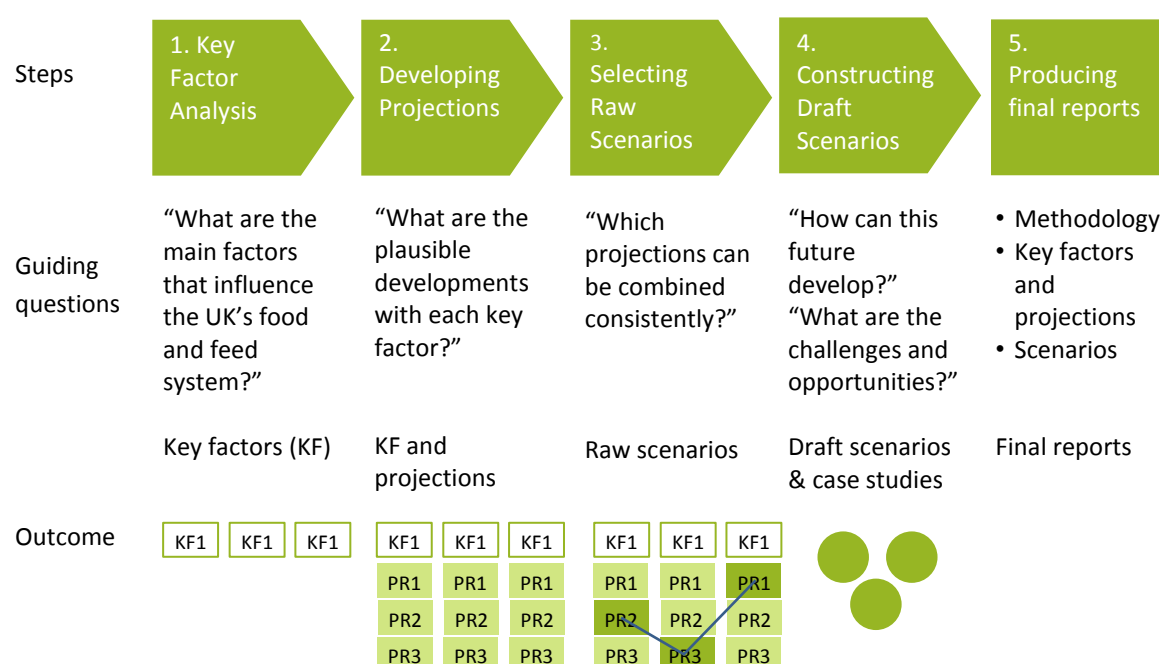


Figure 1: Graphical overview of the process

Built on the premise that the future will be fundamentally different from today, each scenario presents an alternative, but plausible future that embodies a rise in uncertainty and assumes a consequence of actions that becomes increasingly unpredictable. Creating alternative scenarios blend existing trends with uncertainties of the future. While it is entirely possible for all of these scenarios to co-exist in a ‘single’ future, exploring a number of different scenarios addresses deviations expected from a ‘single’ future that typically arises from trends and events outside the vision or awareness of those involved in the scenario development process.

1.2 Scenarios as a strategic planning tool

Scenario planning is a common approach to futures research. It adopts a deliberative, participatory method to build a spectrum of plausible alternative futures using a holistic approach that involved identifying and analysing the key drivers of future change (Pillkahn 2008; Böjeson *et al.* 2005; Bradfield *et al.* 2005). Of specific interest are how these drivers, based on factors that currently exist or are likely to emerge, evolve and interact with each other in the future (Böjeson *et al.* 2005). Scenario narratives provide descriptions of a plausible future, which relay alternative evolutions of whole systems based on a coherent and internally consistent set of assumptions about key relationships and driving forces (Pillkahn 2008). Explicit 'storytelling' pieces describe how the future is planned and shaped through fixed events (including strategies and policies) that illustrate a progression from current state of affairs to the future created in the scenarios (Bowman *et al.* 2012; Pillkahn 2008).

Scenarios illustrate plausible outcomes usually extrapolated from current trends or based on radical or unexpected (but plausible) events (Böjeson *et al.* 2005). They provide policy makers with a tool for strategic planning, assessing the robustness of strategies and policy approaches in different situations (Wright *et al.* 2008). The implications to the food and feed chain from production to consumption is useful for analysing the resilience of future policies and strategies, thus mitigating the occurrence of unexpected consequences and ensuring there are more resilient responses to uncertainties of the future (Wright *et al.* 2008; Bradfield *et al.* 2005; Maack 2001).

1.3 How to use the scenarios for strategic decision-making

The scenarios in this report are intended to be used by FSA as part of a number of assessment methods to inform future policy development. Contingency plans may be developed for each potential future and will often focus on answering the following questions about the strategic direction of the organisation:

- 1) How will the current (or intended) strategies fare in a range of plausible futures?
- 2) What contingency plans are required to ensure the resilience of current (or intended) strategies?
- 3) Are there any knowledge gaps or issues around organisational competence to implement future strategies?

Workshops with targeted stakeholders could be convened to think through these questions and assess the robustness of strategies moving forward. Table 1 summarises how scenarios could be used to respond to strategic questions, and outlines the goals and intentions at each stage.

Table 1: Using scenarios as a decision-making tool

Strategic questions	Stages of the process	Goals and intentions
How will the current (or intended) strategies fare in a range of plausible futures?	Identify the implications of the scenario	The implications of each scenario for the strategies considered are of primary interest. An assessment of the vulnerabilities that exist within the system is needed, along with the elements that are likely to experience the most change in each scenario.
	Outline the risks or opportunities presented by each scenario	The risks and opportunities affect how well strategies are positioned moving forward. The focus should be on assessing how different sectors are affected by changes in each scenario, and identifying the winners and losers among a range of stakeholders.
	Identify interventions to either safeguard against risks or exploit opportunities	Intervention is needed where strategies are likely to fail. While the focus may be on identifying necessary action to hedge against some of the risks presented in the scenarios, opportunities should be seized to maximise the resilience of strategies.
What contingency plans are required to ensure the resilience of current (or intended) strategies?	Future proofing plans for all eventualities	Looking at the connections and interactions across the scenarios will help identify solutions and strategies to address multiple issues, offering some reassurance that the current strategic direction is both future-proof and resilient.
	Rethinking the strategic orientation of existing plans	Identifying critical areas of uncertainty, risk and opportunity may prompt a re-think of existing plans based on the need to avoid critical risks or maximise resilience.
	Moving existing plans forward towards a targeted future	Create a roadmap for the strategies that work best in a particular scenario. This may allow you to champion plans in the interest of innovation.
Are there any knowledge gaps or issues around organisational competence to implement future strategies?	Identify evidence/knowledge gaps and develop internal capacity	The organisation's ability to assess how the future is unfolding and how to adapt plans to dynamic situations is important. This requires identifying the evidence/knowledge, common across all the scenarios, that will need 'to be' in place to capitalise on opportunities and protect against risks. Undertaking a gap analysis of current evidence/knowledge 'as is' compared to the commonalities that will need 'to be' in the future will form the basis for assessing internal capacity and capabilities to implement future plans.

Sources: Pillkahn (2008); Wright *et al.* (2008); Maack (2001); Northrop Grumman Corp. (2000)

1.4 Moving from scenarios to actions

Developing a good strategy or plan requires defining the strategic direction taken relative to the current and future state of the system. From the discussion above, it is apparent scenarios are a useful tool for this process as they allow policy teams to consider what position the organisation might wish to take or how resilient the current direction is for the future. Discussing the scenarios in teams may present decision-makers with other perspectives and possible future options that reveal unfamiliar factors of developments, and raise awareness around environmental uncertainties. Moving from scenarios to action is best summarised as in a two-step process:

- Testing the current (or alternative) strategy/policy/operation against different futures.
- Understanding and applying robust strategy/policy/operation responses that address multiple issues revealed across the different futures, or determining what would be a good strategic position to take in response to critical areas of uncertainty, risk and opportunity identified across the different scenarios.

Considering the implications of multiple scenarios to current strategy or policy is a foreboding task and challenging for many organisations. To support the FSA in overcoming this hurdle case studies illustrating how scenarios could be applied to assess different elements of the system, in this case food products, have been developed by Cranfield University. While this is just one example of the use of scenarios, case studies also add another layer of granularity and provide individuals with more tangible evidence of the strategic implications discussed at the higher scenario level.

2.0 Scenario development

This section of the report describes the scenario logic and assumptions to help the reader interpret the different rates and direction of progress (or development) depicted in each scenario.

2.1 Interpreting the scenarios

The scenarios show different rates and direction of progress (or development) of the system along a path that is based on a single set of consistent projections (Figure 2). The Reference scenario builds on current trends and measures of change, reflecting a trajectory of the current system as it exists today. The conditions in this scenario present a plausible and relatively non-threatening environment, featuring few extremities or unpredictable events and relatively consistent development of the system. Global trading and Resource tensions scenarios are developed by projecting change from the current trajectory (i.e. the reference scenario) showing divergence on the rate and direction of progress or development of the system. The conditions in these scenarios describe radically different futures that may unfold; for instance, an optimistic (Global trading) and pessimistic (Resource tensions) future.

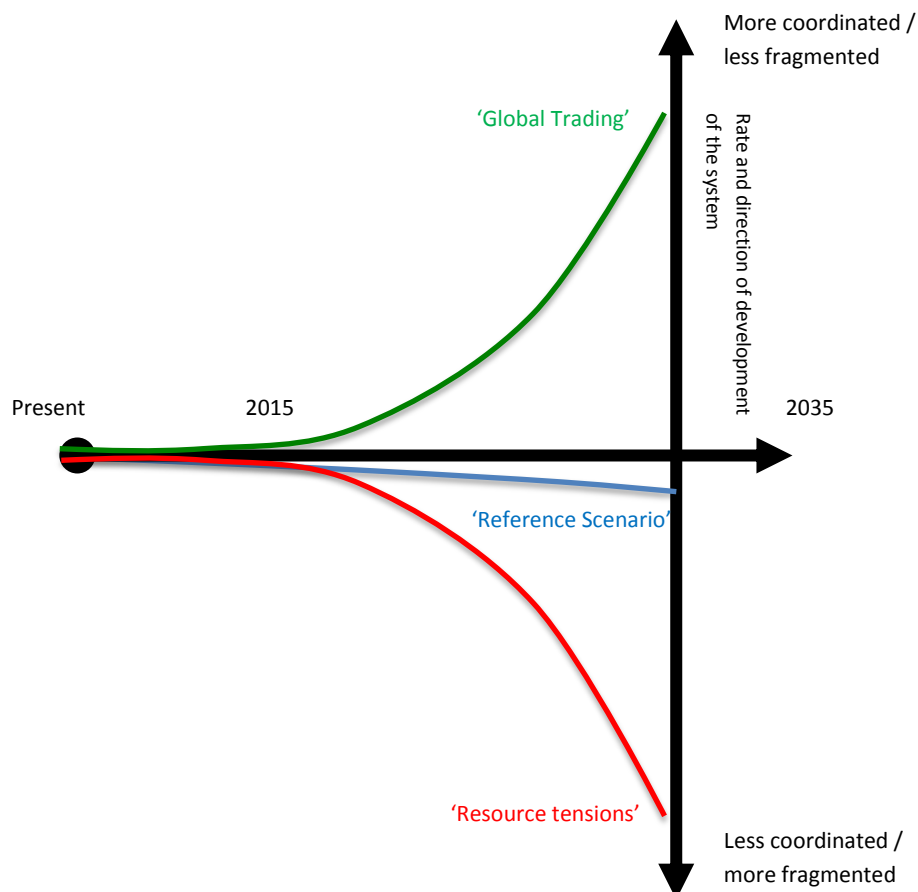


Figure 2: Scenario plots based on the 'cone of plausibility'
(Adapted from Gordon 2008)

2.2 The scenarios

The morphological box (Figure 3) is a matrix that presents the structure for the scenarios. Each scenario comprise of a mix of consistent projections based on the 13 key factors identified by stakeholders as influencing the UK food and feed system over a period of two decades. A detailed breakdown of the key factors and projections are provided in Appendix C.

Inter-national Trade & Relations	Global Markets	State of the UK Economy	Cost of Living/ Disposable Income	Population Size	Families and household	Consumer Attitudes & Behaviours	Innovation & Adoption of Tech	ICT	EU Legislation	Nature of Regulatory Environment	Climate Change	Price & Availability of Resources
Influence of emerging economies comparable to western levels	Increased Globalisation of markets	Steady growth	Increasing food prices alongside disposal income	Stabilisation of population size	No real change to families and households	Price-led consumption	Limited investment and adoption of new technology	Free information is used by industry but not the public	Compromise model	High levels of regulation	Mild to modest effects from climate change	Volatility of markets limits access and increases prices
Global trade agreement	Stable globalisation of markets	Strong growth	Decreasing food prices alongside disposal income	Increase driven by global population trends	Progressive But stable change to families and households	Unsustainable consumer choices	Sourcing technology from foreign suppliers	Free information is used by industry and public	EU legislation with a world market focus	Medium levels of regulation	Gradual Increase in effects from climate change	Market agreements lead to stable access and prices
Trade wars	Decreased Globalisation of markets	Modest growth	Increase in prices but a decrease in disposable income	Increase driven by immigration	Radical change to families and households	Informed and responsible consumption	The UK at the forefront of research and development activities	Industry uses information and tailors industry/consumer interactions	A greater EU	Low levels of regulation	Proactive reduction of climate change	Government Intervention regulates access and prices
Regional alliances		Predominant periods of recession	Increase in disposable income with a real decrease in prices			Retail-led consumption		Tech has less significant role due to a lack of information	World market without EU		Reactive adaptation to volatile climate change	

Figure 3: Morphological box

The colour coordinated lines identify a range of consistent projections that comprise a scenario. The projections that define the scenarios are presented using colour-coded lines: **Reference (blue)**, **Global trading (green)**, and **Resource tensions (orange)**.

A detailed description of the scenarios and analysis of the implications along the entire food chain (from production to consumption) are presented in the following sections of the report.

2.3 Scenario 1 – Reference

Modest growth means the UK economy experiences a growing trade deficit and struggles to maintain its share in the global market. The UK's buying power diminishes as emerging economies, in a more liberalised international market, control the price and availability of goods. Rising food prices continue as energy and agricultural production costs increase. These pressures drive consolidation throughout the food supply chain, and a greater reliance on production and processing within Europe and the UK. More frequent extreme weather events impact on food supply and availability, making prices more volatile. Population growth and urbanisation reflect a shift in lifestyles and food consumption patterns. A prevalence of supermarkets and fast-food outlets increases the availability of cheaper, sometimes less healthy, food choices.

