SCENARIOS REPORT

The Role of the UK Food System in Meeting Global Agreements:

Potential Scenarios

Global Food Security

Sustainable, healthy food for all

Contents

This report is based on the outputs of a cross-stakeholder scenarios exercise run by the Global Food Security programme (GFS). *The Role of the UK Food System in Meeting Global Agreements: Potential Scenarios* follows on from GFS's earlier work on Paris-compliant healthy food systems, which produced a GFS Workshop Report and Insight Report. The scenarios are supported by evidence that is presented in the sub-report *The Role of the UK Food System in Meeting Global Agreements: Supporting Evidence.*

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Scenarios team
The multidisciplinary team of experts who developed the four food system scenarios (in alphabetical order):
Tim G. Benton (Chatham House)
Pete Falloon (Met Office)
Aled Jones (Anglia Ruskin University)
Laura Wellesley (Chatham House)

See appendix for attendees of the taskforce workshops and contributors to the report.
This project was led by Maia Elliott on behalf of the Global Food Security programme.

The electronic version of this report can be found at:
www.foodsecurity.ac.uk/publications/UK-food-system-scenarios-report.pdf

Foreword

Dr Lawrence Haddad
Executive Director of the Global Alliance for Improved Nutrition (GAIN), 2018 World Food Prize laureate, and Chair of the 2021 UN Food Systems Summit's Action Track 1: ensuring access to safe and nutritious food for all.

Scenarios exercises do not predict the future, but they do get us ready for it. They help us think about the uncertainties that we are facing, plan for them, respond to them, and perhaps even shape them. This is particularly important for the food system, as its complex and multi-faceted nature often obscures the opportunities and risks that we may encounter in the future. This high quality scenarios exercise illuminates many of them, which is why I cannot overstate the value of this report for food system stakeholders.

During this time of COVID-19 (a term that had not yet entered the lexicon when this report was initiated) all efforts to help us build and flex our foresight muscles are to be welcomed. The food system is having to operate at increasing levels of uncertainty, and the global pandemic is likely to continue revealing the vulnerabilities of our food system in the months and years to come.

However, there are also other pressing threats to the food system that warrant immediate action, like climate change, political instability and biodiversity loss. These scenarios are designed to aid decision making in just such high-pressure situations, where action to protect people and planet cannot be delayed.

As a UK citizen, I particularly admire this work because it acknowledges that 'change starts at home'. Food systems do not solely exist 'over there' – they exist on our own doorstep, wherever we are. No country has a monopoly on food system dysfunction and no country has a monopoly on the solutions. Therefore, the approaches and solutions developed as a result of this report will not only help UK policymakers and business leaders in England, Scotland, Wales and Northern Ireland, but also in the Netherlands, Nigeria, Nepal, Nicaragua and New Zealand.

The upcoming UN Food System Summit 2021 serves to remind us that transforming the food system is at the heart of the Sustainable Development Goals. Without radical food system change, we can be sure that we will not meet our global targets on hunger, malnutrition, health, climate, and livelihoods, as well as sustainable production and consumption. That is why it is imperative that such food system transformation happens soon. This report gives us the inspiration, the guidance and the vision to transform the UK food system before it is too late.

Executive Summary

In 2015, the United Nations (UN) launched two landmark global agreements: the Paris Agreement and the Sustainable Development Goals. The Paris Agreement is an international commitment to accelerate and intensify climate mitigation efforts, with the aim of keeping global warming below 2˚C above preindustrial temperatures. The Sustainable Development Goals (SDGs) are a universal call to action to end poverty, protect the planet and ensure that all people enjoy peace and prosperity. The global food system is at the heart of both these global agreements, as it currently accounts for a third of global greenhouse gas (GHG) emissions, and all 17 of the SDGs are directly or indirectly connected to the food system.

Recognising that change starts at home, the Global Food Security programme conducted a scenarios exercise with experts from across research, industry and government, to explore how the UK food system could be transformed to help meet these global agreements. Four scenarios were developed based on the selection of two critical uncertainties that are expected to drive unforeseeable changes to the UK food system in the coming years:

1 Will the UK food system be more localised or more globalised by 2050?

2 What would the UK food system look like if it were transformed to focus on climate mitigation (i.e. the Paris Agreement) or wider metrics of sustainability (i.e. the SDGs)?

The exercise produced four unique scenarios, however there were some commonalities across all future food systems. In every scenario, climate change contributed directly or indirectly to higher costs in the food system, and the elimination of food waste and shift towards plant-based diets were key to achieving the global agreements. The scenarios also indicated that both greater self-sufficiency and multilateral cooperation are capable of protecting the UK food system against future climate disruption, and that a sole focus on climate mitigation in the food system could undermine biodiversity, human health and economic equality.

Based on the scenario analysis, this report presents five key messages for transforming the UK food system to meet its global agreements:

1 **Meeting global agreements on climate mitigation and sustainable development requires the radical transformation of the current food system.**

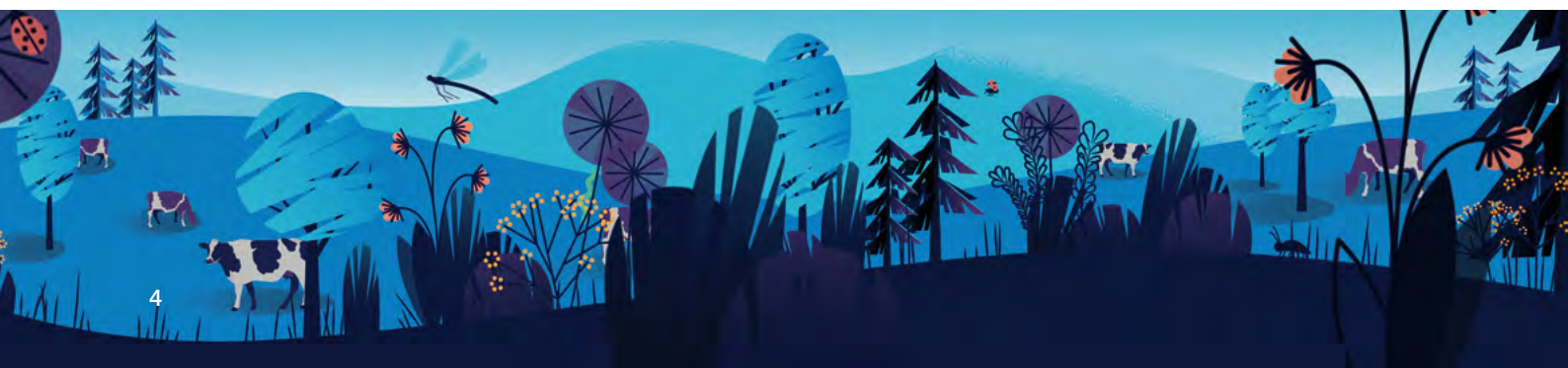
2 **Future food systems must deliver against wider metrics of sustainability alongside ambitious climate mitigation.**

3 **Transforming the food system to meet global agreements requires the development and implementation of a range of systems approaches and systemic technologies.**

4 **Strategies to meet global agreements will vary greatly depending on a country's reliance on global trade.**

5 **Radical action must be taken today to ensure future food security.**

The scenarios in this report do not aim to predict what will happen in the future, nor do they suggest what the preferred future might be. They are designed to stimulate thought, identify opportunities and threats that the UK food system may face in the future, and aid long-term decision-making.



In every scenario, climate change contributed directly or indirectly to higher costs in the food system

Introduction

The global food security challenge

The concept of global food security, where all people have physical, social and economic access to sufficient safe, nutritious, and sustainably-produced food that meets their dietary needs and preferences, is not beyond our capabilities in the modern world. It is increasingly clear that we have the resources, knowledge and technology to feed a global population in a way that is not only sustainable, but regenerative for human- and planetary health.

Yet significant challenges remain. The first, and arguably foremost, challenge is the climate crisis, which the global food system currently contributes to by producing a third of global greenhouse gas (GHG) emissions[1]. Climate change is already increasing the incidence and severity of extreme weather events, as well as long-term and gradual climate risks such as rising sea levels and accelerated glacial melt. These factors will impact food availability, food access, food utilization and food stability on a global scale.

Another challenge is deteriorating public health. Despite our ever-increasing scientific knowledge of the impacts of diet on human health, malnutrition is now the leading cause of early deaths globally[2]. Although malnutrition remains the result of insufficient food in many parts of the world, malnutrition is increasingly found in the form of 'hidden hunger' (micronutrient deficiencies), as well as overweight and obesity through the overconsumption of calorie-dense foods. The health and societal impacts of malnourishment are being felt worldwide, with more than half of the global population now underweight, overweight or obese[3,4]. Transforming global health will require changing consumer behaviour, food production and food environments, through building food literacy and improving access to healthy, sustainable and culturally-appropriate foods.

Poor public health is a symptom of the socio-economic factors affecting food security. The inequitable distribution of resources, the imbalance of power across the global food supply chain, business models that put profit above public health and sustainability, and growing numbers of households that cannot afford to pay the true cost of food, all present significant challenges to transforming the global food system.

Fortunately, our food system is highly dynamic and sensitive to change, allowing it to transform rapidly under new conditions. However, this adaptability does not necessarily translate into desirable outcomes in the short-term. Therefore, putting people and planet at the heart of the global food system will require long-term thinking, investment in schemes without immediate payback, and the willingness to disrupt business-as-usual.

Global agreements

The call for long-term decision making and the radical transformation of the man-made systems that support human life extends far beyond the food system. This was recognised in 2015, when the United Nations (UN) announced two landmark global agreements that aim to facilitate the transition towards a better future for people and the planet: the Paris Agreement and the Sustainable Developments Goals.

Fortunately, our food system is highly dynamic and sensitive to change, allowing it to transform rapidly under new conditions.

The Paris Agreement

The Paris Agreement aims to accelerate and intensify the actions and investments required to combat climate change. The overarching goal of this treaty is to keep global warming below 2˚C above pre-industrial temperatures, with the aim to limit global warming to 1.5˚C[5].

It is evident that the global food system plays a key role in meeting the Paris Agreement, with 90 % of participating countries' 'Nationally Determined Contributions' involving agricultural practices[6]. Transforming food systems is key to addressing climate change for two reasons: Firstly, the food sector produces almost a third of global greenhouse gas (GHG) emissions[7] and accounts for approximately 30 % of global energy consumption[8]. Thus, energy-smart food systems are imperative in the transition towards a carbon-neutral future.

Secondly, food systems are profoundly impacted by climate change. Rising temperatures and increased frequency and severity of extreme weather are rapidly affecting food production, and increasing atmospheric CO_2 concentrations are lowering the zinc, protein and iron content in staple food crops[9]. Elevated sea levels and natural hazards are leading to the loss of agricultural land area and topsoil, and changing climates are allowing agricultural pests and diseases to spread across the globe. For these reasons, food systems will not only need to be transformed to mitigate the effects of the climate crisis, but also to adapt to them.

The Sustainable Development Goals

The second global agreement launched by the UN in 2015 was the Sustainable Development Goals (SDGs). These 17 SDGs are a universal call to action to end poverty, protect the planet and ensure that all people enjoy peace and prosperity[10]. Bold action on climate change is a key area of focus in the SDGs (SDG 13), but this agreement also looks at wider metrics of sustainability, such as education (SDG 4), gender equality (SDG 5), life on land and below water (SDGs 14 and 15), and peace and prosperity (SDG 16). Food systems are often associated with SDG 2 (Zero Hunger) and SDG 3 (Good Health and Wellbeing), however every single SDG can be linked to the global food security challenge either directly or indirectly (see Figure 1). The essential nature of food and the interconnectedness of our food systems make food an ideal starting point for addressing the SDGs.

The food system is an ideal starting point for addressing the SDGs.

Figure 1. The UN's 17 Sustainable Development Goals can all be linked to the food security challenge.

The UK food system

In the UK, our food system is a mix of global, national, and local supply chains. UK farmers produce 52 % of the food we eat, including 80 % of our eggs, meat, and dairy, as well as 62 % of our cereals. Only 23 % of the fruit and vegetables that we consume are currently grown in the UK. Although we import food from 186 countries across the globe, 90 % of the UK's food supply (by value) comes from just 24 countries. The EU supplies about a third of the UK's food, with the Netherlands (supplying 5.9 %), Spain (supplying 5.1 %) and France (supplying 3.3 %) as our top trading partners[11].

In 2019, the UK committed to going Net Zero by 2050, a reflection of growing pressure to decarbonise our society in order to tackle climate change[12]. However, the UK food system is already facing challenges due to changing trade relationships and significant inequality[13,14]. As with transforming the global food system, transforming the UK food system will require long-term thinking, the disruption of business-as-usual, and investment in schemes without immediate payback. These requirements are reflected in Part One of the National Food Strategy[15].

Although this report focuses on the UK food system, its place in the interconnected global food system means that the outcomes of the following scenarios exercise provide valuable insights into possible futures for all countries.

Only 23 % of the fruit and vegetables that we consume are currently grown in the UK

NATIONAL FOOD STRATEGY

Launched in 2019, the National Food Strategy (NFS) provides the first independent review of England's entire food system for 75 years. Besides aiming to ensure that the food system delivers safe, healthy, affordable food for everyone regardless of income or location, the NFS is also seeking to increase the resilience and sustainability of the agricultural sector by identifying ways of restoring and enhancing the natural environment and delivering economic benefits in both urban and rural areas. The government has committed to responding to the NFS with a white paper.

The scenarios exercise

This report details the outputs of a scenarios exercise run by the Global Food Security programme. Experts from research, industry and government explored what the UK food system might look like in the year 2050 if it was transformed to meet the UK's climate mitigation and wider sustainability targets, in a more globalised or more localised context. A large part of the analysis was a consideration of the potential drivers and unintended consequences of these food system changes.

THE VALUE OF SCENARIO EXERCISES

Scenario exercises do not aim to predict what will happen in the future, nor do they suggest what the preferred future might be. These scenarios have been designed to stimulate thought, to identify some of the opportunities and threats that the food system might face in the future, and to inform today's decisions.

Evidence-led speculation is a highly valuable tool for decision-makers addressing complex issues where uncertainty is inherent, especially in situations where decision-making can no longer be postponed in favour of gathering more evidence.

Critical uncertainties

The four scenarios were developed using the two axes method[16]. In a cross-stakeholder Global Food Security workshop which considered the various uncertainties that are expected to drive unforeseeable changes to the UK food system in the coming years, two critical uncertainties were selected to form the two axes in a scenario planning matrix (Figure 2):

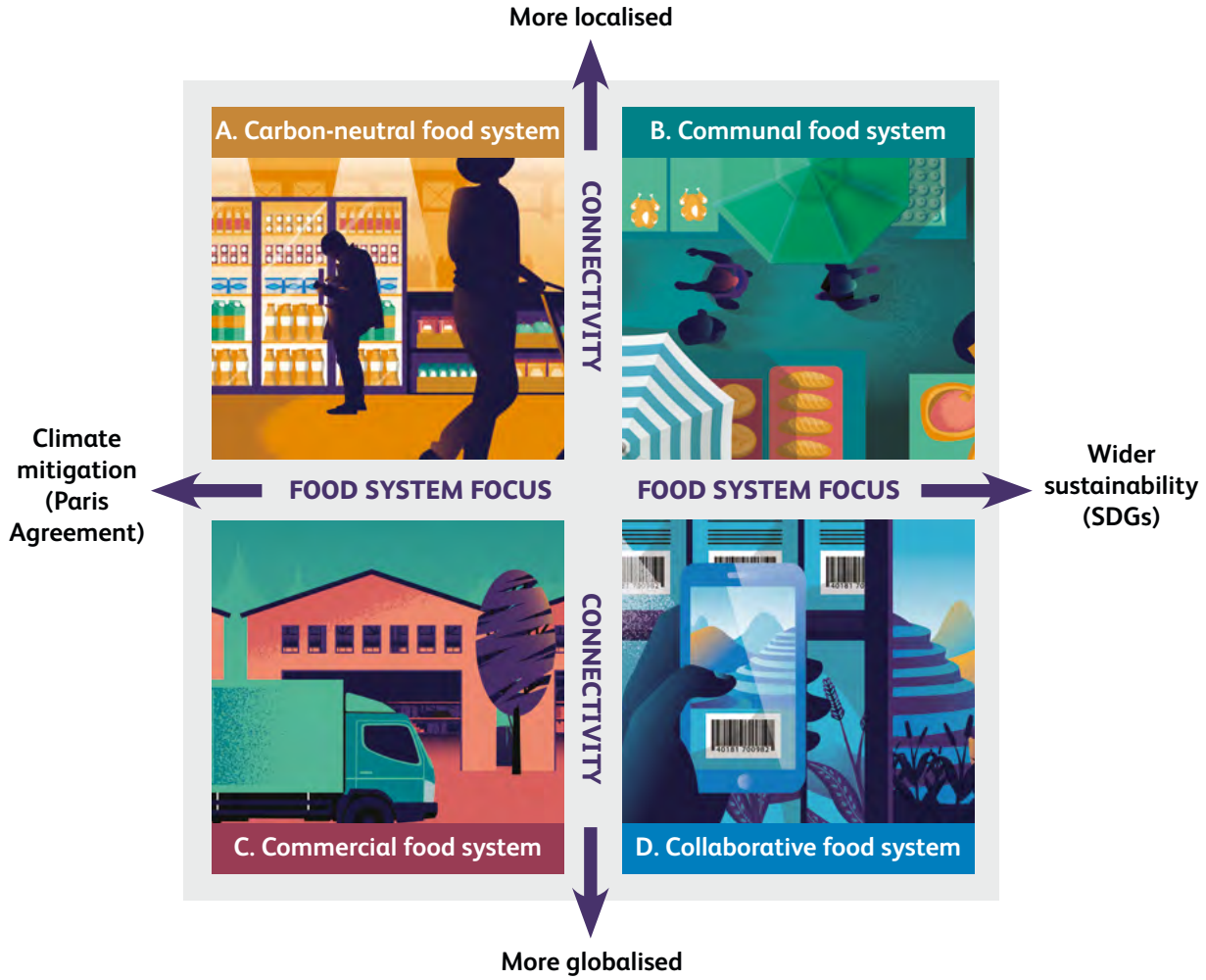
1 Will the UK food system be more localised or more globalised by 2050?