Main characteristics:

- Following periods of recession, the UK economy is now in a period of modest growth (1-1.5% GDP).
- Emerging economies are now established as a force in international markets, competing with traditional suppliers in western economies.
- The UK's open, trading economy is under pressure from expanding markets in emerging economies, which forces diversification of supplies, but also encourages domestic self-sufficiency.
- The food and feed system was affected by gradual increases in climate change, but with foresight, investment in agricultural and infrastructural developments have managed the consequences of extreme weather events.
- Consumers want affordability and greater choice of foods that fits their lifestyle, and are willing to experiment with diverse or convenient diets (e.g. functional foods).
- The gradual change in families and households (e.g. a rise in the number of single-person households) has increased consumption of energy, land-use and the production of waste, which puts pressure on future resources.

International Trade & Relations	Global Markets	State of the UK Economy	Cost of Living/ Disposable Income	Population Size	Families and household	Consumer Attitudes & Behaviours	Innovation & Adoption of Tech	ICT	EU Legislation	Nature of Regulatory Environment	Climate Change	Price & Availability Of Resources
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Regional alliances		Predominant periods of recession	Increase in disposable income with a real decrease in prices			Retail-led consumption		Tech has less significant role due to a lack of information	World market without EU		Reactive adaptation To volatile Climate change	

Figure 4: The Reference scenario overview – key factors and projections

Progression to 2035

2012 – 2015: The UK gradually overcame the financial crisis of 2008, though the economy remained relatively flat with a growth in GDP not exceeding c.1%. This was associated with a relatively small contribution from net trade and a weak rate of global economic growth. Faced with this 'bleak' outlook, UK politicians strived to achieve economic stability and development, through both imports and a thriving export market, to feed the country and drive economic growth.

Despite such ambitions, the UK's open, trading economy was threatened as emerging economies found themselves able to compete with traditional suppliers on western markets. While the UK made strides to supply more of its consumption from domestic agriculture that included horticultural and sustainable intensification initiatives, the success of these schemes was affected by resource constraints and climate change impacts that introduced risks such as animal disease, floods and crop failure. This had an adverse effect on agricultural systems, where for example, land use and crop selection was affected by resource constraints and commodity pricing. Additionally, sustainable intensification efforts prove unsuccessful, as small, family farms are absorbed by larger farming corporations that capitalise on cheaper resources abroad and competition from free markets.

Fluctuation in food prices due to changes in global demand and supply for agricultural commodities, and volatility in commodity prices, had a significant impact for UK consumers, where volatile global markets for products such as animal feed, had a knock-on impact on supermarket prices. This fluctuation in prices was also indicative of the fragmentation of food markets in Europe and the UK. There is a prevalence of supermarkets and fast-food outlets that respond to consumer demand for convenience and affordable foods, which cater for busier lifestyles.

2015–2035: A short spurt of economic growth in the UK gradually came to an end, ushering in a longer period of modest growth with a GDP of c.1.5% in 2035. This was associated with a relatively small boost to both net trade and the rate of global economic growth. Budgets remained constrained, and measures by government and industry to control instability in commodity markets and to build a more resilient global food chain, as well as maintain a supportive environment for competitive UK food producers had limited success. Growth in emerging economies now continues to be a major factor in driving global demand, increasing trade of grain, oilseed products and meats. UK arable farmers capitalise on high grain prices, but livestock farmers are met with strong competition (both in Europe and overseas) due to rising costs of animal feed on international markets.

Reforms of the Common Agricultural Policy (CAP) in terms of reduced subsidies and strict environmental standards are pursued in response to global demand for food and increased volatility in world markets. The response from farmers is to increase output, often compromising expectation of good harvest in pursuit of lower forward prices. Competition among supermarkets encourages consolidation along the supply chain as retailers look to deal with fewer, larger suppliers and producers look for economies of scale. There is a growing trend of larger retail chains (e.g. supermarkets and discount retail outlets), and the size of these retail businesses provides for economies of scale, where retailers are able to streamline distribution systems and extract efficiency savings, which is fed back to the consumers through

lower or discounted prices. Focus on lower prices, usually at the expense of other product dimensions, shapes the discount retail culture. Along with this consolidation, there has been an increase in e-commerce, and local food and speciality markets that provide producers with more direct and alternative channels to consumers. With the increasing amount of food products on offer, consumers are more adventurous and open-minded about their food choices with a change in the type of foods that are available and affordable, and continued growth of the discount supermarket sector.

Scenario implications

Consumers

Economic constraints and busier lifestyles drive demand for convenient and affordable food.

The proportion of consumer spending devoted to food has grown, and there has been a notable change in diets as consumption of more expensive products such as out of season fruits and vegetables, the healthier food choices, declines in favour of convenience food and cheaper produce such as foods high in fats and/or sugar. An increasing proportion of the population respond to pressure on their budgets by trading down to cheaper foods/stores, while some are forced to make trade-offs between food and other household expenses (e.g. energy and housing). At the same time, for a select few, there is growing interest in farmers' markets and local food clusters', a local food production network that offers a direct and alternative channel to fresher, seasonal or healthier foods, and more customer focused product sourcing and production.

Food and non-food retailers

Fluctuation in food prices, consumer demand for convenience and affordability drive 'discounted' or 'value-based' retailing.

Supermarkets dominate food retailing, while there is a substantial rise in the number of discount stores to meet the demand for affordable food. Fluctuating food prices drive diversity in the range of goods stocked in retail outlets. Both 'value' and 'high-end' brands on offer in supermarkets and restaurants cater for a segmented consumer base. However, value items are often prioritised over high-end or luxury items, but convenience in storage and preparation are seen as essential elements to 'value' goods. Supermarkets retain power acting as gate-keepers between suppliers and customers. They develop their own store brands, usually at a discounted price, increasing consumer choice as own brands share shelf space with branded items, thereby expanding product range to include more low cost items.

Catering

The 'budget' consumer sets the trend for consumption.

As consumers seek more value for money, budget options such as 'all you can eat' buffets gain in popularity. Institutional and workplace canteens are also more common as employers increasingly see the value in providing meals for their staff to maintain energy and focus, as well as addressing absence from work. Consumers demand a quick and satisfying meal whilst

less concerned about taste, freshness or quality of the meal. In this difficult economic climate there is a high turnover of high street outlets, and it becomes increasingly difficult to maintain trained and skilled staff to implement good quality control and food safety standards across the sector.

Processing, production and supply

UK domestic self-sufficiency is promoted to combat volatility in commodity markets.

Increasing prices for energy and raw materials led to increased input prices for UK producers, making it difficult to meet the UK needs for low cost ingredients and commodities. Better profit margins available in foreign economies (e.g. China and India) led to increases in food exports from the UK, which also increased food prices in the UK. The UK risks being buffeted by disruptions to supply due to fluctuating international demand and prices. Governments respond by seeking to prompt more localised sourcing within the EU and UK, although the success is limited due to the cost of large scale intervention. Production and processing supply chains are dominated by a small number of large companies. Small companies find it hard to compete with decreasing profit margins leading to increasing cases of adulteration and fraudulent manipulation of food products. The processing industry optimises raw materials by creating new products using previously discarded materials. Production is designed around selling commodities in bulk to a small group of buyers (e.g. major retail chains). Progressive action is taken to deal with the gradual effects of climate change and strategies are put in place to allow farmers to mitigate and to adapt farming techniques to new conditions. However, reduced profit margins may cause producers to select farming systems that achieve lower costs per unit produced, often compromising the sustainability of production. This impacts the environment and biodiversity, reducing essential services provided by the ecosystem and prompting farmers to find alternatives (e.g. yearly replacement of pollinators and soil biota).

2.4 Scenario 2: Global trading

The UK experiences strong economic growth, having fully recovered from the global economic downturn. Global trade agreements lead to a stable increase in commodity prices, which is associated with a lower rate of inflation that takes the pressure off household spending (i.e. increases disposable income). Advances in food processing and modern technology drive innovation in the food system, changing food production and consumption patterns. Consumer interest in environmental and social issues increases and this is reflected in a more responsible (and sometimes healthier) diet, largely among those of higher socio-economic status. The structure of households is changing and suppliers respond by offering goods and services tailored to those changing demographic needs.

Main characteristics:

- Overcoming the economic crisis, the UK economy is growing strongly (approx. 3% GDP per annum).
- Global trade agreements, geopolitical stability, free trade and efficacy of controls, are accompanied by the implementation of risk-based regulations and cooperation in crisis management.
- UK food imports and exports continue to rise, influenced by western nations investing internationally and trade with global retailers from emerging economies.
- Proactive measures are being taken to adapt and mitigate rapid climate change, and these significantly affect the food and feed system. These include measures that protect crops, conserve water and energy and maintain good ecological status.
- High income consumers are generally more altruistic in their choices, opting for healthier diets of high quality and nutritious foods. Ethically conscious consumption drives responsible sourcing (e.g. fairtrade, local produce and products of high welfare standards) and distribution of foods through transparent value chains.
- Local distribution chains and the way that people source food is changing, due to significant variation in families and households (e.g. an increase in single-person households and an ageing population). There is an increase in consumption of energy, land-use and production of waste, which puts pressure on future resources.
- The UK is a leader in food research and technology driven by high levels of innovation that reform the food system, and develop new models for food production and consumption.

International Trade & Relations	Global Markets	State of the UK Economy	Cost of Living/ Disposable Income	Population Size	Families and household	Consumer Attitudes & Behaviours	Innovation & Adoption of Tech	ICT	EU Legislation	Nature of Regulatory Environment	Climate Change	Price & Availability Of Resources
Influence of emerging economies comparable to western levels	Increased Globalisation of markets	Steady Growth	Increasing food prices alongside disposal income	Stabilization of population size	No real change to families and households	Price-led consumption	Limited investment and adoption of new technology	Free information is used by industry but not the public	Compromise model	High levels of regulation	Mild to modest effects from climate change	Volatility of markets limits access and increases prices
Global trade agreement	Stable Globalisation of markets	Strong growth	Decreasing food prices alongside disposal income	Increase Driven by global population trends	Progressive But stable change to families and households	Unsustainable consumer choices	Sourcing technology from foreign suppliers	Free information is used by industry and public	EU legislation with a world market focus	Medium levels of regulation	Gradual Increase in effects from climate change	Market agreements lead to stable access and prices
Trade wars	Decreased globalisation of markets	Modest Growth	Increase in prices but a decrease in disposable income	Increase Driven by immigration	Radical change to families and households	Informed and responsible consumption	The UK at the forefront of research and development activities	Industry uses information and tailors industry/ consumer interactions	A greater EU	Low levels of regulation	Proactive reduction of climate change	Government intervention regulates access and prices
Regional alliances		Predominant periods of recession	Increase in disposable income with a real decrease in prices			Retail-led consumption		Tech has less significant role due to a lack of information	World market without EU		Reactive adaptation To volatile Climate change	

Figure 5: The Global trading scenario overview – key factors and projections

Progression to 2035

2012– 2015: The UK addressed its budget deficit, gradually restoring growth to the economy. This was assisted by a significant contribution from net trade and a strong rate of global economic growth. The economic crisis of 2008 was met with a concerted international response, where multilateral rules were introduced to tackle trade restrictions, making improvements at the global level. While international guarantees increased trade volumes, this was tempered by high and volatile commodity prices spurred by preferential agricultural policies set largely by western economies. The UK's farmers benefitted from high prices, but often surpluses of poor quality goods were deposited on the international market, slowing the progress on global food security and increasing levels of inequality among countries.

More frequent extreme weather events (e.g. floods and droughts) created regular food price 'spikes', which affected the poorest in the UK. This, alongside increased demand from population growth, resource scarcity, rising costs (energy, fertiliser, and transport) and climate change, led to a step change in political attitudes and a drive for sustainable trade and technological advancement. Large businesses drove the UK economy as political agendas pushed the implementation of innovative and economically viable food technologies. New initiatives were planned to fill the skills gap and boost the knowledge economy.

Government proactively encouraged responsible exploitation of new technologies alongside active and balanced discussion of their risks and benefits. Healthy and fair competition was promoted across the food supply chain through changes in consumer and retail behaviour, and optimum use of land, including forestry management and biofuels production. These developments had the overall aim of ensuring sustainable production, reducing the impact of climate change and driving stability in prices.

2015–2035: The UK's economy now enters in a period of strong and sustained economic growth (GDP of c.3% in 2035), having benefitted from the contribution of large emerging economies that helped to restore global demand. The World Trade Organisation (WTO) plays a

key role in maintaining a liberal trading platform since the Doha Development Round was agreed. Doha has led to increased collaboration between emerging and western economies to lower trade barriers and restore confidence in international trade. Multilateral agreements have benefitted the UK in terms of reduction in trade-distorting domestic support, export subsidies and improved market access for agricultural, industrial and primary products. While this has contributed to greater equity in international trade, western economies, including the UK, are exposed to new risks from animal diseases, food contamination and adulteration.

As economic vigour is restored globally, the UK makes significant investment in research and development, and boosts the technical skills of its workforce to maintain a lead in knowledge-based sectors (e.g. manufacturing). This drives a high level of technological innovation that reforms the food system and develops new models for food production and consumption. A more technology-intensive agricultural and food sector, and a shrinking British workforce, increases the demand for highly skilled and unskilled workers, prompting the UK to 'rethink' its policy on immigration.

High energy, land, fertiliser and water costs continue to raise food prices, and episodes of high prices and volatility are still common in food markets. However, an increase in disposable income maintains the accessibility and affordability of food for the majority of consumers. However, income disparity remains a problem with social stratification apparent across the UK. In recognising that the poorest consumers, who spend proportionally more on food, are the most affected by rising food prices, the UK Government works with retailers and consumers to implement new technology, and disseminate integrated information and advice on the impacts of food on health and the environment. The Government's 'sustainable food' mandate is in full effect and is targeting food safety problems, and nutritional issues including those associated with inequality and disparity in income levels.

Scenario implications

Consumers

Choice for consumers is seemingly limitless in a technologically advanced food sector.