2 What would the UK food system look like if it were transformed to focus primarily on climate mitigation (i.e. the Paris Agreement) or wider metrics of sustainability (i.e. the SDGs)?

Food system connectivity

The vertical axis in Figure 2 is based on the first critical uncertainty, which questions the degree of food system connectivity in 2050. This uncertainty is underpinned by the recognition that the future we envisioned at the start of the 21st century differs greatly from the future we envision today. International rules-based cooperation had led to unprecedented periods of stability and global integration, and there was even discussion of a world without nation states[17]. However, the last 20 years has seen more extreme views, polarisation and inward-looking nationalism, driven by growing inequality, perceptions of immigration, the climate crisis, and now COVID-19[18]. We are radically and rapidly diverging from the future that we envisioned after the Second World War, and adapting to this new world is proving increasingly challenging.

Figure 2: Four future food system scenarios arising from two critical uncertainties. The scenarios explore the impacts of differing connectivity (more localisation or more globalisation) and differing food system foci (meeting the Paris agreement targets for climate mitigation or meeting the Sustainable Development Goals for wider sustainability).



Environmental and geopolitical factors are currently threatening the stability of local, regional and global societies and their governance, undermining the reliability of the global market[19]. This development could drive the UK to increase its resilience through building more regionalised supply chains. However, it could also act as a driver for the revitalisation of multilateral cooperation and continue the UK's trajectory towards globalisation. Therefore, this critical uncertainty was selected to form the first axis for the scenarios exercise.

Food system focus

The horizontal axis in Figure 2 is underpinned by growing evidence that failure to achieve the targets laid out in the Paris Agreement and the Sustainable Development Goals (SDGs) will escalate environmental costs, health costs, inequality, and social disruption in the UK[21]. The food system has the potential to mitigate these negative outcomes[19], so the assumption was made that the UK food system will be transformed to address these challenges in the near future.

However, the future will look very different depending on whether the UK food system is transformed to address the wider SDGs (e.g. biodiversity, health, equality, alongside bold climate action) or whether it focuses primarily on addressing the climate emergency (i.e. the Paris Agreement).

Building the narratives

After the two critical uncertainties had been selected, a multidisciplinary team was brought together to build the four narrative scenarios, considering the potential drivers of food system change in each scenario, and the impacts of these changes on public health, the economy, the environment, and society. Experts from across academia, industry and government attended a taskforce workshop to feedback on the scenarios (see *Appendix*). Their input was incorporated into the final report.

The scenarios team did not attempt to predict what the UK food system will look like in the future, however the scenarios did have to be plausible. Evidence supporting the plausibility of the events in these scenarios can be found in the sub-report *The Role of the UK Food System in Meeting Global Agreements: Supporting Evidence*[22].

Potential food system futures

Year 2050: the climate has changed significantly

In each of the four scenarios depicted in Figure 2, locked-in climate change is directly or indirectly impacting UK food production and key growing regions that supply the UK.

The average global surface temperature has risen by 1.5°C, accompanied by an increase in the frequency and intensity of extreme temperatures and precipitation. On average, the UK is experiencing milder, wetter winters and hotter, drier summers.

Although warmer temperatures boost the UK's winter wheat yields some years, the overall impact of climate change on the UK food system remains negative. The unusually hot summers that occurred once a decade between 1981 and 2000, are now occurring nearly every other year. The changes in climate are not steady, with the UK still experiencing occasional cold winters, dry winters, cool summers and wet summers. The variability makes it very challenging to adapt the food system to the changing climate.

Changing temperature and rainfall patterns have also aided the spread of pests and diseases to areas previously untouched, affecting livestock and crop production. Sea levels are rising, affecting the salinity of fresh water and soil, and every year valuable arable land is lost to flooding. Root vegetables are now much harder to grow in drier UK soils, however the changing climate has given the UK the potential to grow a wider range of crops on its arable land, such as sunflowers, grain maize, soya, fruits and vines.

SUPPORTING EVIDENCE

Evidence supporting the various elements that feature in the following four scenarios can be found under the corresponding headings in the sub-report *The Role of the UK Food System in Meeting Global Agreements: Supporting Evidence*[22]. For example, to find supporting evidence for an element described in section B.2 of this report, please browse the sections under heading B.2 in the supporting evidence report.

A The carbon-neutral food system

The first scenario describes a future in which the UK food system is more localised in 2050 than it was in 2020, and where climate mitigation has been the major driving force in transforming the food system.

A.1 The carbon-neutral food system scenario

It's the year 2050, and the UK food system is characterised by inward-looking policies, a strong push towards domestic food production and reducing food imports, and a commitment to lowering GHG emissions.

Food production is now dominated by ultra-efficient, large-scale, state-owned conventional farms, as well as aero- and hydroponic vertical farms. These megafarms produce a range of staple foods in bulk to supply the population's food needs and have adopted some climate-resilient food production systems to protect against extreme weather in the UK. Despite the expansion of the agricultural sector, ever-increasing mechanisation has steadily shrunk its workforce.

Some smaller-scale, high-end farms still exist, producing a small fraction of the UK's food supply using greenhouses and traditional farming methods. This has allowed the wealthiest in society to continue enjoying diverse diets that are rich in animal protein.

For most of the UK population, food choice in 2050 is lower than in 2020, as carbon pricing has made high-emission foods and home cooking less affordable for the average citizen. The typical diet consists of pre-cooked foods that have legumes or low levels of white meat as their main protein source, and are calorie-rich from our grain production. For the less affluent, food availability is limited and highly seasonal, as the cost of vertical farming has made these fresh foods prohibitively expensive.

The drive to reduce individual carbon footprints has also impacted other aspects of citizen behaviour, such as the elimination of household food waste and the preferential use of smart devices during periods of maximum solar input.

Food policy focuses almost solely on increasing UK self-sufficiency whilst reducing GHG emissions. However, these policies are disjointed across health, energy, the environment and land use planning, resulting in poor efficiency across the whole food system. Although methane-free cattle have since been engineered, beef production is very costly due to embedded emissions and the land required for feed production.

Both the state-owned and small-scale farms have successfully reduced their GHG emissions beyond the farm gate, but there are strong differences in the processing and retail parts of their food chain. The small-scale farms process and distribute their produce directly within a small local radius, while the large, state-owned farms processing and retail operations are highly centralised, with ultra-efficient, zero-emission machinery and transport that distributes their produce in bulk through a large number of smaller, standardised food hubs and supermarkets.

Food prices are high, as climate-smart food system tech and imports are increasingly expensive. During times of shortage the poor are strongly affected, with food bank usage commonplace.

A.2 Impacts of carbon-neutral food system

POPULATION HEALTH

While the rich have continued to enjoy varied, high-quality diets, the poorer citizens have faced a reduction in dietary diversity and nutritional balance, widening the health gap. The vast megafarms have impacted the wellbeing of the less-affluent by drastically changing the UK's rural landscape, removing affordable and easy access to nature-based recreation. The rich are still able to enjoy the pastoral tranquillity surrounding the pockets of small-scale farms, where they experience greater psychological wellbeing. Those who have access and can afford it make greater use of allotments, with positive effects on mental and physical health.

ENVIRONMENT

Deep emissions cuts across the food system required carbon rationing and reducing the use of agrochemicals, resulting in overall lower productivity per unit land area. Despite the reduction in livestock farming, the need to produce more food domestically, coupled with increased need for renewable energy farms and the production of bioenergy crops with carbon capture and storage (BECCS), has led to conflicts for land.

The focus on emissions cuts has resulted in the neglect of broader environmental issues in agriculture, leading to the extensive loss of woodland and biodiversity. However, the demand to produce a greater variety of foods domestically has promoted crop rotations, improving soil health, and measures to reduce GHG emissions have improved in air and water quality. The growth of aquaculture has reduced large-scale marine fishing, allowing national marine biodiversity to recover.

ECONOMY

The UK's commitment to net zero emissions by 2050 and the transformative agricultural policy it introduced in the 20's catalysed emerging markets for low carbon technologies and mechanisation across the food system (e.g. precision agriculture, robotics, decarbonised transport). Advanced tools for food traceability and personalised carbon footprint tracking have since been implemented, leading to greater transparency.