Higher disposable income opens up a range of food choices for most consumers. 'Smarter' technologies are affordable to many and are integrated in consumer food decisions, whether that is use of 'smart' technologies in homes for automated ordering (online), bespoke specifications and personalised flavours, or cheap sensors that provide consumers with an unprecedented amount of information about the foods they buy and consume. Such technologies, for example, allow consumers to easily assess information concerning the safety, health or sustainability of their eating habits, although not all consumers base food choices on sustainability. A larger immigrant population, along with the increased ethical consciousness of consumption, increases demand for specialist products in niche markets (e.g. ethnic and organic foods).

Food and non-food retailers

High levels of innovation, investment in new technology and integration of ICT in the supply chain drive personalisation, diversification and specialisation in retailing.

Personalisation of products becomes common as retailers seek to cater for different lifestyles and special needs, and technology allows for greater flexibility in production (e.g. bespoke flavours). The primary mode of shopping shifts away from stores to online/automated ordering, and shared distribution systems emerge to compete with traditional supermarket retail chains, thereby allowing consumers to access food from a range of retailers or direct from manufacturers and producers. These provide direct access to consumers, shifting the power away from retailers. An expansion in the number of online-retailers creates challenges for food safety and reduces the traceability of food products. Waste increases as the use of secondary packaging (e.g. expanded polystyrene and corrugated boxes) increase among online traders. To sustain an evolving food sector, there is a demand for new skills to match technological development.

Catering

Hi-tech operations are adopted to provide a 'gastronomic' experience that meets expectations for quality, taste and nutrition.

Consumers eat out on a regular basis at restaurants, pubs and institutional catering facilities, and demand high quality, tasty and nutritious meals. In response to consumer demands, fast-food outlets and restaurants source better ingredients, catering to a healthier diet. Online and mobile ordering systems improve access to quick meals. An increasing number of specialist food services cater for niche markets, for example, changing fusions due to increasingly varied demands from consumers. Caterers also have access to 'smart' technology (e.g. safe self-heating foods for home deliveries or that are delivered to the elderly), which helps to ensure their supplies are sourced efficiently and are stored in the correct way.

Processing, production and supply

Environmental and economic sustainability drive technological innovation in processing, production and supply.

Global trade agreements provide a level playing field for international trade, which benefits the UK by improving market access for agricultural products, stimulating higher prices for farmers. As consumers demand safe, healthy and sustainable foods, primary producers are driven to further invest in food technologies. However, there are a number of producers that focus on developing counterfeit products, which mimic high-end goods to be sold through less controlled retailers (e.g. online retailers). New farming practices are widely adopted with greater use of technology in the production of food. This includes the adoption of genetically modified and bioengineered crops and artificial meat, where they are shown to 'bear fruits' not only for consumers (e.g. super-nutritious food staples), but also less environmentally damaging (e.g. oceanic self-sustaining food farms). Resilience to climate change is high. Strategies are put in place to assess and manage related risks. A focus on prevention drives the implementation of improved and resilient farming practices that safeguard against new viruses and diseases; however, more centralised and concentrated food production systems mean sporadic disease events often have significant economic impacts.

2.5 Scenario 3: Resource tensions

The UK economy experiences long-term economic difficulties with no real growth. International markets work largely on bilateral agreements driven by industry. This leads to protectionist measures such as embargoes and trade restrictions, resulting in market volatility and an increase in commodity prices. Volatile climate change adds to other resource pressures. The consumer is challenged by increasing food prices; choice is mainly based on cost with an increase in stockpiling practices, reflected in a preference for foods with a longer shelf life. The prevailing economic climate increases consumers' tolerance of risk prompting a regulatory change including a reduction in safety standards (e.g. higher mycotoxin levels) and ready implementation of food technology (e.g. GMO and nanotechnology).

Main characteristics:

- The UK economy experiences long periods of negative/zero growth (not exceeding 0.5% during 2010s and remaining low throughout the following decade).
- Geopolitical and resource instability causes distrust in markets, which reduces global trade. This stimulates a drive towards self-sufficiency globally, including the UK, where national producers become the main suppliers of food and produce.
- Agriculture and food systems are affected by volatile and extreme climate change (e.g. droughts, floods, new pathogens and saltwater intrusion) prompting the investment of available resources in responding to these changes.
- High food prices coupled with a reduction in disposable income drives consumers to source food on the basis of value for money; there is a greater tolerance for risk leading to food fraud, adulteration and mislabelling of foods.
- The structure and composition of families and households remain broadly as they are today.
- Economic constraints restrict investment in new technology; industry drives research and sources existing technology abroad to implement in the production, processing and distribution of food.

International Trade & Relations	Global Markets	State of the UK Economy	Cost of Living/ Disposable Income	Population Size	Families and household	Consumer Attitudes & Behaviours	Innovation & Adoption of Tech	ICT	EU Legislation	Nature of Regulatory Environment	Climate Change	Price & Availability Of Resources
Influence of emerging economies comparable to western levels	Increased Globalisation of markets	Steady Growth	Increasing food prices alongside disposable income	Stabilization of population size	No real change to families and households	Price-led consumption	Limited investment and adoption of new technology	Free information is used by industry but not the public	Compromise model	High levels of regulation	Mild to modest effects from climate change	Volatility of markets limits access and increases prices
Global trade agreement	Stable Globalisation of markets	Strong growth	Decreasing food prices alongside disposable income	Increase Driven by global population trends	Progressive But stable change to families and households	Unsustainable consumer choices	Sourcing technology from foreign suppliers	Free information is used by industry and public	EU legislation with a world market focus	Medium levels of regulation	Gradual Increase in effects from climate change	Market agreements lead to stable access and prices
Trade wars	Decreased globalisation of markets	Modest Growth	Increase in prices but a decrease in disposable income	Increase driven by immigration	Radical change to families and households	Informed and responsible consumption	The UK at the forefront of research and development activities	Industry uses information and tailors industry/ consumer interactions	A greater EU	Low levels of regulation	Proactive reduction of climate change	Government intervention regulates access and prices
Regional alliances		Predominant periods of recession	Increase in disposable income with a real decrease in prices			Retail-led consumption		Tech has less significant role due to a lack of information	World market without EU		Reactive adaptation To volatile Climate change	

Figure 6: The Resource tensions scenario overview – key factors and projections

Progression to 2035

2012– 2015: The UK economy experienced another period of recession that limited its growth in GDP to c. 0.5% in 2015. The harsh global economic environment broke down international cooperation and global trade agreements started to deteriorate. The WTO lost influence as countries pulled out when sanctioned for implementing protectionist measures (e.g. embargos and trade restrictions). These measures consolidated supply chains, created more local suppliers, and drove low-value production, investment and management of substitute ingredients.

Major corporations led international trade, but as regulation became more difficult to comply with in economically challenging times, the UK broadened its trade policy to include preferential agreements with countries in Asia and Latin America. Extreme weather events (e.g. floods and droughts) disrupted food production in the UK and led to export restrictions, and high and volatile food prices. Faced with imports that were highly constrained, the pressure to maintain supplies in the UK encouraged sporadic incidents of adulteration and mislabelling across the food chain (e.g. an increase in GM feed, deliberately labelled non-GM, entering the UK).

There was a gradual transformation in consumer attitudes to food as people appear to have a greater tolerance for risk and new food technologies. This meant that alternative sources of food such as those grown in laboratories were becoming desirable and a 'black market' food trade emerged. Low income consumers were losing interest in the provenance of food as price became the sole basis of choice. This led to increasing incidents of food fraud and greater division in diets, as poorer consumers made unhealthy choices and struggled with diet-related diseases.

2015–2035: A prolonged period of recession means the UK economy remains fragile in 2035. The lack of international coordination and a failure to adequately reverse the slump in international trade meant there was little stimulus for global economic growth over the last two decades. Struggling to maintain an economic advantage, western countries now adopt bilateral deals to combat the effects of the recession. While the expectation is that these deals will stimulate growth in trade, most lead to trading blocs with discriminatory rules that result in trade wars.

UK's trade suffers from huge inefficiencies as scarce resources are frequently interrupted and poorly utilised. Similarly shortages and uncertainty over supplies of raw materials causes price volatility, and leads to supply chain disruptions. A spin-off is the relatively low responsiveness to consumer demand, and expensive and low quality goods produced. The effects of climate change leads to changes in farming techniques and the nature of crops grown in the UK (e.g. sunflower replacing rape seed).

The declining economic activity in the food sector creates unemployment and a reduction in investment opportunities, decreasing the availability of safe and nutritious food for consumers. 'Black market' trading is now prevalent, where contamination of supply chains is a problem, particularly with respect to foods imported from outside the EU that offer cheaper alternatives, often of dubious origin. Unequal distribution of wealth and income between fractions of society translates to significant disparity in consumer power. As producers increase

supplies of cheap and low quality foods to maximise profit, there are important health implications for the poorest of consumers.

Scenario implications

Consumers

Widespread food poverty means 'value for money' is the 'mantra' as the recession drives price-based consumption.

Food poverty is widespread across the population with those on lower incomes hit the hardest. Variety in the diet is limited as access to sufficient food for survival is prioritised and choice of food goods is limited due to disrupted supply. This is reflected in a growing interest in foods that help people stay satiated and an increase in stockpiling of dried, frozen, canned or other long lasting foods, as well as food rationing by consumers to safeguard themselves against future fluctuations in the availability of food. Consumers use a wider range of places to source food as traditional retail and catering is unaffordable for some or offers an inconsistent supply of goods. As a consequence some consumers opt to grow and trade food with friends and family to supplement food purchases. For many eating out is a treat or saved for special occasions.

Food and non-food retailers

Retailing is shaped by fragmented supply chains and increasing diversity in the range of organisations that supply food.

Delivering a consistent and reliable supply of food is a challenge for retailers in this climate. This results in a range of responses with some more formally integrating supply chains, and others that are increasingly driven to procure through spot markets or a wider range of intermediaries. An increase in food fraud and adulteration is driven by the need to maintain marginal profits and retailers seek any means to acquire goods in high demand (e.g. dried, frozen, canned or other long lasting foods). Black markets emerge for higher-cost and difficult to source goods. These are often of dubious origin and quality, and safety is often compromised. Alongside traditional supermarkets, there is a growth in smaller opportunistic trading, for example mobile units (trucks) used for home supply or distribution in areas of food poverty or informal trading and swapping of goods locally or through the internet (e.g. a food replica of local free-cycle group websites).

Catering

Poverty stricken consumers seek out 'big-society' initiatives to meet dietary requirements.

Many consumers supplement their diet with food offered free or at reduced cost. This is through a mix of the public sector, social enterprise and charities, which increase the range of operators in this sector as well as the sectors' prominence in terms of its share in the market. A smaller number of restaurants, takeaways and coffee shops remain for the wealthy and those eating out on special occasions. Similar to retail, there is pressure to cut corners to maintain

marginal profits while meeting consumer demand for cheap food that often results in a compromise on food quality and safety (e.g. substitution of ingredients and tampering with use-by dates). There is a high turnover of employees that are poorly trained and lack the necessary skills to implement good quality control and food safety standards.

Processing, production and supply

A 'resource-grab' mind-set prompts business-led trade agreements.

Bi-lateral trade agreements with countries in Asia and Latin America are adopted to combat the recession and stimulate growth in trade, but these lead to 'trade wars' that cause problems in the UK's ability to trade and maintain supply chains. Widespread food poverty has incited a wave of 'recklessness', which encourages a greater risk tolerance. This gives rise to a number of local production systems that lack accountability and traceability along the food chain. There is an economic advantage gained in adulteration and substitution for lower quality materials with an increased health risk to consumers. GM crops and foods are actively promoted, with little resistance from the public as they offer a cheaper alternative. Government and industry stockpile raw materials to safeguard against fluctuating supplies. Companies adopt multiple supply chains to ensure a stable supply base. There is a drive towards intensification of food production, where farmers with a greater tolerance for risk adopt novel food production technologies to increase yields (e.g. GMO and GM insects for pest control). Storable grains become more important; this is offset by a reduction of fresh produce, which has implications for import routes and arable land in the UK. Resilience to climate change is low. Responses to frequent extreme weather events and patterns are reactive and uncoordinated (e.g. protection of crop yield and water reserves). Farming techniques are altered and there is notable change in the selection of crops grown locally.

Case studies

Purpose and selection of cases

Three case studies are produced to explore what the triggers for change in food production and supply will be in the next twenty years. The aim is to explore, through case studies, what might be the emerging food safety implications for production and retail in the UK, under each scenario.

The case studies outline the impacts on the food/feed chain under each scenario, demonstrating the use of the scenarios as a tool for strategic thinking and decision-making. Three distinctive case studies were selected to illustrate some of the plausible effects that the projected scenarios can have on important and sensitive foods, which are part of the UK diet. These include a sandwich product with mixed ingredients, directly purchased and eaten as is by consumers, meat which is a raw product and ingredient, and soya which is an important animal feed component and a source of food ingredients.

In the case study analysis, specific attention is given to assessing the risks and contingencies for each raw commodity and its processing into food/feed. The main components of the food/feed chain examined are:

- Consumption
- Food retailing and catering
- Processing
- Production and supply, including (where possible):
 - pre-harvest
 - post-harvest
 - transport

The case studies provide relevant details on the issues at stake and offer insights into intervention that may safeguard against impacts on the food/feed chain, and assist in the delivery of food/feed standards and safety controls. The following sections summarise the main implications for the food/feed chains under each scenario.

Implications for sandwiches

Why sandwiches:

Sandwiches were chosen as an example of a multicomponent processed food, purchased directly 'ready-to-eat'. Sandwiches play an important part of the UK diet. British consumers eat more than 11.5 billion sandwiches each year and more than half of these were made and consumed in the home. The UK sandwich industry currently employs over 300,000 people and had a market worth of approximately £4.3bn in 2012. Chicken is the most popular filling in commercially made sandwiches, accounting for approximately 30% of all commercially made sandwiches. Roughly 40,000 tonnes of chicken is consumed in sandwiches each year (British Sandwich Association 2011). Sandwiches have multiple supply routes including those prepared at home, made to order in delis/cafes/restaurants, pre-packed through major retailers or institutions; all of which have an element of manual handling during preparation.