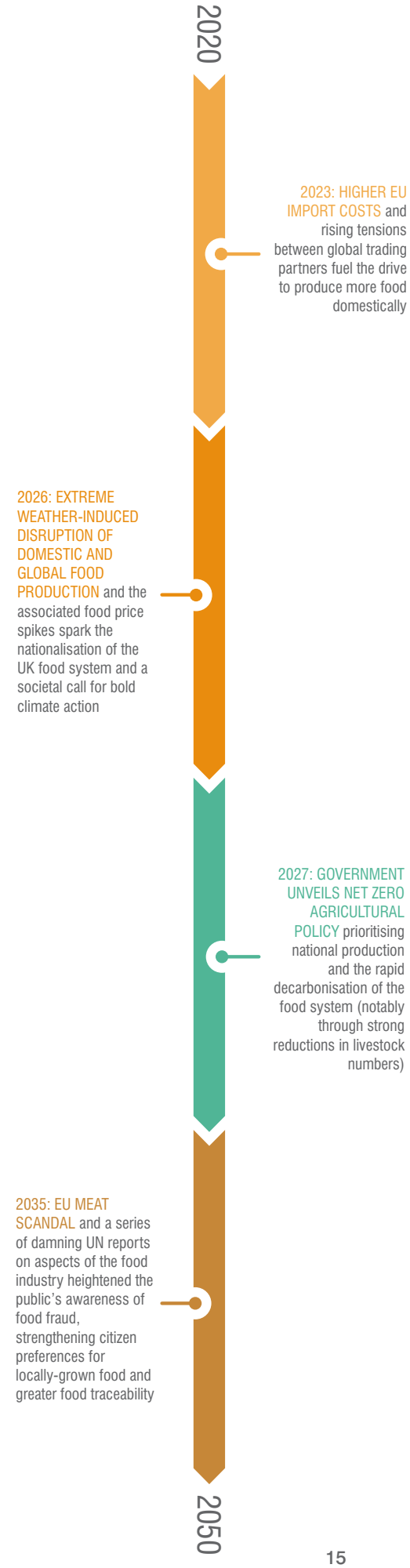
These technological advances have given rise to a food system workforce specialising in robotics, nutrition and bio-fortification, ultra-processing, renewable energy generation, and BECCS. New land management skills were required to overcome the initial barriers to achieving the marked land use transitions, such as investment and financial support, the provision of information on the costs of low carbon farming, and consideration of land ownership issues.

SOCIETY

The divide between rural and urban areas has been exacerbated by the changing face of agricultural production, which has undermined traditional rural communities and reduced the agricultural workforce. Small, traditional farms and the livestock sector have gone under, while large-scale modern farms, vertical farming and aquaculture enterprises have flourished.

Growing polarisation in diet and wellbeing has increased social tension and resentment between rich and poor. Carbon rationing is implemented via personal carbon trading (as individual per-capita emissions credits, alongside parallel schemes for industry), however this scheme coupled with the growing sense of unfairness has fuelled civil unrest.

A.3 Key events that shaped the carbon-neutral food system



B The communal food system

This scenario describes a future in which the UK food system is more localised in 2050 than it was in 2020, and where wider sustainability has been the major driving force in building this food system.

B.1 The communal food system scenario

Following the political instability and climate disruption of the twenties, the UK has been forced to reduce its reliance on international trade, and by 2050 the national food system is characterised by a local-production-for-local-consumption ethos. Although the UK has not entirely retreated from international trade, the former faith that the global market can solve complex challenges such as climate change without state intervention has since been abandoned.

Measures to reduce wealth accumulation by the richest have redistributed the UK's land and wealth amongst the population, increasing livelihoods and quality of life. Local production systems have diversified, with more complex rotations and smarter land use, allowing more food to be grown locally and reducing the UK's reliance on exports and imports. Farm sizes are polarised, with some large-scale farms providing generic commodities, and a wider range of smaller-scale farms producing the rest.

Local markets are now at the centre of the UK food system, reviving the UK's forgotten foods, seasonal eating and creative ways to utilise food excess. The drive to grow more of the nation's food supply domestically has decreased the availability of many types fruit and vegetables that were once considered staple foods, as well as the amount of food produced per capita. However, public understanding of the value of food production and natural resources has increased, stimulating the drive towards a low-waste, communal economy. "Waste not, want not" is the national catch-phrase.

Food prices are higher than they were thirty years ago due to the loss of productivity from comparative-advantage and trade, coupled with the need to diversify production and reduce the scale of farming. Higher food prices have reduced household food waste, releasing agricultural land for reforestation, green energy production and BECCS. Agricultural diversification has fostered a resurgence of biodiversity and made UK food production increasingly resilient to the changing patterns of weather associated with climate change. However, mild food shocks still occur when extreme weather hits the UK.

The UK remains open to flows of innovation and services, targeted at ensuring the more complex production of higher quality food that advances the UK's environmental-, climate-, social- and health goals.

UK agricultural policy supports the sustainable production of climate-friendly, nutritious foods, while health policy uses financial incentives to encourage citizens to adopt healthy, sustainable diets. The internalisation of external health costs and longer supply chains have eliminated the market value of ultra-processed foods.

The UK populace now buys more food for home preparation, and despite the reduction in food choice, the typical UK diet includes more fruit and vegetables, and less sugar, starch and fat than in the 20's. Meat is eaten occasionally, and more fish protein is consumed from local aquaculture.

B.2 Impacts of the communal food system

POPULATION HEALTH

A greater focus on healthy diets, the increased public health cost of ultra-processed foods, and government schemes to make healthy, sustainable food available to the poorest in society, have significantly reduced the incidence of diet-related diseases in society whilst reducing health inequality between the rich and the poor. The de-intensification of agriculture at scale has produced cleaner air and water, boosting public health and encouraging people to enjoy the outdoors more actively. Greater equality in society has improved the population's mental health, gradually leading to greater social solidarity.

ENVIRONMENT

Prioritising sustainable, local production has enabled growers to adopt farming practices that protect their soil and local water sources. However, in places where one or both of these resources are inadequate, there is tension between the need to produce food and the inability to do so sustainably – or at all. The focus on wider metrics of sustainability alongside ambitious climate mitigation, has produced a healthier environment that is more capable of providing ecosystem services that contribute to a higher quality of life, as well as protecting the UK from the continuing effects of locked-in climate change.

ECONOMY

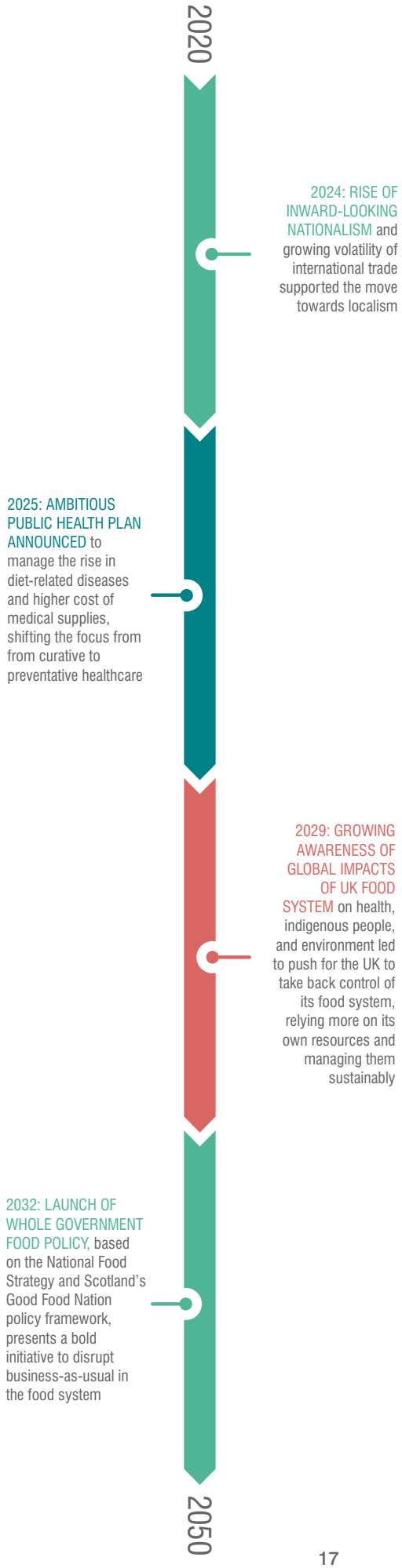
Market actors have generally responded positively to the wholescale structural changes that disrupted incumbent technologies and markets, actively generating new ideas and approaches to support the shift towards a circular and sustainable economy that promotes equality, well-being and lower emissions. In addition, the disconnect from the global market has provided some unexpected boosts to growth by preventing multinational corporations from taking profits out of the country and leaving the costs to be met locally. There was initial frustration from long-term trading partners when the UK closed its doors to trade, but this diminished when it became apparent that lighter-touch globalisation enables more effective approaches to collective problems like climate change.

SOCIETY

The transition towards a more sustainable and healthy economy and lifestyle has been a rocky road. Despite government support, the poorest often still get caught in the regressive pincer of rising food prices and the need to buy less and differently, and parts of the older generation resent the changes that shifted them away from the cheap, unsustainable foods that they were raised with. Coupled with the intensifying food ethics of younger generations, this nostalgia causes societal tension, particularly when the food system is disrupted by extreme weather in the UK.

Nevertheless, a greater focus on sustainability, wellbeing and fairness as part of an alternative economic model has led to a more positive society. The reconnection of people with local food production has fostered a greater sense of local community and reduced the burden of loneliness and mental illness, particularly in the elderly.