Scenario 1 – Reference

Supply area	Key implications for sandwiches
Consumption	Economic constraints and busier lifestyles make sandwiches a convenient and affordable option. A general increase in prices drive low-income buyers to source sandwiches from non-specialised retailers who may have less knowledge/understanding of food safety risks and regulations (e.g. allergen labelling, appropriate use-by dates or information of food additives). Under the current climate change projections, the temperature will increase in the UK and this will affect mixed products that are not stored properly. A larger number of consumers may prepare more sandwiches at home and bring them to work.
Food retailing and catering	Supermarkets will remain the major supplier of sandwiches to the market, and in the interest of supply chain resilience will be driven to adopt good food safety and hygiene practices. In time non-specialist food retailers that offer cheap sandwiches will become an alternative source. Problems will appear if the required storage conditions are not met because of the need to maximise profits. For example, consumers may purchase sandwiches on their way to work because it is a quick and cheap option, but there is a direct risk to consumers if these sandwiches are stored inappropriately or sourced from a non-compliant retailer or manufacturer.
Processing	The industry uses lower quality ingredients. Risks include poor hygiene practices and poorly trained staff leading to production problems, increasing microbial and chemical contamination risks, particularly in ready to eat perishable produce such as lettuce and tomatoes. The wrong preparation process (e.g. mishandling of ingredients or adoption of poor hygiene practices) increases the risk of cross-contamination during processing. Substitution of poor quality ingredients (e.g. saturated fats, sugar or salt) increases the risk of heart disease and obesity.
Production and supply	Increasing costs for energy and raw materials is traded off against the quality of ingredients used. Low quality ingredients have major implications with regards to nutritional quality (e.g. inclusion of high fat and/or sugar content) that may adversely affect consumers' health in the long-term. The microbial stability of products will remain checked under the current system of HACCP. The need for cheap ingredients may lead to the use of non-regulated suppliers, which bring with them the high risk of chemical and biological contamination of, for example, the chicken and dressing used in sandwiches. There is very little investment in research and development, but it focuses on ingredients/fillings that have a longer shelf life.

Scenario 2 – Global trading

Supply area	Key implications for sandwiches
Consumption	Consumers are more conscious about their purchasing, utilising smart technologies in the home for automated ordering and assessing the nutritional value of their sandwiches. Price is less of a concern for some consumers who look for tastier and better quality products. Despite favourable economic conditions in an era of increased choice, low-income consumers will be exposed to lower priced products that may be of low microbial and chemical quality. As such resilience to food borne diseases may be reduced due to lower quality public health.
Food retailing	While supermarkets remain the major supplier of sandwiches to the market, these products are also widely available from many different sources including catering companies. However, consumers may demand different types of bread and the types of fillings may change. However, this fragmented food chain poses a challenge for the implementation of rigorous controls. Improvements in packaging

	provide better storage conditions for longer periods. The level of technological innovation across the food sector means the inclusion of smart package labelling is possible and this reduces risks.
Processing and catering	Technological developments ensure high quality processing and improved analysis of microbiological and chemical contamination. However, there is a need to further develop the skill set of staff within the sector to sustain quality and safety improvements.
Production and supply	Despite an increase in the price of sandwiches, the quality of ingredients is maintained. The UK's economic position allows for good sourcing of ingredients that ensures high microbiological safety and nutritional quality. This will include imported foods which are required to cater for a wide range of tastes.

Scenario 3 – Resource tensions

Supply area	Key implications for sandwiches
Consumption	Low levels of cooking skills, tight budgets and food poverty mean sandwiches offer a quick and easy food choice for many, and a 'means for survival' for a few. In the interest of keeping costs low, consumers switch to cheaper fillings, prepare more sandwiches at home as opposed to buying and make use of leftovers. Potential also exists for the substitution of food unfit for human consumption, and for fraud, where consumers are misled by ingredients in sandwiches. There will also be less fresh produce and poor quality ingredients (e.g. saturated fats, sugar and salt) being used. There is likely to be higher risk of exposure from the chicken used due to the presence of bacteria, and perhaps antibiotics due to non-adherence to withdrawal times for use of veterinary medicines.
Food retailing and catering	Snacks and sandwiches offer an easy way to add value to food, so are likely to form part of the grey economy of itinerant traders seeking to supplement their incomes. Additionally, there is a low level of food hygiene and nutrition awareness in the 'grey economy' as access to appropriate food handling and nutrition courses requires registration of the company, thus the skills required to run a safe business are not acquired. This poses a challenge for regulators in keeping abreast with a more transient sector, particularly in relation to increased risk of contamination from unskilled food handlers. Similarly, sandwiches are a popular choice for distribution amongst food poverty schemes and institutional retailers. The risks associated with inadequate chilling during storage and transportation increase. Fresh produce is less frequently used as an ingredient to keep costs low. There is potential for fraud through the substitution of illegal ingredients.
Processing	The role of the food processing sector diminishes as the industry shrinks. For the few that remain, there are risks due to poor hygiene and nutritional practices and poorly trained staff that lead to production problems, and increased microbial and chemical contamination risks, particularly in ready to eat produce like cucumber, lettuce and tomatoes. Increased summer temperatures and the high price of energy during winter, leads to poorer temperature control in production areas, increasing the risk of microbial growth at this key control point for commercially produced sandwiches.
Production and supply	The increased price of ingredients has created sourcing problems. Manufacturers are tempted to source the cheapest option and producers have the temptation to adulterate their products to maintain profits. Under these conditions there is a much higher risk of food fraud (e.g. substitution for poorer quality chicken products leading to higher contamination of the perishables or use of illegal bulking agents or unsafe recycling/repackaging of material including abuse of use

	by dates). Sourcing of perishable ingredients is more local as climatic events and issues with global trade interrupt supplies. This makes control much more complicated since a lot of producers of uncontrolled raw ingredients emerge. Non-perishable components are sourced globally from low cost suppliers, leading to a breakdown in food safety (e.g. higher microbial loads, pests, moulds, toxin levels).
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Implications for meat

Why meat:

Meat was selected as an example of a key primary food product and ingredient, with associated considerations including sustainability, nutrition and safety. There was a large global increase in meat consumption between 1961 and 2002 and a corresponding jump in its environmental impact. Among industrialised countries, the UK and USA are among the few whose meat consumption levels have remained relatively stable (FAO 2012). Despite this, in both the EU and the UK, the quantities of meat that are currently imported from other countries (e.g. Brazil and Argentina) have increased significantly in last decade. These regions have been identified as areas of high risk for food issues over the next 20-30 years due to socio economic problems and the effects of climate change (DARA 2012). Meat and meat products constitute one of the main protein sources in a normal diet for most people in the UK. It also contains other nutrients including iron, zinc and B vitamins that are essential for a healthy life. Consequently, identifying some of the potential risks associated with this important food chain is necessary for consumer protection and ensuring food safety.

Scenario 1 – Reference

Supply area	Key implications for meat
Consumption	As the consumer experiences budget constraints, most seek out cheap (and sometimes poorer quality) meat products to maintain their dietary habits. Though there is a degree of choice, consumption is determined by price rather than quality. This contributes to the incidence of food-borne diseases (e.g. <i>Clostridium perfringens</i> , <i>Listeria monocytogenes</i> , <i>Campylobacter jejuni</i>), particularly in sensitive sub-populations (e.g. children, the elderly, pregnant women and immune-suppressed individuals). Additional monitoring of imports of foods of cultural importance will be required. Potential exists for the entry of unacceptable levels of veterinary medicine residues in the food chain. These may be administered to animals in a non-compliant manner, and also result in drug resistance build up in animals thus impacting on meat provision.
Food retailing	Increasing use of processed foods, including meat products, constitute a good alternative to maintain the quantity of meat consumed weekly. However, safety may be compromised if retailers attempt to reduce costs, thus increasing the risks for microbiological, chemical contamination and antibiotics (<i>E.coli</i> EHEC and VTEC, <i>S. aureus</i> and salmonellae). There is an increase in the consumption of ready meals and fast foods under these conditions, which may constitute poorer quality ingredients resulting in increased risk of meat contamination and shorter shelf-life.
Processing and catering	The use of lower quality meat may result in a higher risk of contamination with veterinary medicines/antibiotics for processing. Meat of lower microbiological quality used as ingredients for processed foods increases the risk of cross-contamination during processing. The risks posed from poor hygiene practices and poorly trained staff lead to production problems, increasing microbial contamination (e.g. <i>Clostridium perfringens</i> , <i>Listeria monocytogenes</i>) and chemical contamination risks (i.e. from equipment cleaning products). There will be less choice of meats offered in traditional catering facilities, and some pressure to source cheaper meats in order to maintain profitability, which could lead to poorer quality or fraud (e.g. substitution with cheaper meat, meat substitution).

Production and supply	High quality meats sourced and processed in the UK are destined to be exported by producers that find it more profitable. This in turn, increases demand for processing lower quality meats, either imported or home produced, for internal markets, thus exposing UK consumers to foodborne diseases. Cheap, low quality imports to meet demand will increase monitoring requirements including for fraud and substitution of species. Such supplies may contain levels of veterinary medicines/antibiotics above that recommended by the Veterinary Medicines Directorate (VMD).
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Scenario 2 – Global trading

Supply area	Key implications for meat
Consumption	There is greater awareness of product shelf-life as choice, availability and product knowledge increases. Potential issues about bacterial pathogens arise due to the wider range of processed foods available and an increase in the number of companies operating within the market, which makes regulation and control difficult. There will be more locally sourced food and this will have implications for the relative scale of movement of animals, the proximity to slaughterhouses and distribution chains.
Food retailing	The wider range of available meat products across the retail sector stimulates an increase in capability to trace ingredients. New developments in product packaging extend meat shelf life (e.g. bio-packaging, novel active packaging systems), but may have implications for microbial safety, where such systems could lead to new microbiological contaminants and an increase of toxins. The use of high quality products reduces risks across all sectors, including catering and retail. This is helped by good traceability and certification.
Processing and catering	The technological developments in the sector allow for highly mechanised meat production plants for a wider range of end-product foods. Highly trained staff and fully mechanised production lines improve hygiene. Hygiene concerns during processing are important to ensure downstream food safety, post-packaging. Improvements in meat quality and processing reduce the need for monitoring of traditional contaminants (e.g. antibiotics, toxins, microorganisms), but emphasise the relative benefits to consumers of newly devised products.
Production and supply	A high quality standard for meat production is maintained with little implication for safety. This is as a result of wider use of new technologies for improved food safety systems and enhanced product integrity. The quality of feed used to support production remains high thus maintaining a good quality meat supply, which leads to low or minimal microbial/disease issues from animal or food chains.

Scenario 3 – Resource tensions

Supply area	Key implications for meat
Consumption	Poor economic conditions mean a large number of consumers source and consume low quality meat products. For many consumers meat becomes unaffordable. This has serious health implications with an increasing number of diet-related diseases. Alternative sources of protein may be sought by many consumers. High consumption of fast foods and processed meat products, containing low quality meat ingredients, and sourced from cheap, but non-compliant suppliers, lead to an increase of meat-related food poisonings or infections. There is an increased risk of exposure to bacterial diseases via the animal food chain due to a breakdown of residue monitoring and inspection in such meat products.
Food retailing	There is an inconsistent supply of quality meats and meat products with a small number of 'top end' retailers maintaining quality standards, but only supplying consumers that can afford to 'eat out'. There is a proliferation of local and outlet type stores selling low quality meat-based products to a population that has less choice. The economic squeeze affects both meat quality and contamination, where shelf-life is often compromised due to a loss in traceability and reduced monitoring of retailers. There is an increase in the operation of a number of small, illegal retailers trading without proper hygiene controls, selling meat of unknown origin and capitalising on a growing, low-income consumer market. This will have implications for the relative level of exposure to contaminants of such products, but may be circumvented by offering alternatives to high priced meat.
Processing and catering	The tendency to source meat from cheaper producers increases the possibility of meat imported from external sources being compromised (e.g. poor traceability), requiring government intervention to ensure minimum stocks are available for meat products. The risks posed result from poor hygiene practices and poorly trained staff, which leads to production problems, increased microbial and chemical residue contamination risks, particularly in highly processed products that can accumulate contamination in every step of the chain (e.g. tainting of products, substitution with undeclared or other illegal meats, presence of veterinary drugs/antibiotics). The impacts are not only on quality, but an increase in the risks of higher contamination from spoilage bacteria which further limits shelf life.
Production and supply	The increase in prices coupled with a reduction in consumer spending on foods, leads to an increase in the amount of cheap imported meat. This in turn, leads to significant problems with safety assurance and meeting quality thresholds for the UK. Animal feed sources (and thus diets) change because of changing climates (e.g. shortage in cereals for use as feed). This may lead to the use of animal feed produced from poor quality /safety feed grains containing several contaminants that could be introduced in the human food chain (pesticides, mycotoxins, veterinary medicines/antibiotics). Local meat producers are forced to use more intensive systems to compete with cheap imports (in the interest of cost reductions) and this impacts on the quality of food supplied. A reduced level of surveillance is associated with an increased risk of fraud during production and before processing (e.g. increased contamination with hormones, antibiotics, and bacterial human pathogens from meat, species substitution and other fraud).

Implications for soya

Why soya:

Soya was selected as an example of a key, globally traded component both of animal feed and of food ingredients. Soya beans represent an important food/feed chain for the UK since approximately two-thirds of all manufactured food products contain derivatives or ingredients made from soya (FAO 2012). Examples of its use include soya oil in salad dressings and mayonnaise; and as a vegetable fat for baking and frying. Lecithin from soya is an emulsifier in some chocolates, breakfast cereals, ice creams, sweets and spreads. Soya flour is used to extend the shelf-life of many products and improve the colour of pastry crusts. The flour is gluten-free, which means it can be used to replace wheat or rye flours in bread-making and other baked products. Isolated soya proteins are used for biscuits, sweets, diet drinks, pasta and a variety of frozen foods. Soya protein improves the consistency of meat products and it is added to many foods including pizzas, noodles, bread and other foods for special dietary needs, for example, soya drinks, which serve as a substitute for cows' milk for those who are lactose intolerant or allergic to milk. Various cheese- and other milk- and meat-substitute products, such as miso, tofu and tempeh, can be made by fermenting soya protein (FAO 2012). Research suggests that the intake of soya in the UK is between 1-3.5g per day (FAO 2012). Soya is a high protein fibre ingredient in animal feeds, after the extraction of oil for food use. In the UK, many consumers are dependent on imports of soya and thus this could have implications for the relative risks and contingencies, which may be required for this raw commodity and its processing into food/feed. A large proportion of soya beans, both GM and non-GM are imported from the USA and Latin America, specifically Argentina and Brazil.

Scenario 1 – Reference

Supply area	Key implications for soya
Consumption	Faced with economic constraints, consumers source cheaper food products. This puts pressure on producers and processors to reduce costs. High quality soya derivatives are substituted with lower quality ones. Since many soya by-products are used in ready-meals, higher prices drive the industry to use cheaper and riskier sources that potentially increase microbiological risks for consumers. Monitoring of final products for human consumption is required, which increases the need for more extensive quality/safety checks. There is pressure to use more soya with growing acceptance of GM- soya as ingredients. Alternative sources of protein are sourced to reduce reliance on soya in animal feed. These include mixtures of rapeseed/pea/bean mixtures, use of synthetic amino acids, and commercial sources of synthetic valine.
Food retailing	A number of cheap, low quality retail outlets emerge as a result of the economic situation. Cutting cost poses increased risk of contaminants (e.g. agrochemicals, mycotoxins) entering the food chain. There is an increase in the number of retailers selling cheap feeds that contain lower quality soya by-products, which potentially leads to a decrease in livestock production with a knock-on increase in meat prices.
Processing	Improved sorting is needed to prevent contamination (e.g. pesticides, mycotoxins) and separate out low quality material. This specifically impacts on food and feed quality (by-products), and hence livestock, where entry into the meat food chain could be compromised. Processing of soya beans for extraction of different by-products requires several chemical treatments. The need to reduce costs will pose a problem if it impacts the safety controls during and after processing. There is a possibility of chemical contaminants in final products (e.g. Hexane, agrochemicals).

	Detection and separation of Non-GM and GM-Soya for food uses may be required as added pressure is put on sources of soya beans, especially if limited supplies are available.
Production and supply	<p>Complete dependence on imports makes it difficult for the UK to control or influence volatile/increasing prices. The UK looks for cheaper sources, with indirect impacts on quality (e.g. chemical contaminants in soya products such as soya flour, oil and milk)</p> <p><u>Pre-harvest:</u> Climate change impacts on soya cultivation worldwide. Temperature increases could reduce yield by approximately 30-40%.</p> <p><u>Post-harvest:</u> Increases in population creates an increase in the consumption of soya-rich ready meals, which raises demand. Medium/long-term storage compromises product integrity under some climate conditions. Pest and mould contamination control during storage is needed.</p> <p><u>Transport:</u> The fatty, hygroscopic content of soya, coupled with the environmental changes experienced during long distance transport increases the probability of detrimental quality (e.g. rancidity problems). Increased moisture, pest and mould could lead to toxin contamination.</p>

Scenario 2 – Global trading

Supply area	Key considerations for soya
Consumption	A more environmentally conscious population with concerns for “food miles” stimulates more responsible sourcing of soya. Due to increased prices there are more choices for soya derived products, including animal feed, but different quality (i.e. grades) levels appear on the market, requiring further control by authorities to ensure compliance.
Food retailing	No major changes.
Processing	Funding for research and development stimulates new technological improvements that ensure higher quality food for human consumption, but increase the possibility of higher contamination of discarded soya fractions that could re-enter the food chain as animal feed (e.g. cows fed with contaminated soya-based feed). This is mitigated to some extent as consumers demand a high-quality product and are prepared to pay for it. New technology is developed to help this happen.
Production and supply	<p>Despite the sustained economic growth in the UK, the price of soya increases due to increasing global demand. Maintenance of UK quality standards implies an increase in raw soya prices due to competition with emerging economies.</p> <p><u>Pre-harvest:</u> Developing new areas of cultivation, where Good Agricultural Practices are adopted, mitigate reduced yields. Additionally research and development of new heat resistant and climate-resilient plant varieties raises yield.</p> <p><u>Post-harvest:</u> Investment in state of the art, real time monitoring systems leads to a reduction of end-point, pre-processing checking/measuring of contaminants.</p> <p><u>Transport:</u> Traceability and monitoring systems are needed to meet UK standards. Lengthy transport of commodities is expected, but legislative requirements from chemical and microbiological contaminants are met.</p>

Scenario 3 – Resource tensions

Supply area	Key considerations for soya
Consumption	Under poor economic conditions, low-income families suffer from health-related disease due to increased consumption of poor quality products. Special care is required for vulnerable sections of the population (e.g. children, the elderly, pregnant women and immune-suppressed individuals). The lack of adequate supplies of soya (Non-GM and GM-soya) for animal feed results in the sourcing of alternative protein including full fat rapeseed, and mixtures of rapeseed/pea/beans. These alternative protein sources requires a different set of feed safety monitoring and control regime, which places additional burden on regulatory and food safety requirements.
Food retailing	Food fraud including adulteration or substitution of soya by-products is a growing risk. The emergence of retailers offering alternative, non-controlled soya/soya by-products in both the food and feed chains requires government action to avoid related risks. Under the current economic conditions, the cost of monitoring programs to check the quality of these products could be unaffordable.
Processing	The need to maintain profits drives processors to cut corners as a way of maintaining marginal profits, but quality and safety are severely compromised. Product adulteration and substitution increases (e.g. increased moisture content, cheap raw materials, compromised microbiological quality and shelf-life) to maximise marginal profits. The quality of products for specific sub-populations is compromised (e.g. soya milk for those who are coeliac).
Production and supply	<p>Yield and quality are likely to decrease because of the effects of climate change and a reduction in the fertility of soils. This raises prices and allows entry of low quality raw materials into international markets, including the UK. Competition and price for quality soya increases and the UK needs to accept lower quality, riskier products. Soya will be substituted with local feed ingredients, which may not have the same high value protein content.</p> <p><u>Pre-harvest:</u> There is little adherence to Good Agricultural Practices and more problems with pests, diseases and toxins occur. Extreme climate change events impact on soya resilience and reduce yields, leading to food insecurity and increased prices. Subsequently, this increases reliance on expensive fertilisers and pesticides, which encourages farmers to retain low quality outputs to increase minimal profit margins. Where used, pesticide residues may become an important contaminant.</p> <p><u>Post-harvest:</u> Poor grain quality necessitates extensive monitoring. Reduced traceability is also a risk, which could lead to contamination resulting from mycotoxins, pests and rodent problems.</p> <p><u>Transport:</u> The drive to cut costs compromises quality (e.g. mixing of cargos with different raw commodities). Toxin contamination and hygiene issues increase.</p>

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Appendix B: Methods

Scenario construction: the process

Key factor analysis

Developing the key factors involved an assessment of what would drive and shape the future of the food and feed system in the UK.

A key factors workshop was held on 23rd May 2012 at the FSA's London offices to identify a variety of key factors derived from a 360° environmental scanning process based on a PESTLE analysis. The PESTLE framework, which covers a range of political, economic, social, technological, legislative and environmental factors, allowed for an analysis of the external macro environment (big picture) in which the food and feed system operates. The purpose was to detect and understand the broad, long-term issues that influence the food and feed system.

The outputs of the workshop served as the foundation for identifying the key activities taking place in the food and feed environment. The main output from the workshop was a number of key driving factors identified (see Table i). IEHRF and FSA officials augmented the workshop with a comprehensive desk study, using a number of reports related to the topic, and discussion around the factors that influence UK's food and feed system. A list of 13 key factors was presented to the FSA for approval. These key factors then formed the basis for the rest of the scenario building process.

In addition to the key factors developed for the scenario analysis (see Table i), devolution and regionalisation was another factor identified by workshop attendees. Whilst this factor will inevitably shape the work of the FSA in developing future policy, further analysis suggested that it was not a significant driver of the UK food and feed system. This was revealed in the cross-impact analysis where it was determined that projections, specific to this factor, had very little impact on or consistency with, other key factors' projections (see scenario discussion).

Table i: List of final key factors for food and feed systems

PESTLE area	Key factors
Political	<ul style="list-style-type: none"> • International trade and relations
Economy	<ul style="list-style-type: none"> • Global markets • State of the UK economy • Cost of living / disposable income
Society	<ul style="list-style-type: none"> • Population size • Families and households • Consumer attitudes and behaviours
Technology	<ul style="list-style-type: none"> • Innovation and adoption of technology • Information and communications technology
Legal	<ul style="list-style-type: none"> • EU legislation • Nature of the regulatory environment
Environmental	<ul style="list-style-type: none"> • Climate change • Price and availability of resources

Key factor projections development

With the list of key factors identified and approved, the next phase involved describing possible projections for each key factor. Projections represent alternative, plausible developments for a particular key factor.

From the information gathered as part of the key factors analysis, a brief outline of each key factor was produced in a draft report, sketching out information relating to the food and feed system in the UK for 2015 and 2035.

The draft set of key factors was then presented at a workshop held on 26th June 2012 at the FSA's London Offices, with experts from IEHRF, representatives from the FSA and external stakeholder organisations in attendance. During the course of the workshop, working groups discussed, revised and enhanced the proposed key factors and developed a set of plausible, possible projections for each factor.

Using information gathered at the workshop, IEHRF produced a draft Key Factor and Projections Report. In the report draft projections were identified for the year 2035, reflecting on UK and international issues, where possible. In creating the draft key factors and projections, a comprehensive desk research was carried out, various data evaluated and trends analysed. Following feedback provided by the FSA's experts, the final Key Factors Report was developed.

It should be noted that if this material is to be used to identify scenarios for an individual country in the UK, it is anticipated that the key factors would, by and large, remain the same. At most, they may need to be augmented to include additional information concerning the specific country in question. For instance, it would be necessary to review each projection to determine whether or not it applied to the development of the food and feed system in that country and/or whether it needed adapting.

The morphological box

In the scenario process, the morphological box is the methodological link between the outcome of phases one and two, and phase three. This method allows the complex, multidimensional set of key factors and corresponding projections to be reduced to a matrix (see Figure ii). The matrix provides an overview of all the possible combinations for each key factor projection. A complete set of key factor projections is termed a projection bundle or draft scenario. In this case, based on 13 key factors and 46 projections, over one million draft scenarios are possible.

International Trade & Relations	Global Markets	State of the UK Economy	Cost of Living/ Disposable Income	Population Size	Families and household	Consumer Attitudes & Behaviours	Innovation & Adoption of Tech	ICT	EU Legislation	Nature of Regulatory Environment	Climate Change	Price & Availability Of Resources
Influence of emerging economies comparable to western levels	Increased Globalisation of markets	Steady Growth	Increasing food prices alongside disposable income	Stabilization of population size	No real change to families and households	Price-led consumption	Limited investment and adoption of new technology	Free information is used by industry but not the public	Compromise model	High levels of regulation	Mild to modest effects from climate change	Volatility of markets limits access and increases prices
Global trade agreement	Stable globalisation of markets	Strong growth	Decreasing food prices alongside disposable income	Increase Driven by global population trends	Progressive But stable change to families and households	Unsustainable consumer choices	Sourcing technology from foreign suppliers	Free information is used by industry and public	EU legislation with a world market focus	Medium levels of regulation	Gradual Increase in effects from climate change	Market agreements lead to stable access and prices
Trade wars	Decreased globalisation of markets	Modest Growth	Increase in prices but a decrease in disposable income	Increase driven by immigration	Radical change to families and households	Informed and responsible consumption	The UK at the forefront of research and development activities	Industry uses information and tailors industry/ consumer interactions	A greater EU	Low levels of regulation	Proactive reduction of climate change	Government intervention regulates access and prices
Regional alliances		Predominant periods of recession	Increase in disposable income with a real decrease in prices			Retail-led consumption		Technology has less significant role due to a lack of information	World market without EU		Adaptation To volatile Climate change	

Figure ii: The morphological box

Scenario analyses: the process

Identifying draft scenarios

When preparing for the consistency analysis and selecting the draft scenarios, a rough cross-impact analysis was carried out to identify the relationships and interdependencies of each key factor. As can be seen in Figure ii, each key factor combination was analysed in terms of its impact direction and severity, with zero meaning “no impact”, one “some impact” and 2 “strong influence” (white cells represent 0).

Using the set of key factors and projections and the results of the cross-impact analysis as a basis, the project team then performed a consistency analysis. That is to say, it was analysed whether projections could be combined in such a way as to produce coherent, plausible scenarios. Owing to the complexity of this task, the software tool EIDOS was used to support the analysis. The aim was to verify the consistency of each projection against the others in order to construct alternative scenarios. The project team checked each possible combination to assess whether or not this combination was consistent in a given scenario; a judgement as to whether (or to what extent) two factors can coexist. Consistencies were evaluated on a scale ranging from -3 (highly inconsistent, not conceivable in the same scenario) to +3 (highly consistent, entirely conceivable in the same scenario). See Figure iv for an overview of the consistency analysis.

The results of the consistency analysis were reviewed, developed and ideas for potential alternative scenarios discussed as part of an internal workshop. A set of three consistent draft scenarios were then selected: these included a reference scenario (the situation should current policies, strategies and agreements continue to develop into the future) and two scenarios exploring more disruptive possible future developments.

Designing the scenarios

The next phase elaborated on the three draft scenarios selected (see Figure v). Besides the Reference Scenario', two additional scenarios are outlined in greater detail: 'Global trading' assumes multilateral agreements tackle trade restrictions, improving market access for agricultural, industrial and primary products, 'Resource Tensions' assumes trade wars will create huge inefficiencies and poor allocation of resources, that lead to price volatility and supply chain disruptions.

The scenarios have been described earlier in this report. The discussion has a UK focus for 2035 and includes a roadmap of developments within the scenario environment from 2012 to 2015 and 2015 to 2035. Each scenario presents an overview of the opportunities and challenges for the food and feed system on the whole, and specific case studies that examine the impacts on key food/feed chains.

Experts on the UK's food and feed system reviewed the draft scenarios in a workshop on 15th November 2012. The plausibility of the scenarios, and the implications, opportunities and challenges in relation to the FSA's development of policy was debated. The workshop provided the necessary data to review the scenario environments, and refine / enhance the characteristics and description of each scenario.

The final Scenario Report was produced, incorporating feedback gained from the workshop.