B.3 Key events that shaped the communal food system



C The commercial food system

This scenario describes a future in which the UK food system is more globalised in 2050 than it was in 2020, and where climate mitigation has been the primary focus in the transformation of the food system.

C.1 The commercial food system scenario

The UK food system is dominated by imports and is heavily dependent on globalised supply chains. Only a small share of the UK's demand for food is met through domestic production, and this is predominantly wheat, root vegetables and certain soft fruits such as apples, pears and plums. The UK rural landscape is no longer dominated by agriculture; instead, bioenergy feedstock and plantation forests are defining features of the UK countryside, together with huge solar- and wind farms.

Farms are large-scale and commercially run, employing circular and regenerative agriculture to minimize the inputs of organic and inorganic fertilizers. Family farms are virtually non-existent, except in the uplands of Wales and Scotland where a handful of communities continue to farm small herds of cattle, sheep and goats. These livestock systems have been designed to produce minimal volumes of methane and exist to supply red meat to those who can afford it.

Although climate-driven shocks to harvests and trade flows have increased the price of food, supermarkets are able to keep prices relatively stable by switching from just-in-time supply chains to maintaining considerable stocks.This approach is made possible by the high share of basic fortified foods that have been processed to maximize its shelf-life. The global ground and marine transport fleets are now fully decarbonised, and air freight is rarely used, transporting only the highest-value, most perishable, exotic foods.

Economy-wide carbon pricing has had a significant impact on the range of foods that are accessible to the average UK consumer. The most emissions-intensive foods, such as grass-fed ruminant meat and paddy rice, are now available in small quantities on global markets and are prohibitively expensive for all but the ultra-rich. Other carbon-intensive foods that were commonplace in the UK in 2020, such as eggs, dairy products, coffee, chocolate, fish and vegetable oils, are now sold only in limited quantities and at a high price. Insect-based and algal protein products are commonplace.

Following a large upswell in investment in cultured meat technologies and growing pressure from investors in food companies to phase out animal-derived products, cultured meat is now commercially available, although it remains prohibitively expensive for most. High household energy prices have discouraged cooking at home, and many low-income families rely on tinned and instant foods.

Artificial intelligence is now ubiquitous in food chain logistics and food loss and waste from farm to plate is marginal. Many food outlets and households have waste-to-energy bioreactors that link to the national grid and offer subsidies to users. Others rely on government-run programmes for food waste collection, the yields from which are used for domestic biomaterial production or to produce digestate for export to countries where soil fertility has suffered greatly from climate change.

C.2 Impacts of the commercial food system

POPULATION HEALTH

The health impacts of radical shifts in the food system are positive for people with higher-than-average incomes and education, as they are able to afford and prepare healthy foods with low carbon footprints. The associated reduction in red meat and calorie-rich, ultra-processed food consumption has eased the burden of diet-related diseases among this group. Private insurance companies are also offering personalised products to optimize the healthiness and carbon efficiency of these individuals' diets.

For those with less income, time and options, the story is different. Most fresh and whole foods are now too expensive to access on a regular basis. Dietary diversity has fallen since supermarkets began mass-stockpiling cheap tinned and preserved foods, with negative impacts on mental health. These long-life foods are increasingly fortified to combat the rising malnutrition in vulnerable segments of society.

ENVIRONMENT

Locked-in climate change has yielded increasingly frequent and severe climate events, damaging infrastructure and degrading vulnerable habitats such as wetlands. Although the public is supportive of ambitious climate mitigation, there is a sense of collective loss from the radical transformation of the UK countryside. The expansion of bioenergy crops and plantation forests has created landscapes that have been optimised for carbon capture over biodiversity, resulting in homogenous, wildlife-poor landscapes. Biodiversity also suffers in and around urban areas, as households prioritize high-tech home and community environments over green spaces and gardens.

ECONOMY

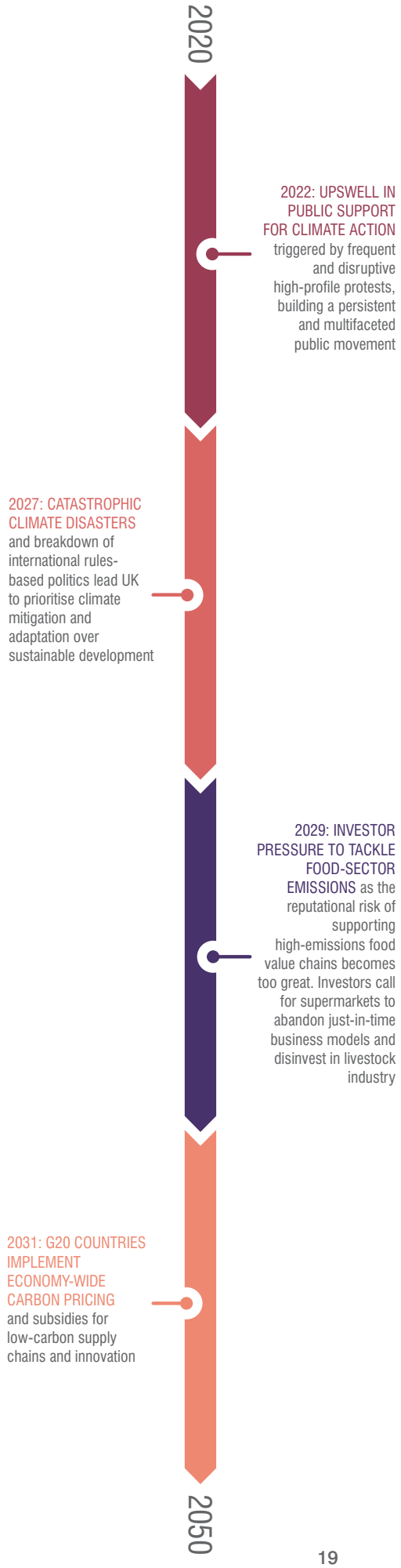
Carbon pricing has radically altered the UK economy and its position in global markets. Large-scale investment in novel technologies to support ambitious climate action saw the UK emerge as a global leader in circular agriculture and landless cropping systems - technology that it now exports to developing-country markets.

The manufacturing and retail industries have been hit particularly hard by carbon taxes and the sharing economy, which have suppressed the demand for many consumer goods. Although this shift has led to significant job losses, unemployment support is minimal, with the UK's balance of payments significantly tighter than it was in 2020.

SOCIETY

A deep political rift has emerged in the UK between those who support radical climate mitigation as an economic imperative, and those who call for a more holistic approach to environmental sustainability and equitable development. The shift in consumer demand and private-sector disinvestment from carbon-intensive food supply chains unfolded more rapidly than the UK agriculture sector had anticipated, and without sufficient support, many livestock producers and farmers were unable to transition to climate-mitigating food production systems in time. The social unrest this has caused has been exacerbated by the inflow of climate refugees from southern Europe and neighbouring regions.

C.3 Key events that shaped the commercial food system



D The collaborative food system

The collaborative food system scenario describes a future in which the UK food system is more globalised in 2050 than it was in 2020, and where wider sustainability has been the major driving force in the transformation of the food system.

D.1 The collaborative food system scenario

The UK is considerably greener in the year 2050, with rural areas seeing a richer variety in landscapes and urban spaces covered with green walls. Greater carbon- and food literacy has made the UK diet considerably greener too, reducing meat consumption and creating healthier food environments. The shift towards nutritious plant-based diets has reduced the levels of obesity, diabetes, and heart-related conditions, as well as improving mental health, and reducing the climate impacts of the UK diet on the tropics.

Although lower intensification on farms has led to lower agricultural productivity, the efficiency of food production has increased due to global governance arrangements that guide what food is best grown where in the world. This has minimised the impact of food production on the environment, which is now internationally recognised as a global commons. Having developed a world-class, low-carbon livestock system that promotes biodiversity and supports reforestation, the UK's primary export is now high quality, grass- and insect-fed beef. The use of soya for animal feed has long since been abandoned.

Food production and supply chains are managed through co-operative structures, giving a much stronger voice to citizens through part-ownership of the food production system. Advanced communications and tracking technologies are common throughout the food system, with ubiquitous apps and data portals in shops that allow the UK public to see exactly where, and under what conditions, their food is being produced. This increased transparency has given farmers in developing countries a stronger negotiating position, reducing the global inequality between countries.

A global food investment bank has been established to proactively support sustainable practices across the full food supply chain and provide insurance for any global food shocks. It is partnered with a physical food bank, which includes 80 days of key food supplies that are replenished for particular emergencies.

Extreme weather events have prompted agricultural management practices with built-in redundancy, resulting in a significant food surplus in years with less climatic shocks. Advancements in food preservation technologies ensure this surplus can be used to restock the physical food bank. Remaining food surplus serves as the main input to the biofuel-, bioplastic-, and biopharmaceutical industries.

Locked-in climate change has led to some public backlash against the shift in society, prompting a subset of the population to question the legitimacy of the UK's ambitious climate strategy and the wider Sustainable Development Agenda. Participatory democracy models were initially captured by special interest groups, as it took a long time to increase participation in democratic processes across society. However, a new public-private form of government is now in power, consisting of elected officials and cooperative structures.