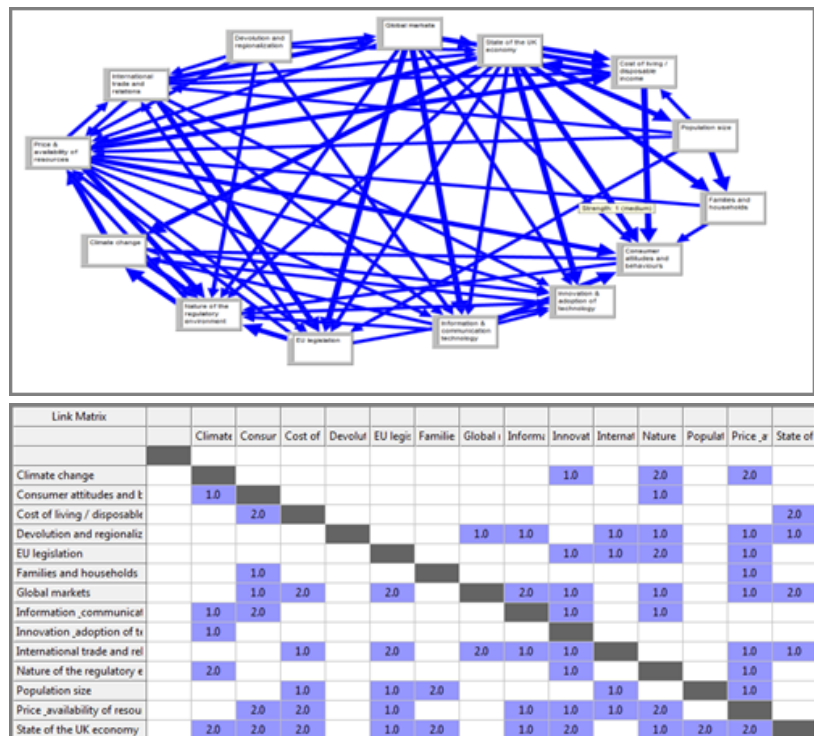


Figure iii: Cross-impact analysis on EIDOS



Figure iv: Consistency Matrix (complete) in EIDOS

Implications for key food/feed chains in each scenario

A two-stage analysis of the three scenarios developed was conducted. The first produces an overview of the challenges and opportunities arising in general, and the second, narrows the focus to present implications for three foods illustrative of broad groups (processed product, raw food/ingredient and feed/ingredient), under each scenario. At both stages of the analysis, challenges and opportunities arising within the scenario environments are clarified.

The overview focuses on key aspects of the food and feed system that are fundamental to understanding the implications of developments in the scenario environment. These include:

- (a) production and supply;
- (b) processing;
- (c) retail and non-retail distribution;
- (d) catering; and
- (e) consumption.

The overview is supplemented with case studies that examine the implications for three foods illustrative of broad groups (processed product; raw food/ingredient; feed/ingredient). Each case study examines the potential risks and contingencies for the raw commodity and its processing into food/feed. These offer insights into intervention that may safeguard against impacts to the food/feed chain, and assist in the delivery of food/feed standards and safety controls. The cases focus on the key aspects of the food and feed system with some attention paid to pre-harvest, post-harvest and transport, that are integral to the production and supply of food/feed.

It should be noted that the scenario implications were identified using expert elicitation methods (workshop discussion and input from the FSA's project officers). While it is understood the impacts on some of the identified fields might be ambiguous, a rigorous 'sense-checking' approach was applied to the analysis to reduce the uncertainty inherent in aggregating disparate opinions from experts.

Appendix C: Key factors and projections

International trade and relations

Definition: “International trade and relations (including the future of the EU)” describes the UK’s position within the Global and European political panorama, in terms of key players and associations (e.g. future of EU) and trading policies (liberal trade vs. protectionism) and trading communities (true global trading system vs. association into smaller trading communities).

- **Crucial facts:** The UK is amongst the seven top ranking national economies in the world and relies on an open economy for both trader and investor. Open international trade is regulated by General Agreement on Tariffs and Trade (GATT), which dates back to 1947 and was updated in 2012¹. Developed countries acknowledge and invest in the benefits of an international open trade platform, and the UK is no exception. However, maintaining such practices depends on the capacity to manage (justified) geopolitical motivations and concerns, where confidence in markets plays a significant role². For example, the current financial crisis has resulted in an increase in protectionist measures in 2008/09 (i.e. 14% in developed countries and 7% in emerging economies)³. The balance between economic protection and protectionism will dictate the future structure of international trade.

To be considered for 2015/2035:

- The increasing organisation of countries in trading blocks (e.g. NAFTA, EU, Mercosur, PARTA, etc.)⁴.
- Increasing influence of the WTO in regulating international trade, with developing countries and trading blocks more active in filing disputes³.
- Negotiations at the Doha meeting addressed the reduction of trade barriers allowing for more efficient exchange of products among countries and this encourages economic growth⁶.

Projections:

1) Influence of emerging economies comparable to western levels

The UK and the international community invest in the advantages of liberal international trading markets. International organisations such as the WTO, with governmental cooperation, provide a regulatory service and dispute settlement, and help to regulate a healthy international market. Despite overwhelming support for free international trade, there are instances of protectionism driven by political reasons. Emerging economies have an influence in international trade (e.g. the BRICs) that is similar to that of western economies (e.g. EU and USA) and play a significant role in the development of the trading rules and policies.

2) Global trade agreement

The on-going work of multiple governments to regulate and ensure a liberal trade platform resulted in complete global agreement in trade. The role of international organisations ensures fair competition amongst countries, and improves the transparency of available stocks and of efficacy of existing controls. Existing

cooperation creates a climate of trust amongst trading communities, contributing to geopolitical stability. Trust promotes the implementation of risk based control policies and cooperation in crisis management.

3) Trade wars

The struggle for control of resources and the work of political influences results in a climate of distrust amongst and between partners, leading to an increase of WTO disputes, reversing a trend for decreasing disputes observed in the first decade of the 21st Century. Distrust and power struggles resulting in geopolitical instability leads to self-interest based trade wars. There is increasing divergence between countries' political agendas and their ideology on international relationships, ultimately affecting the level of openness in international markets.

4) Regional alliances

The struggle to control resources results in the organisation of international trade into regional alliances. These alliances involve small groups of countries, with common political interests and/or sharing similar geographical traits, e.g. EU and North America, which display open trading relations amongst group members. However, they also implement protectionist measures towards outsiders. Despite small pockets of liberal trade, overall international trading practices are frustrated by significant protectionist measures. The geopolitical panorama is complex, where political motivations drive countries' international agendas.

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Global markets

Definition: “Global markets” describes the system in which the international markets operate, expressed in terms of the global flow of goods and resources (imports and exports) – i.e. the activity of buying or selling goods and services. It also considers the transnational nature and structure of large corporations alongside local structures, including both supply and demand side drivers.

- **Crucial Facts:** The UK is a significant player in the development of global trade¹. Global economic prospects suffered a significant setback with the onset of the economic crisis in 2008 and despite efforts to reverse the effects of the crisis, new setbacks occurred in 2011². The crisis was felt in developed countries and in emerging economies alike, slowing down global economic growth³. Current reports describe international markets and volumes of trade showing signs of economic recovery (IMF and WB)^{2,3}. Nonetheless, financial institutions warn of an increase in protective measures being applied across the globe, potentially reducing international trade and generating geopolitical tensions⁴. The evolution of global markets will depend on factors such as political motivations to increase exports or to protect national industries, and the struggle for resources.

To be considered for 2015:

- Economies remain frail with a reduction in the rate of expansion in world trade by 13.8% (2010), 5% (2011) and 3.7% (2012)⁵.
- Developing countries apply for new protectionist measures^{7,8}.

To be considered for 2035:

- Global trade is predicted to expand, growing from USD 37 billion in 2010 to USD 287 billion by 2050⁶.
- Germany, the UK, France and Italy are expected to grow by 1.5 % annually until 2050, shrinking their share of G20 GDP from 24 to 10% by 2050.

Projections:

1) Increased globalisation of markets

Global markets for food are fuelled by a net increase in the global flow of goods and resources (imports and exports), led by the major world economies (e.g. US, EU and UK) and emerging ones (e.g. South East Asia, India and South America). Western corporations invest internationally and there is a proliferation of transnational and integrated retailers, with new global leaders materialising from emerging economies. In the UK food imports and exports grow as food is sourced from an increasingly diverse range of countries.

2) Stable globalisation of markets

The evolution of global market for food maintains the current trajectory, presenting a static mix of trade in terms of EU/US trading partners and some supply/demand from emerging markets. While emerging economies are influential in shaping global trade, this level of influence does not directly translate into the food and feed system as food

safety concerns and trust in partners to maintain quality standards remain a problem (e.g. china's melamine incident).

3) Decreased globalisation of markets

World economies, including the UK focus on self-sufficiency, encouraging investment in "home grown" food products. Therefore, national food producers are the main supplier of the UK food market. The global market plays a significantly smaller role for the UK, where countries adopt measures to protect their resources.

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State of the UK economy

Definition: “The state of the UK economy” is used to mean the size and future development of UK’s economic output, expressed in terms of real GDP, average annual growth, and origin (expenditure approach).

- **Crucial Facts:** With an economic output in excess of £1.4 trillion in 2011, the UK is one of the Top-10 economies in the world in terms of real gross domestic product (GDP). It ranks thirty-seventh in terms of GDP per capita^{1,2}. About 77% of the UK’s economic output is generated from services (financial services alone account for 10%³). England’s share of the UK economy has consistently been around 84% over the past decade. Unemployment stands at 7.8% (2010), up from approximately 5% between 2000 and 2008. Since emerging from recession in 1992/93, the UK economy has enjoyed a period of sustained growth, exceeding many other Western European countries and achieving average growth rates of 3%. However, the country was hit hard by the global financial crisis in 2008 and has been affected by periods of recession since.

To be considered for 2015:

- From 2012 onwards, the IMF expects growth rates to be around 2.5% on average, equating to a GDP of more than £1.7 trillion in 2016 (at 2011 prices)².
- Oxford Economics forecasts an annual growth rate of 2.7% for the UK between 2010 and 2020⁴.

To be considered for 2035:

- From 2020 to 2030, Oxford Economics expects the UK economy to grow at 2.0% per annum.⁴
- HMT Forecasts annual GDP growth rates to grow between 1.1% and 2.4% for years 2013 – 2016 respectively^{5,6};
- PwC forecasts growth rates of between 2.3% and 2.4% in the years from 2013 to 2019⁷.

Projections:

1) Steady Growth

The UK economy recovers from the 2008 economic crisis, and slowly, but surely, returns to trend growth. From 2012 onwards, growth rates tend to fluctuate between 2% and 3%, reflecting solid underlying economic growth. The structure of the UK current account remains unchanged.

2) Strong Growth

After overcoming the crisis, the UK economy experiences a period of economic boom. Annual growth rates fluctuate around 3%, and although the economy slows around 2020, broadly speaking, the UK population is in a better state. The strength of UK exports significantly improves the UK’s trade balance.

3) Modest Growth

The UK economy struggles to cope with the aftermath of the crisis and growth trends are modest, particularly from 2020 onwards, levelling out at around 1–1.5%. The value

of exports remains lower than that of imported goods and services, leaving the UK with a trade deficit.

4) Predominant periods of recession

The UK economy experiences prolonged periods of negative/ zero economic growth against the back drop of high and rising unemployment, a worsening trade deficit and inflation (cost push) from rising imported raw material costs. Economic growth remains significantly below trend growth; not exceeding 0.5% during the 2010s and remaining relatively flat during the decade that follows.

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Cost of living/disposable income

Definition: “Cost of living/disposable income” describes the affordability of food in relation to household disposable income. The distribution of income in the UK population is an indication of inequalities in spending power, which is often used as a measure of living standards that can be compared to those in other countries.

- **Crucial Facts:** Disposable income is the total personal income after taxes. It presents a measure of the household’s spending power, which is directly related to discretionary income (i.e. the quantity of money left after taxes and household bills are paid)¹. The availability of disposable income, tempered by the rate of inflation, may affect consumers’ attitudes to spending or saving, and impact on their choice and patterns of consumption². Analysis of the fluctuation of disposable income and consumer purchasing patterns suggests there may be an impact on the quality of the diet. For example, an increase in income is associated with an increase in the average caloric intake per capita^{3,4,5}. In developed countries inequalities in disposable income are associated with significant dietary differences, where those on high income tend to have a more varied and nutritional diet, while low income families opt for cheaper sources of food that is often less nutritious, to meet their daily caloric demand^{4,5}.

To be considered for 2015:

- Household disposable income is expected to increase by 4.3% from 2012 to 2015, however maintaining levels that are below those of 2006¹.
- Unemployment rates are expected to reduce from 8.1% in 2011 to 6.5% in 2015⁵.
- Household debt-to-income ratio is expected to fall from 150% (2012) to 140% in 2015¹.
- Assuming stable bank and market rates, inflation is likely to be below 2% up to 2015⁶.

To be considered for 2035:

- By 2050, growth in developed markets is expected to rise by 0.2%, though remain 2-3% below 2000 levels⁷.
- There is an expected 7-8% increase in the working population from 2010 to 2050⁷.

Projections:**1) Increasing food prices alongside disposal income**

Increases in the price of goods and household energy costs are matched by salary increases and disposable income. The UK population enjoys easy access to affordable food and the percentage of the population at risk of food poverty returns to prerecession levels. Economic drivers encourage households to stockpile food goods, as opposed to buying in small quantities.

2) Decreasing food prices alongside disposal income

Decreases in the price of food goods and of household energy costs are matched by decreases in salary and disposable income. The UK population has access to affordable food, but the percentage of the population at risk of food poverty returns to recession levels. Economic drivers discourage those in the lower incomes bands from stockpiling food goods, incentivising households to purchase in small quantities.

3) Increase in prices but a decrease in disposable income

The increase of the price of food and household energy (possibly due to an increase in the cost of raw materials and resources) are matched by decreases in salary and disposable income. An increasing percentage of the population are struggling to access affordable food, resulting in an increase in the percentage of the population at risk of food poverty.

4) Increase in disposable income with a real decrease in prices

Stable geopolitical conditions and technological and agricultural improvement minimises supply shocks of raw materials and contributes to static nominal food prices and a real decrease in the price of goods and household energy. This is matched by salary increases and disposable income on the whole, but there are spin-offs such as further inequalities between households as some markets outperform others.

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Population size

Definition: “Population size” describes the fluctuation in the total number of individuals living in the UK. The definition includes fluctuations in birth and death rates and the rate of immigrant population.

Crucial Facts: The UK and global population are increasing. The current size of the UK population is close to 59 million^{1,2}. Government projections for population size vary, but recent statistics suggest an increase to 70 million by 2027^{1,2}. Population size is directly related to the overall daily caloric demand of the UK population as well as resources that have to be made available (water and energy) which may be diverted from food production and processing uses. An increasing population affects the quantities of food and goods that have to be sourced and distributed across the UK, influencing importation routes and agricultural practices⁴.

To be considered for 2015:

- The population is projected to become older gradually with the average (median) age rising from 39.7 years in 2010 to 39.9 years in 2020 and 42.2 years by 2035^{2,4}.
- Population growth in developed nations is expected to decline from an average of 0.4% (2010-2020) to 0.1% (2040-2050)⁷.

To be considered for 2035:

- The world population estimated at 6.9 billion in 2010 is set to rise to 8.6 billion by 2035^{5,6}.
- The UK population is projected to increase from an estimated 62.3 million in 2010 to 73.2 million in 2035 (10.9 million)².
- From the projected increase of the UK population (10.9 million), 5.8 million (53%) is due to projected natural increase (more births than deaths) and 5.1 million (47%) is due to projected net migration².

Projections:

1) Stabilisation of population size

The UK population does not grow in line with global population growth due to low fertility rates and stabilisation of the net-migration level in the population (assuming net-migration levels between 0k to 50k). There is acute ageing of the UK population driven by higher life expectancy.

2) Increase driven by global population trends

The UK population grows in line with global population growth, reflecting a steep increase that is driven by high fertility rates, higher life expectancy and a proportional increase in net-migration levels (equal or above 100k). High fertility rates and an increasing immigrant population outweigh the UK's ageing population.

3) Increase driven by immigration

The UK population growth stems mainly from a disproportionate increase in net-migration levels (equal or above 100k). There is progressive ageing of UK population due to lower fertility rates and higher life expectancy, which is not in line with global population trends.

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Families and households

Definition: “Families and households” describes the type of household, including single people living alone, lone parents (with or without adult), couple (with or without adult) and other households with members either related by blood or marriage or living (or staying temporarily) at the same address.

- **Crucial Facts:** Trends in families and households show changes in society, a common variable used by policy makers to consider issues such as employment, health, food production and security^{1,2,4}. The composition of households shape behaviour as well as the demand for convenience. Studies show that householders that are older, wealthier and more educated consume healthier foods (e.g. organic or free-ranged foods). While younger householders consume foods that are convenient, but not necessarily healthy (e.g. fast-foods)^{1,2,3,4}. Similarly, the type of family can impact on consumption of energy, land-use and production of waste, which puts pressure on future resources. For example, current trends show one-person households consume much more per capita than four-persons households (e.g. approximately 40% more products and packaging, 60% more electricity and gas, and produce 60% more waste)⁵.

To be considered for 2015:

- In 2011, there were 25.5 million households in Great Britain, an increase of 1.6 million since 2001 and 9.2 million since 1961^{5,8}.
- The number of one-person households in the UK has increased from 12% of households in 1961 to 29% in 2011, compared to four-persons household that decreased from 19% (1961) to 13% (2011)^{5,6,8}.
- A smaller proportion of households in Great Britain have children living in them in 2011 than in 1961, and those households with children have fewer children living in them^{5,8}.

To be considered for 2035:

- The ageing population (age 60 and above) are expected to increase by approximately 33% in 2035 from a base year of 2010⁸.
- National projections for household growth and composition reveal an increase in the total number of households by 29% by 2031^{5,8}.
- This increase is driven by the increase in one person households which will replace married households as the most common household by 2031, reflecting 65% of all new households^{5,8}.

Projections:**1) No real change to families and households**

Families and households remains the same with no real increase in one-person households. This results from a stabilisation of household numbers where the amount of one-person households is in balance with larger households. This stabilisation is associated with an increase in the proportion of the younger sections of the population living in a couple with one or more dependents and a reduction in single-parent households.

2) Progressive but stable change to families and households

The change to families and households in the UK is progressive, but stable. There is a steady increase in the number of one-person households that results from a decrease in the proportion of the younger sections of the population living in a couple with one or more dependents, combined with a steady increase in single-parent households and the aging population.

3) Radical change to families and households

There is a significant proportional change to the UK families and households. This is associated with a high increase in one-person households that results from a lower proportion of the population living in a couple with one or more dependents and an increase in single-parent households, combined with a high increase in the aging population.

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Consumer attitudes and behaviours

Definition: “Consumer attitudes and behaviours” describes the consumption and lifestyles choices, which affect purchasing decisions, attitudes and behaviours of individuals regarding food, health, society and sustainability, and risk taking. It also describes the level of active social and community engagement (as opposed to passive engagement) to take action on social and environmental issues.

- **Crucial Facts:** Consumer behaviours are those activities that people engage in when selecting, purchasing and using products and services to satisfy needs and desires. Consumers, in the exercise of choice, have the ability to influence demand, which shapes food production practices, import routes and food distribution through retailers or restaurant services². Contractions in demand are associated with food scares, e.g. BSE, whilst expansion in demand is the current trend for functional foods⁴. A documented prediction for the general population associates demand primarily with economic factors, whereby environmental and social concern is a secondary influence. The drivers of consumer choice and behaviour are difficult to predict, though include a combination of push and pull factors. For example, trends in health stimulate consumer demands for foods that promote good health and wellbeing, while developments in the food industry have segmented the types of food available to consumers^{3,4}.

To be considered for 2015:

- Public consumption is expected to shrink in 2012 and 2013 due to continued fiscal consolidation that aims to ensure public debt is sustainable and to restore confidence¹.
- In lieu of economy recovery (beyond 2013) domestic demand is expected to take over from net exports as the main driver of recovery, stimulated by restored business, consumer confidence and rising disposable incomes¹.

To be considered for 2035:

- From 2020, demand for basic resources such as staple crops is expected to increase and prices will rise².
- Consumers are expected to be more conscious and informed about health and growing links between diet and good health, thus demanding innovation and greater responsibility from retailers or businesses^{2,3}.

Projections:

1) Price-led consumption

The high cost of food goods and reduction in disposable income results in spending that focuses on value for money, with social and environmental concerns relegated to a secondary influence. The consumer does not have the option to select products according to personal values; instead purchase choice is limited to finding desirable goods at the right price. The population is price-conscious, utilising basic rations or reduced portions of food, but also exhibiting self-reliance. Where the option is available and economical, consumers source food from direct and local sources, tending to swap and sell goods using peer-to-peer networks. Associated with this trend is an increase in home grown and local produce, but only if it is the cheapest option.

2) Unsustainable consumer choices

The available disposable income is enough to spend on food goods above the essentials so the population is more selective in their choice. For the consumer, environmental and social concerns have little influence on choice, which is driven by personal needs, including health concerns and willingness to experiment with a diverse or convenient diet. A significant part of the population enjoys experimenting with an exotic diet, whilst expecting that it is readily available and that seasonal variation does not influence availability / access to goods.

3) Informed and responsible consumption

Higher amounts of disposable income allows consumers to be more altruistic in their choice, where consumption behaviour is aligned with social and environmental values, and concerns typically associated with maintaining a healthy diet of high quality / nutritious food. The population is engaged and informed, where more ethical and conscious consumption drives responsible sourcing (home-grown or local produce) and distribution of foods through transparent value chains.

4) Retail-led consumption

Disposable income is high with consumer spending peaking so the population is over-reliant on consumerism, seeking pleasure from goods. For the consumer, environmental and social concerns are not a personal duty, but the responsibility of businesses and government. Consumers are brand-conscious and only seek out goods from trusted retailers or businesses at any cost.

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Innovation and adoption of technology

Definition: “Innovation and adoption of technology” describes potential opportunities and risks presented by technological development, and the adoption of new technology by the food and feed industry for production, preparation and distribution of food goods.

- **Crucial Facts:** Technological evolution and a rapid innovation rate have changed the way food is produced, transported, processed and distributed. This has contributed to a transition from locally produced goods to the internationalisation of markets. It is expected that technological development will be able to alleviate some of the pressures associated with the need to increase production output. However, there is on-going debate on the benefits and risks associated with new technologies, with the current EU regulatory system prohibiting the use of some technologies (e.g. GM products and some pesticides). Cost is a significant factor in the level of investment in technological development and its adoption because of restrictions imposed by the short- and long-term profitability of new technology.

To be considered for 2015:

- An increasing investment in agricultural research by developing countries (led by China) comparative to developed countries^{1,2}.
- The Sustainable Agriculture and Food Innovation Platform co-funded by Defra and BBSRC with up to £90M investment over 5 years³.
- The UK is recognised internationally for its research in agriculture and food, including climate change, aquaculture, food safety, nutrition and international development^{3,5}.

To be considered for 2035:

- Achieving the world caloric needs for 2030 will result in a continued requirement for support for agricultural research and use of technology for food production^{4,5}.

Projections:

1) Limited investment and adoption of new technology

Economic constraints and financing conditions limits the opportunities for investing in new tech without foreseeable short-term gains, such as supply chain and information sharing technology. The government does not intervene and investment in agricultural and food technology is reduced. Slow uptake of new technology is supported by a sceptical public that is wary of the potential negative effects of new tech in food goods. The political body is influenced by the public’s perception of technology contributing to restrictive EU regulation, where a risk-averse research and development culture, constricts the development and uptake of new technologies.

2) Sourcing technology from foreign suppliers

Emerging economies become equal partners in a global food chain, investing in research and development to gain a competitive advantage. This results in high-levels of investment in research and development, and the growth of new technology (e.g. GMOs and new compounds for pest control) mainly overseas. Economic and financial conditions in developed countries prohibits investment in new technology that does not ensure short-term benefits, thus companies opt for importing new technology and patents. Overall there is an increase in technological development, especially in

controlling sources and transmission of information for controls and forecasts across the whole of the food chain.

3) The UK at the forefront of research and development activities

The corporate interest and role of developed countries in investing in food production in developing countries mean that this market will continue to influence global food networks. The UK government sustains investments in research and development driving innovation and adoption of technology in the production, distribution and monitoring of food goods. The UK becomes a leader in the field of food research and technology, and exports are regarded as a lucrative investment. Change in public opinion increases with wider acceptance of new technology, contributing to less restrictive regulation.

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Information and communications technology

Definition: “Information and communications technology” (ICT) describes the role and impact of technology in providing information and access to the products from the food chain, and in engaging communities in the debate and support of food related issues (e.g. health, source, trading policy, sustainability, green economy).

- **Crucial Facts:** ICT innovations made information available at any time and in large amounts, resulting in increasing transparency across the food production chain. However, where private interests lie in not sharing information, companies will oppose its publication, as observed in a shift from publication to patenting of new ideas^{1,2}. Integrated information systems provide information for farmers on weather, soil, fertiliser, disease, pest, and crop variety, and support crop management (e.g. irrigation and application of fertiliser), contributing to yield increases and a reduction in environmental impacts. Communications technology allowed for maximising transmission of information across the food chain, increasing the quality control of suppliers. However, whilst this is possible at a national level it remains a challenge for the international food chain. A continually increasing amount of information has created concerns over “information overload” or “infobesity”. Infobesity challenges the capacity to analyse all available information and may lead to an incapacity to act based on an overload of contradicting information.

To be considered for 2015/2035:

- From 1980 to 2004 continuing knowledge for research has shifted from journal publication to patents³.
- 60% of products entering the food service supply chain do not have a globally recognised unique item identifier assigned by the manufacturer⁴.
- Modern information and communications technology offers vast scope for improving the quantity, quality and accessibility of information available about the global food system⁵.

Projections:**1) Free information is used by industry, but not the public**

The globalisation of food systems and increased availability of information makes it readily available across the whole of the food chain (stock levels, techniques used, conditions at source and technological development and patents). This information is used to support farming, trade and management of the food chain (demand forecast and source management). Industry widely shares information with the general public. However, this presents an overwhelming tsunami of information (infobesity), causing an inability to engage and respond. Consumption choices are made with less information as the public is unable to determine which are trusted sources and are unsure where to access reliable information.

2) Free information is used by industry and public

The globalisation of food systems and increased availability of information makes it readily available across the whole of the food chain (stock levels, techniques used, conditions at source and technological development and patents). This information is used to support farming, trade and management of food chains (e.g. demand forecast

and source management). Industry widely shares information with the general public with multiple sources of varying credibility available; the general population relies on trusted groups and organisations to sort information (e.g. expert blogs and media companies). The population is informed and purchasing decisions made in accordance with information provided by info-management parties.

3) Industry uses information and tailors industry/consumer interactions

The globalisation of food systems develops on the back of corporative investment. Information is available across the whole of the food chain (e.g. stock levels, techniques used, conditions at source and technological development and patents), but is owned mainly by the industry. There is information widely available to the population who do not seek it proactively and follow the advice provided through trusted relationships between suppliers, consumers and government, which are used to 'nudge' consumer behaviour. Technology for the public is associated with creating a consumer experience and maintaining consumer loyalty.

4) Technology has less significant role due to a lack of information

The geopolitical situation constrains the exchange of information, and governments and industry strategically protect information to gain competitive advantage. Available information to support farming, trade and management of food chains (demand forecast and source management) is limited, making producers and distributors invest in domestic sources and markets. Information is not available to the public, undermining the potential of knowledge sharing tools (e.g. internet and social media). The lack in transparency impacts on consumer trust and choices, which are based on limited information and speculation, creating a culture that is risk averse and suspicious of foreign products and technological improvements.

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EU legislation

Definition: “EU legislation” relates to the future role of the European Union as a representative of its members in global trade and as a provider of laws, directives and agreements that drive and influence policies regulating production, processing and distribution of food goods, and also in defining the responsibilities regarding the effects of food production to human health, ecosystems and economic growth.

- **Crucial Facts:** The EU is the central body, defining and reforming regulations, subsidies and guidelines (e.g. Common Agricultural Policy (CAP)) applied by member states, providing representation in settling trading disputes^{1,2,3,4}. The Eurozone debt crisis generated uncertainty in the role of the EU as an influence in global policy and as a central regulatory body for its members. The medium-term impacts of the debt crisis will play a major part in the future of the EU². EU has filed 85 and responded to 70 disputes in representation of its members from 1995 to 2011⁴, a role with increased significance considering the increasing participation of developing countries in the WTO dispute settlement mechanism³. Regulatory reforms, such as CAP reform, aim for a more dynamic, competitive, and effective agriculture sector able to respond to Europe 2020⁸.