D.2 Impacts of the collaborative food system

POPULATION HEALTH

Although the UK primarily produces high quality red meat, the embedded costs of its production has made it prohibitively expensive for regular consumption. Instead, the UK population favours more climate-friendly and affordable white meat and plant-based proteins. Coupled with the reduction in sugar- and saturated fat consumption, the shift towards plant-based foods has made the UK diet healthier and more balanced. Biofortification is commonplace in food production, and although the range of available ingredients has decreased, creative food processing provides a wide range of food choices.

The decreased incidence of diet-related diseases has lowered healthcare costs and reduced the health gap between socioeconomic groups. However the sense of personal responsibility for health management has led to the widespread stigmatisation of diet-related diseases, fuelling a long-standing debate whether public health funds should be used in its treatment.

ENVIRONMENT

The shift towards plant-based diets and the reduction of food waste has significantly lowered the environmental footprint of the UK's food system. Food waste has been minimised through the integration of technology along the global supply chain, such as advancements in refrigeration, packaging and access at the retail end.

The shift in UK diets has released vast areas of land abroad for the global regeneration of climate-mitigating forests and biodiversity, and the UK's world-class livestock system applies agroforestry principles to support biodiversity and climate mitigation at home. Soil health and water management are prioritised in the UK, and emission-lowering techniques that sustainably intensify agriculture are now the norm globally. This has reduced the use of fertilisers, pesticides and other chemicals.

ECONOMY

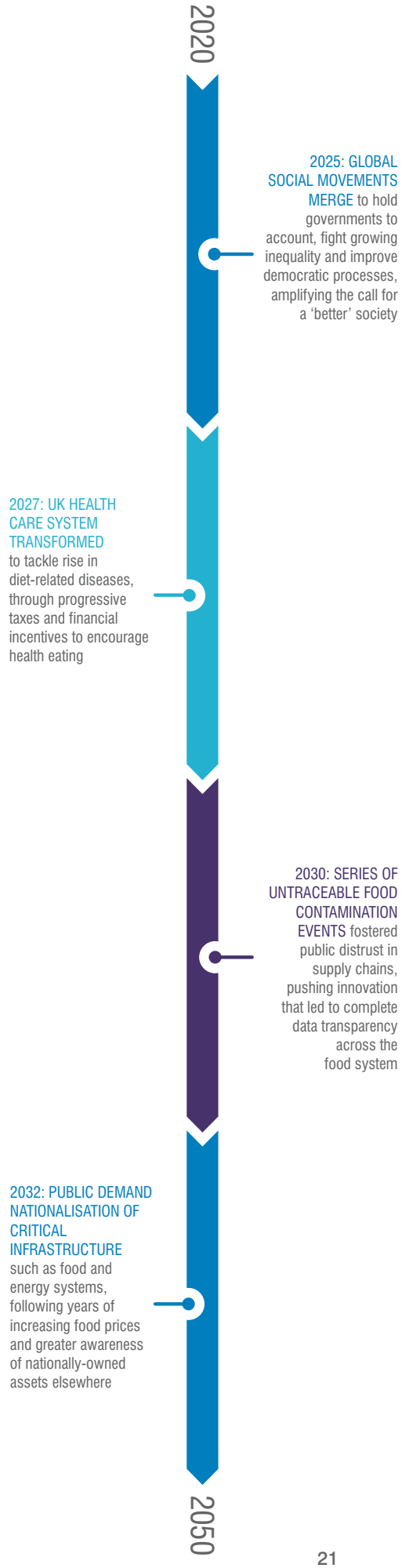
Global economic power is concentrated within four large blocs: the European Union, China, India and the USA. Despite having a smaller global economic say, the UK has created a new leadership dynamic with Canada and New Zealand around the implementation of the Sustainable Development Goals (SDGs), allowing it to continue to have significant global political sway. Economic power has moved to participatory democratic processes and cooperatives, and more transparent, citizen-driven governance structures now counter the power of private capital. Food processing, storage and data management are much larger components of global economic activity, and the biofuel, bioplastic, and biopharmaceutical sectors have boomed since their integration into the food system.

SOCIETY

The UK's public sector ethos now shapes future strategic discussions, the SDGs have provided a framework for a mass re-alignment of asset ownership of the critical commodities for human flourishing. Data transparency across the food system has led to a significant decrease in unethical practices and a consequent increase in societal trust.

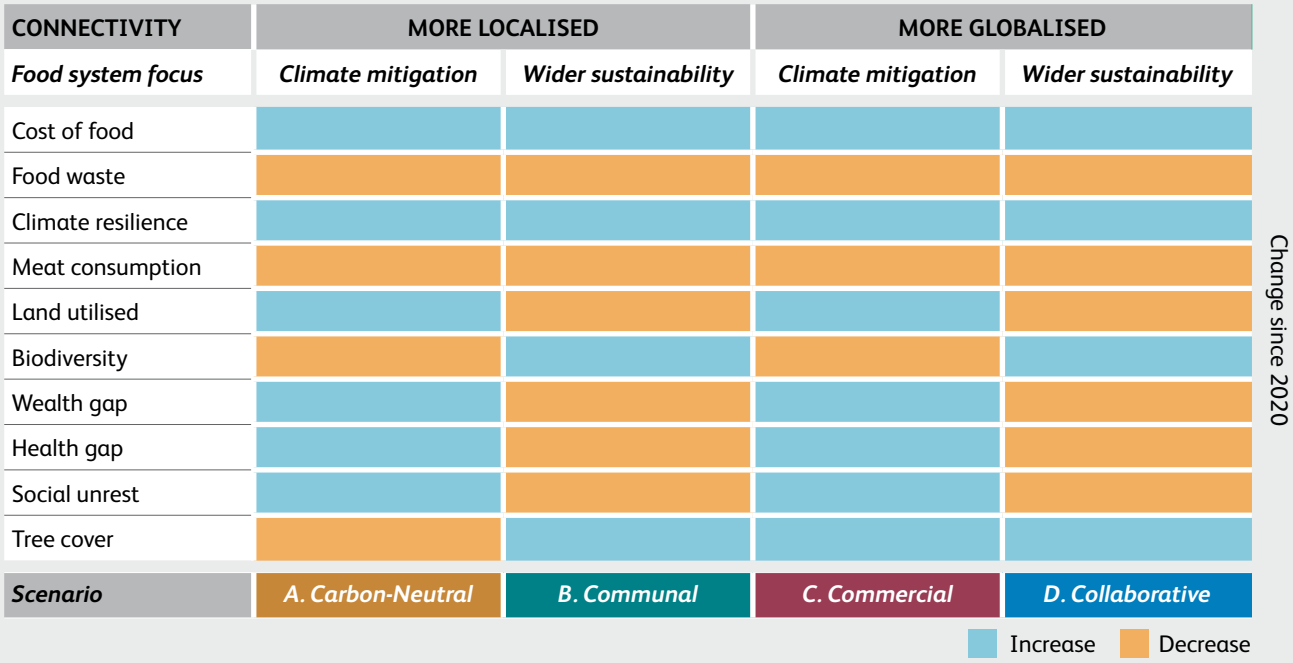
The significant and visible reduction in national and global inequality, combined with the achievement of several climate mitigation milestones, has resulted in citizens feeling more in control of their lives. Increasing numbers of people have taken on greater personal responsibility for their local communities, including health, wellbeing and the environment.

D.3 Key events that shaped the collaborative food system



Scenarios analysis

Although the scenarios are just four examples of innumerable possible futures, they reveal many of the opportunities and potential pitfalls to consider when making decisions that will impact the future of our food system.



COMMON THEMES ACROSS ALL FOOD SYSTEMS

The inevitable rise of food prices.
In every scenario, the cost of food had increased compared to the year 2020. This effect was often driven by climate change-induced food loss, trade disruptions and resource depletion. However, other drivers also increased food prices, such as changing trade relationships, the use of more expensive technologies across the food system, and internalising the external costs of food (e.g. health care and environmental costs). Although food price spikes are typically accompanied by greater civil unrest[23], this only occurred in the two scenarios that had greater inequality (A and C). In the scenarios where the food system had been transformed to simultaneously reduce inequality (B and D), social unrest decreased despite higher food prices.

The win-win of eliminating food waste.
Another recurring theme across the scenarios was a drastic reduction in food waste across the supply chain, both for food systems with a focus on climate mitigation and wider sustainability. The UK currently wastes 10.2 million tonnes of food every year, producing more than 20 million tonnes of GHG emissions[24,25]. Reducing food waste would not only reduce GHG emissions, but would also reduce the amount of land required to feed the population. This could allow agricultural land to be released for reforestation, biodiversity, renewable energy production and BECCS, bringing the UK closer to its climate-mitigation targets and the Sustainable Development Goals.

Climate resilience will be central to future food systems.
Although every future scenario adopted measures to manage climate-induced food shocks, approaches differed significantly depending on the degree of reliance on international trade. In the carbon-neutral and communal scenarios (A and B), the UK sought to increase its climate resilience by transitioning towards more localised food systems. However, this made the UK more vulnerable to the impacts of climate change at home. The more globalised commercial food system (C), on the other hand, used supermarket stockpiling of long-life fortified foods to protect the UK from climate shocks, but at the cost of dietary diversity. The more globalised collaborative food system (D) demonstrated that greater climate resilience could also be achieved through increasing global cooperation.

Dietary shift is key to addressing global challenges.
Significant dietary change featured heavily in every scenario, highlighting the importance of reducing our consumption of high-emission, resource-intensive foods to meet our global climate mitigation and sustainability goals. Red meat is an example of such a food, with the livestock sector currently occupying 48 % of the UK's land area[26]. Therefore, a reduction in the consumption of red meat could not only release pastureland for climate mitigation, nature and recreation, it could also support the regenerative potential of smaller-scale livestock farming, whilst ensuring high animal welfare standards and improving population health.

CLIMATE MITIGATION AND WIDER SUSTAINABILITY

Land use and biodiversity go hand-in-hand.
In the scenarios that focused primarily on climate mitigation (A and C), more UK land was utilised for green energy generation, BECCS and forest plantations, and biodiversity decreased. However, in the food system scenarios with a focus on wider sustainability as well as climate mitigation (B and D), dietary change and technological advancements allowed land to be taken out of production and biodiversity flourished. This relationship indicates that designing landscapes for climate mitigation without considering wider metrics of sustainability could pose a risk to biodiversity.

Closing the wealth gap closes the health gap.
In the food system scenarios that that focussed on wider sustainability alongside climate mitigation (B and D), both the wealth- and health gaps decreased, whereas in the scenarios with a primary focus on climate mitigation (A and C), they grew. In the absence of support systems for the poorest, health is inextricably tied to wealth, as money protects against malnutrition by increasing the affordability of more nutritious foods, as well as serving as a buffer against sudden changes in food prices. Although the cost of food went up in all four scenarios, the scenarios with a focus on climate mitigation and wider sustainability had been transformed to reduce inequality and support the poorest, allowing more people to afford and access nutritious foods, boosting public health. This trend highlights the reality that poor health is a symptom of economic poverty, and that reducing the wealth gap is key to reducing the health gap[27].

Increase accessibility of nutritious plant-based diets to improve public health.
Although meat is an excellent source of protein, as well as several key vitamins and minerals such as vitamin B12, niacin, and selenium, there is growing scientific consensus that the overconsumption of red meat (particularly processed meat) is associated with poorer health outcomes[28]. In the scenarios however, the reduction in red meat consumption was only associated with improved public health if measures were put in place to increase economic and physical access to nutritious plant-based foods. Without this access, the reduction in meat consumption contributed to increased malnutrition in poorer parts of the population.

OTHER OBSERVATIONS

Reduce land footprint of UK food system to increase tree cover.
Both globalised food systems were associated with more tree cover in the UK, but for different reasons. In the commercial scenario (C), less UK agricultural land was required due to the greater reliance on food imports, giving space for reforestation. The collaborative scenario (D) saw the UK adopt a land-intensive livestock production system, however it also implemented agroforestry techniques which increased UK tree cover. The communal food system (B) demonstrated that more tree cover could be achieved in a more localised setting by reducing the UK population's consumption of red meat.

Tree cover does not always support biodiversity.
In the two scenarios with a focus on wider sustainability alongside climate action (B and D), biodiversity increased with the increase of tree cover. In the climate mitigation-focused carbon neutral scenario (A), decreased tree cover had a negative impact on biodiversity. However, biodiversity decreased in the commercial scenario (C) despite the increase in tree cover. This was due to the introduction of forest plantations that were designed solely for climate mitigation purposes, without considering biodiversity. This indicates the potential pitfall of missing win-win opportunities by not considering wider metrics of sustainability when taking bold climate action.

Research agenda

This scenarios exercise has highlighted several major research questions for the UK food system, presented here in no particular order. These questions have been informed by the expert taskforce (see *Appendix*) as well as the scenarios analysis, and overlap significantly due to the systemic nature of the food system.

Which combinations of food system interventions can deliver systemic transformation of the UK food system to safeguard human and planetary health?

Trade-offs are inherent to system change, and there is no such thing as a 'silver bullet' intervention. Therefore, a key research priority is understanding what those trade-offs may be in the food system, and developing an array of interventions that can be introduced in unison to minimise the negative impacts on people and the natural world. This could involve researchers working closely with citizens, food system actors and other stakeholders to integrate real-world data into food system models and scenario planning, which could then be used to test food system interventions prior to implementation. This research has the potential to increase support for transformative changes across the food system.

How can we maximise the climate mitigation potential of the UK food system in line with the Sustainable Development Goals?

The UK has committed to going Net Zero by 2050, a medium-term goal that warrants bold, disruptive action in the short-term. The UK food system holds promising potential to reduce greenhouse gas emissions, however it is vital that opportunities to improve wider sustainability are not missed in the drive to decarbonise the food system. Multi- and interdisciplinary research and cross-stakeholder collaboration is required to identify these win-win opportunities and develop UK food system interventions that can balance the UK's climate mitigation targets with wider metrics of sustainability (e.g. increasing biodiversity, reducing poverty, and improving good health and wellbeing).

How can we reduce the land footprint of the UK's food system?

There are substantial opportunities to reduce the land footprint of the UK food system at home and abroad, which would release land for regenerating biodiversity, replenishing the UK's natural capital, delivering greater self-sufficiency, implementing bold climate mitigation, and improving the UK's climate resilience. The research community has already identified a multitude of strategies to lower the land footprint of the UK diet, ranging from diversifying UK agriculture, accelerating sustainable intensification, prioritising soil health management, and optimising ecosystem services, through to encouraging behaviour- and dietary change, reducing food loss and waste, and biofortification. Understanding how different strategies interact and can be combined to optimise UK land use is another key research priority.

How can we shift UK diets towards healthy and sustainable foods?

Approximately two thirds of the UK population is considered malnourished (including overweight, obesity[29], under-nutrition[30], micronutrient deficiencies, or a combination of these), and 2.7 earths would be needed if the average UK consumption of natural resources was replicated around the world[31]. Therefore, it is imperative for food security that the UK diet shifts towards healthier and more sustainable foods. Research is urgently needed to understand what drives behaviour change in the food system, as well as to characterise the combinations of low-agency population interventions that yield the greatest benefits. Other key research areas include developing universal metrics to determine the relative healthiness and sustainability of

different food products, transforming obesogenic food environments, and managing the transition towards more sustainable business models across the supply chain that support a healthy diet for all.

How can we internalise the external costs of unhealthy and unsustainable diets in a way that makes nutritious and sustainable diets more accessible for everyone?

A common argument against internalising the external costs of food is that this would be regressive, disproportionately penalising the poorest and most vulnerable. However, we need to recognise that the external costs of unsustainable and unhealthy diets are already being disproportionally met by the most vulnerable in society, and these groups currently have the lowest access to healthy and sustainable foods. Therefore, there is a need to develop fiscal interventions that discourage the production and consumption of unhealthy and unsustainable food products, while simultaneously making healthier and more sustainable options more accessible for those on lower incomes. Research is needed to characterise the external costs of food production and consumption, develop a suite of fiscal interventions to internalise these costs whilst protecting the poorest, and understand how it could be implemented from a practical and social perspective.

How can we increase the resilience of the UK food system?

The UK food system is facing a multitude of threats, ranging from climate change-induced extreme weather, to the breakdown of international rules-based cooperation. Research is urgently needed to understand how these threats might interact, and to develop optimal combinations of approaches to increase the resilience of the UK food system. These approaches might include increasing redundancy in the food system (e.g. through increasing food storage capacity); diversifying UK food production, processing, manufacturing, retail and consumption; breeding resilience to extreme weather into crops and livestock; determining the optimal balance between local, national and global food systems; and the digitisation of the food system.

Key messages

1

Meeting global agreements on climate mitigation and sustainable development requires the radical transformation of the current food system.

The Paris Agreement and the Sustainable Development Goals (SDGs) require stakeholders across the food system to embrace transformative change, including the implementation of nutrition-sensitive, biodiversity-enhancing, low-footprint food production, the anticipation and mitigation of higher food prices, support for widespread dietary change, and the transition towards circular economies.

2

Future food systems must deliver wider metrics of sustainability alongside ambitious climate mitigation.

Bold climate action is central to meeting the Paris Agreement and protecting the UK's food security. However, doing so as part of a broader SDG agenda has the potential to also regenerate ecosystems, reduce socio-economic inequality and improve population health. These global agreements could be addressed in parallel by harmonising climate mitigation strategies with the policies and actions that aim to advance the sustainability agenda.

3

Transforming our food system to meet global agreements requires the development and implementation of a range of systems approaches and systemic technologies.

The explicit acknowledgement of the systemic nature of the food system is required to develop approaches that can maximise win-wins and minimise the trade-offs. The key role of dietary change, novel technologies, and eliminating food waste in every scenario emphasises the importance of investing in systems research and systemic innovation.