To be considered for 2015/2035:

- EU will continue to play a role of world actor/model/leader on the global stage. Its power in defining global rules and to actively engage in dealing with global challenges depends on member's investment in a United Europe^{3,5}.
- The “euro crisis” will have faded away in the mind of most Europeans by 2030, however its immediate and medium-term impact on European growth and competitiveness represents a turning point in European integration^{3,5}.
- The EU will reform its market management instruments by 2013, with commodities such as milk, sugar and the planting of vines suffering elimination of supply controls¹.

Projections:

1) Compromise model

The UK accepts, albeit with frequent disputes and tensions, the EU as the central governing body for policy and regulatory developments responsible for implementing existing controls, and for issuing penalties for non-compliance. There is limited buy in to the idea of centrally regulated Europe, which creates tensions and manipulation of EU policy for gaining economic and political advantages. Political motivation influences policy development, which is reactionary to adverse events, lacking foresight and is slow to take up new and existing policies. There is a lack of trust in EU's capacity to ensure all members enforce food safety and fraud controls of similar quality and effectiveness.

2) EU legislation with a world market focus

The record of the existing food safety and anti-fraud controls supports a climate of trust amongst trading partners (EU members and developing countries). International trade regulation organisations, such as the WTO, gain influence in providing a regulatory service, gradually replacing the EU in the role of a legislative body. Industry (e.g. transnational organisations) participates and is influential on the policy development

process. EU regulation and standards for food production and distribution are replaced by international regulation such as Codex Alimentarius. The EU, including the UK, invests in sustaining and developing an international regulatory body.

3) A greater EU

Tensions and an increase in protectionist measures are associated with world trade, which highlights the benefits of ensuring an open EU market is available. There is uncertainty concerning the EU's capacity to ensure all members enforce food safety and fraud controls of similar quality and effectiveness. EU based industry are drivers in maintaining and sustaining an open and well-regulated Europe, participating actively in policy development exercises. The EU expands in size (e.g. Turkey and Ukraine) and increases its influence as a regulatory body.

4) World market without EU

The UK is no longer part of the EU and relies on contract law alongside international trade regulation organisations such as the WTO to provide a regulatory and dispute service for world trade. The UK invests in sustaining and developing an international regulatory body and UK industry (e.g. transnational organisations) participates and is influential on the policy development process. Food production and distribution is regulated by UK law in line with international standards such as Codex Alimentarius.

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Nature of the regulatory environment

Definition: “Nature of the regulatory environment” describes the approaches to and attitudes towards policy development and implementation on food issues, including the approach to risk in regulation and the effect of disputes and of litigation in the development and implementation of policies and controls.

- **Crucial Facts:** The guidelines associated with authorisation of practices and products by the food industry are mandated by European guidelines. These guidelines and approach to determine what is and is not allowed, shape the future of the food and feed system^{1,3,5}. Food regulation resulting from a process that starts with a hazard characteristic assessment considers the likely application of the product (its use and quantity). Current debate focuses on the pros and cons of a hazard or a risk based approach to develop regulation and to provide an appropriate level of protection without being either overly restrictive or overly precautionary^{1,4}. An alternative to regulation such as self-regulation or co-regulation may be part of a future system of controls⁶. This provides a regulatory challenge to understand the role of government in setting and enforcing food standards².

To be considered for 2015/ 2035:

- The Red Tape challenge aims to reduce unnecessary burdens of data reporting, handling and storage for both the operator and regulator, by allowing companies to use data portals to provide direct access to their environmental compliance data (2016)^{4,6}.
- The FSA outcomes for 2010-2015 include ensuring regulation is effective, risk-based and proportionate⁵.

Projections:

1) High levels of regulation

The European and UK regulatory process favours high levels of regulation and is risk adverse and restrictive to the industry's movement towards self-regulation, providing guidelines to regulate it. The regulatory process encompasses a combination of hazards and risk assessment studies, and decisions on prohibition and acceptability, relying mainly on hazard characterisation of new products (technological or chemical) and disregards use in normal and controlled conditions. The process is influenced by political motivations possibly resulting from a lack of trust from politicians of the scientific work developed by EU agencies, thus relegating scientific evidence to play a secondary role in informing decisions.

2) Medium levels of regulation

The European and UK regulatory process acts in partnership with the industry, developing a process of co-regulation, though also allows for self-regulation within the industry. The regulatory process is more open to the use of new products (e.g. GMOs and new compounds for pest control). Political and economic motivations have some influence in the regulatory process; however, political initiatives such as the better regulation agenda, support decision-making that considers risk/regulation trade-offs with support from data and existing assessments.

3) Low levels of regulation

The European and UK regulatory process has a reduced role in the regulation of the food and feed system, which relies on the industries' capacity to self-regulate. Politically motivated initiatives such as the 'red tape challenge' lead to increasing deregulation, where the pro-growth and pro-innovation agenda is promoted to mitigate further change and to free-up industry sectors (i.e. SME) from regulatory burden. Decisions on prohibition and acceptability are based on scientific evidence, but can be influenced by industry and political pressures leading to more permissive approaches. Government plays an overarching role in defining practices and benchmark criteria for licencing and certification.

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Climate change

Definition: “Climate change” describes the UK’s capacity to assess vulnerability and adapt to and prepare for the challenges and opportunities presented by new climatic conditions. Response mechanisms, including both adaptation and mitigation, are crucial for managing the consequences of climate change, including more frequent weather extremes (e.g. floods and droughts), as well as dealing with new and emerging plant and animal diseases.

- **Crucial Facts:** Changing climate conditions presents not only challenges, but also opportunities to maintain and increase food production levels. The food system makes a significant contribution to emissions of greenhouse gases and will be impacted by measures to reduce these. It is also accepted that with changing climatic conditions there is a need to assess areas of vulnerability to identify appropriate response mechanisms^{2,4,5}. This may include adapting current agricultural practices, through crop selection and production type, to prevent losses and/or maximise productivity. Success depends on the capacity to manage a new range of effects resulting from climate extremes (floods and droughts) and managing the change in ecological composition (invasive species and emerging diseases)^{4,5}. Current studies focus on evaluating how significant that change will be and the size of the impact to policy and industries associated with food production, food processing and distribution. Whilst mitigation or adaptation is feasible, uncertainty on the severity of climate change is key to nature of decisions taken^{1,2,3}.

To be considered for 2015:

- Global- and national-scale studies suggest climate change will increase the frequency of droughts and water stress for some parts of the UK^{1,2}.
- Several European-scale and national-scale assessments suggest an increase in the flood risk associated with climate change in the UK².

To be considered for 2035:

- Simulations by the AVOID programme project in the UK suggests a moderate increase in water stress associated with climate change, though the extent is uncertain prior to 2100.
- Global-scale and regional-scale assessments suggest that by 2080 the UK could experience coastal flooding from sea level rise, possibly affecting 1 million people annually if adaptation measures are not implemented².

Projections:

1) Mild to modest impacts from climate change

Changes in climate conditions are mild and have modest effects on the food and feed system. A slower rate of climate change allows producers to protect crops from climate change impacts (including extreme weather events), and conventional import and distribution routes do not suffer significant disruptions. Technological developments and the implementation of an efficient strategy to manage resources, successfully overcomes resource stresses, e.g. water shortages and the increasing prices of raw materials. Mitigation is not a priority as the effects of CC are mild resulting in the

measures implemented not having any significant impact on the configuration of the food and feed system.

2) Gradual increase in impacts from climate change

The effects of climate change (CC) develop gradually, impacting the feed and food system, but allowing for and accompanied by planned, progressive adaptation. The food and feed system is capable of adapting and profiting from new emerging conditions. Planned with foresight the implementation of mitigation and adaptation measures allows farmers to adapt farming techniques to the new agricultural conditions and invest in infrastructural developments to manage the consequences of extreme weather events. Gradual increase in the effects of CC promotes progressive implementation of mitigation strategies, which responds to the severity of climate change. This in return has a progressive impact on measures taken within the feed and food system (e.g. livestock vs. crops).

3) Proactive response to significant climate change

Rapid climate change drives a precautionary agenda, involving both adaptation and mitigation measures, which leads to significant changes in the food and feed system. Implementation of policy and management solutions is planned with foresight. Reducing the rate of climate change remains the main objective, where reduction of GHG emissions drives change through the whole of the food and feed chain from production to distribution. Technological development and policies focus on environmental protection (e.g. to protect crops, conserve water and maintain a good ecological status).

4) Reactive adaptation to volatile climate change

The extreme rate of change in climatic conditions significantly impacts on food and feed production capacity. All available resources are diverted to maintain agricultural production levels and to manage the consequences of increasingly frequent extreme weather events. There are limited opportunities to invest and implement mitigation measures as all resources are allocated for adaptation. Technological development focuses on protecting crop yield and water reserves.

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Price and availability of resources

Definition: "Price and availability of resources (such as water and energy)" describes development in the price of resources used in the production, processing and distribution of food products. Resources include water, land (soil quality), raw materials, fertiliser, energy, technology, and ecosystems services. The accessibility of resources and sufficiency of use are also considered.

- **Crucial Facts:** The system of governance (growth or sustainability-led), rate of development, use of technology and life-style changes are shaping how resources are managed. Population growth, economic development and climate change are driving demands for food, water, energy and raw materials^{1,2}. Studies show the expansion of cropland may decline due to soil degradation and expansion of other sectors on fertile agricultural land². Other challenges relate to prices for nitrogen, phosphorus and potassium fertilisers that are increasing far more than world grain prices. The availability of water is decreasing with continued growth in domestic and industrial water consumption; droughts brought on by climate change will potentially increase the level of crop irrigation; and prices for fossil fuels are likely to increase the cost of energy². Global food security now depends to a large extent on fertilisers and fossil fuels. Evolution in the price of resources for food production depends greatly on managing capacity and on a global effort for fair trade, competition and access.

To be considered for 2015:

- Approximately 20,000–50,000 km² of productive land globally are lost annually through land degradation, mainly due to soil erosion^{3,7,8}.
- Asia's share of global nitrogen consumption was 62% in 2010 with China representing more than half of that share⁴.
- Forecasts suggest nitrogen fertiliser demand will grow at 1.9% annually through to 2015. A growth rate of 2.4% a year is estimated for phosphate and 3.7% for potassium⁴.
- Proportional increases in international fertiliser prices over 2008-2009 have been higher than price increases for food commodities⁴.

To be considered for 2035:

- Food production is estimated to rise by 70% between 2005/2050 to meet the demands of an increasing population^{5,6}.
- By 2035, 1 in 3 people will be living in water stressed areas. There will be significant pressures on water available for domestic and industrial use and for food production⁹.
- To meet higher demands for fertiliser, production may need increase by between 50% and 100% by 2050⁶.
- Globally the land required for agricultural production may increase by 165 million ha in 2050, though 70% of land conversion will occur in Africa and South America¹⁰.

- Overfishing may lead to the collapse of commercial fisheries and seafood industries by 2048¹¹.
- Demand for energy will increase to approximately 50% by 2030. Fossil based fuels will remain a key source of energy though sold at a much higher price^{12,13}.

Projections:

1) Volatility of markets limits access and increases prices

Resources to produce food are limited/unavailable, causing volatility in price and availability, incentivising unfair competition, and possibly tensions and conflicts for control of resources. These tensions further compromise transparency in stocks aggravating resource management. Yield production levels stabilise after adjustment to working with limited resource, where technology plays a key role. Controlling resources is a lucrative strategy, leading to an international resource grab dynamic (e.g. prime land, water rights, energy reserves), where trade dynamics are based on who controls and who can pay, excluding some poorer populations, sectors or countries.

2) Market agreements lead to stable access and prices

The food and feed system is able to manage efficiently, access to and use of finite resources for food production and distribution (e.g. prime land, water rights, energy reserves, fertilisers). Organisations responsible for regulating international trade (WTO and EU) successfully protect resource availability, and implement the tools and mechanisms to manage and avoid price volatility. This results in stable prices and resource availability as well as access to acceptable alternatives. There is an increasing effort to minimise losses (e.g. using maize and sugar surpluses to produce energy).

3) Government intervention regulates access and prices

Governments play a key role in managing and regulating access and use of national resources for food production and distribution. Active intervention to manage the flow of resources includes food production guidelines (selection of products that fit the local and national resource availability). International trade is used as a tool to save resources (e.g. water savings through international trade of food goods). The food and feed system has to cope with controls imposed nationally and internationally. Resources (e.g. prime land, water rights, energy reserves, fertilisers) are used as a key tool to gain political advantage and leverage.

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Appendix D: List of Acronyms

Acronym	Term
BBSRC	Biotechnology and Biological Sciences Research Council
BRIC	Brazil, Russia, India, China
BSE	Bovine Spongiform Encephalopathy
CAP	Common Agricultural Policy
CC	Climate Change
IEHRF	Institute for Environment, Health, Risk and Futures
DEFRA	Department for Environment, Food and Rural Affairs
Doha	Doha Development Agenda
EC	European Commission
EU	European Union
FAO	Food and Agriculture Organisation
FSA	Food Standards Agency
GAP	Good Agricultural Practices
GATT	General Agreement on Tariffs and Trade
GDP	Gross Domestic Product
GHG	Greenhouse Gases
GM	Genetically Modified
GMO	Genetically Modified Organisms
GMP	Good Manufacturing Practice
HACCP	Hazard Analysis and Critical Control Points
ICT	Information Communications Technology
ICTSD	International Centre for Trade and Sustainable Development
IDG	Institute of Grocery Distribution
IFS	Institute for Fiscal Studies
IFT	Institute of Food Technologists
IMF	International Monetary Fund
KF	Key Factor
Mercosur/Mercosul	Mercado Común del Sur/Mercado Comum do Sul English: Southern Common Market
NAFTA	North American Free Trade Agreement
ONS	Office for National Statistics
PARTA	Pacific Regional Trade Agreement
PESTLE	Political, Economic, Social, Technological, Legislative, Environmental
PwC	PricewaterhouseCoopers
QA	Quality Assurance
RFID	Radio Frequency Identification Technology
SMEs	Small-to-Medium Enterprises
WB	World Bank
WBCSD	World Business Council for Sustainable Development
WTO	World Trade Organisation

Appendix E: Report sign-off

Cranfield University

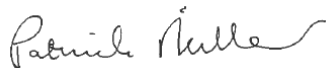


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