4

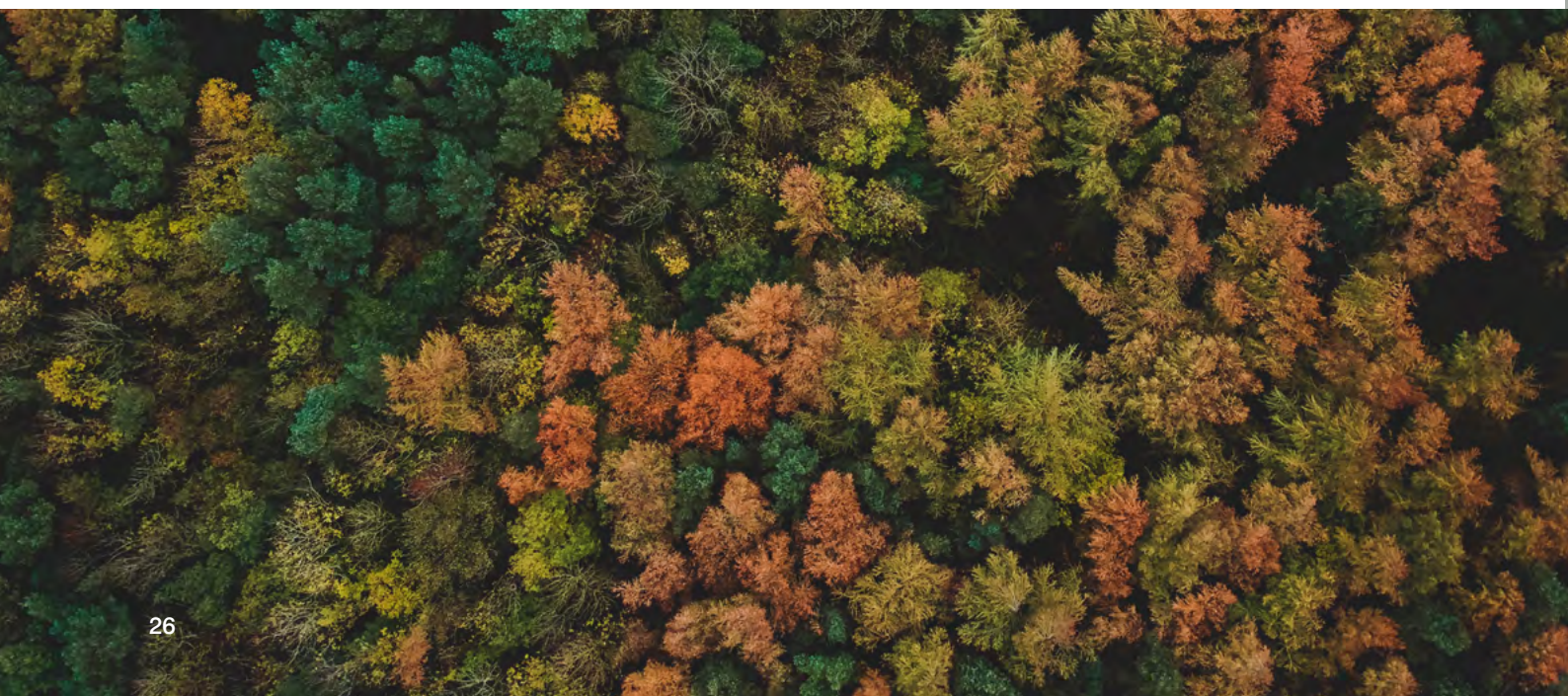
Strategies to meet global agreements will vary greatly depending on a country's reliance on global trade.

There is no one-size-fits-all approach to honouring these commitments, and each nation's strategy needs to be adaptable to changing global circumstances, particularly with regard to trade and multi-lateral cooperation. If globalised trade deteriorates, countries reliant on the globalised food system must be ready to adjust their strategies.

5

Radical action must be taken today to ensure future food security.

Reshaping the food system to safeguard our food supply in the future is a long-term process that requires immediate cross-societal mobilisation and strong leadership. By highlighting potential opportunities, trade-offs and pitfalls, evidence-based speculation is a powerful tool to inform decision-making and guide this process.



Appendix

Taskforce and contributors to the report (in alphabetical order)*

Tim Benton, Chatham House

Riaz Bhunnoo, Global Food Security

Mark Bush, Public Health England

Andy Challinor, University of Leeds

Dan Crossley, Food Ethics Council

Mark Driscoll, Forum for the Future

Caroline Drummond, LEAF

Maia Elliott, Global Food Security

Pete Falloon, Met Office

Lucy Foster, DEFRA

Helen Harwatt, Harvard University

Aled Jones, Anglia Ruskin University

Nahum Kidan, DEFRA

Jenny Macdiarmid, University of Aberdeen

Emma Mansbridge, London School of Hygiene and Tropical Medicine

Cami Moss, London School of Hygiene and Tropical Medicine

Helen Munday, Food and Drink Federation

Karl Ritz, University of Nottingham

Henri de Ruiter, RIVM National Institute for Public Health and Environment

Pauline Scheelbeek, London School of Hygiene and Tropical Medicine

Cristobal Uauy, John Innes Centre

Laura Wellesley, Chatham House

**Contributors do not necessarily represent their organisation's views.*

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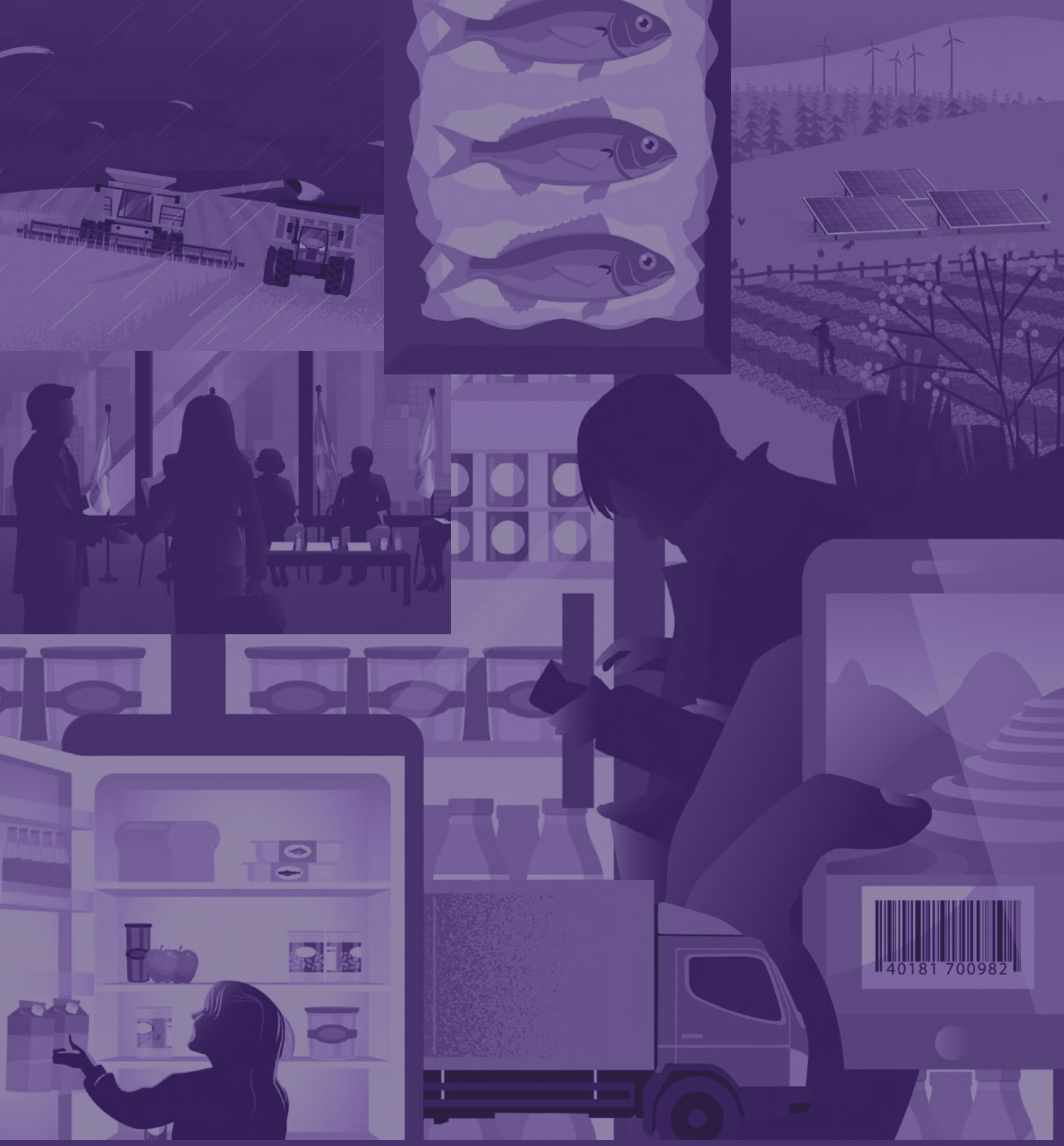

Global Food Security

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For further information please visit:
www.foodsecurity.ac.uk

Email: info@foodsecurity.ac.uk
@FoodSecurityUK