WHAT COULD THE UK AGRI-FOOD SYSTEM LOOK LIKE IN 2050?

WHAT IS THE AFN NETWORK+

The AFN Network+ is a unique network of 1,000+ academics, researchers, third sector organisations, policy makers, and agri-food industry professionals from farmers to retailers. Together, we are working to identify key research gaps that may be holding the UK food system back from transitioning towards a net zero UK by 2050, while also enhancing biodiversity and healthy ecosystems, nurturing livelihoods, supporting healthy consumer habits, and minimising the environmental impacts of overseas trade. Our findings will inform the next decade of research investments in this area by UKRI (our funder and the UK research councils umbrella organisation). Alongside our core research, we run in-person and online events, produce topical resources, and give out hundreds of thousands of pounds of funding a year. AFN Network+ is coordinated by the University of East Anglia, University of the West of England, University of York, and University of Leeds, and is a £5m, 3-year project funded by four research councils; the Biotechnology and Biological Sciences Research Council, Economic and Social Research Council, Engineering and Physical Sciences Research Council, and the Natural Environment Research Council.

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Summary

This paper describes four scenarios for how the world might be in 2050 and what sort of agri-food systems may exist within them. It then summarises what policy planning and research will be needed under each of these futures, to move the agri-food system towards a net zero UK.

The net zero challenge

The UK Government does not currently have a plan for how the agri-food system will contribute to its 'net zero by 2050' commitment, even though the sector accounts for around a quarter of the UK's greenhouse gas emissions. There is also no consensus around a vision for a sustainable UK agri-food system.

The rapid pace of global change and recent geopolitical instability pose challenges for thinking about the future, and past trends cannot simply be extrapolated forwards. The research needs of the different plausible worlds require careful but urgent thought, since innovations can take decades to deploy at scale.

Four futures, four paths to net zero

Scenarios help thinking about possible challenges and opportunities ahead, and provide a route for planning and decision-making. Our four 'plausible futures' were developed around how the world could change in terms of geopolitics and stability, markets and social change.

In all four scenarios, the UK reaches net zero emissions by 2050, but in different contexts, via different pathways, and with different implications. The key features of each scenario are as follows:

> SCENARIO A: **'BUILD BACK FAST AGAIN'** – an unstable and globalised world, where economic growth is key (essentially business as usual).

Permanent economic crises increase inequality and reduce financial support for farming; climate and trade volatility make resilience-building important for households, supply chains and agriculture; access to agricultural inputs become more variable globally; technology is seen as the saviour but with little success; food is grown intensively and is mostly ultra-processed; large areas of less productive farmland are given over to other uses; strong corporate control exists with small margins for food producers.

> SCENARIO B: **'CIRCULAR WORLDS'** – geopolitically stable and globalised, underpinned by circular sustainable systems and values.

Sustainability and wellbeing are a stronger focus than economic growth; mixed and diversified farming systems increase, where farming shares more land with nature and more trees are integrated; agriculture features lower yields with fewer inputs, but technologies help agro-ecological/regenerative farming; more people have 'flexitarian' diets based on more 'whole foods', less ultra-processed foods, and more local food networks; a circular economy reduces resource pressures; carbon-border taxes make imports more expensive; food is more expensive but this is 'offset' by less waste and shifts in diet; farmgate prices are higher and more farmers have dual careers.

> *The rapid pace of global change and recent geopolitical instability pose challenges for thinking about the future, and past trends cannot simply be extrapolated forwards.*
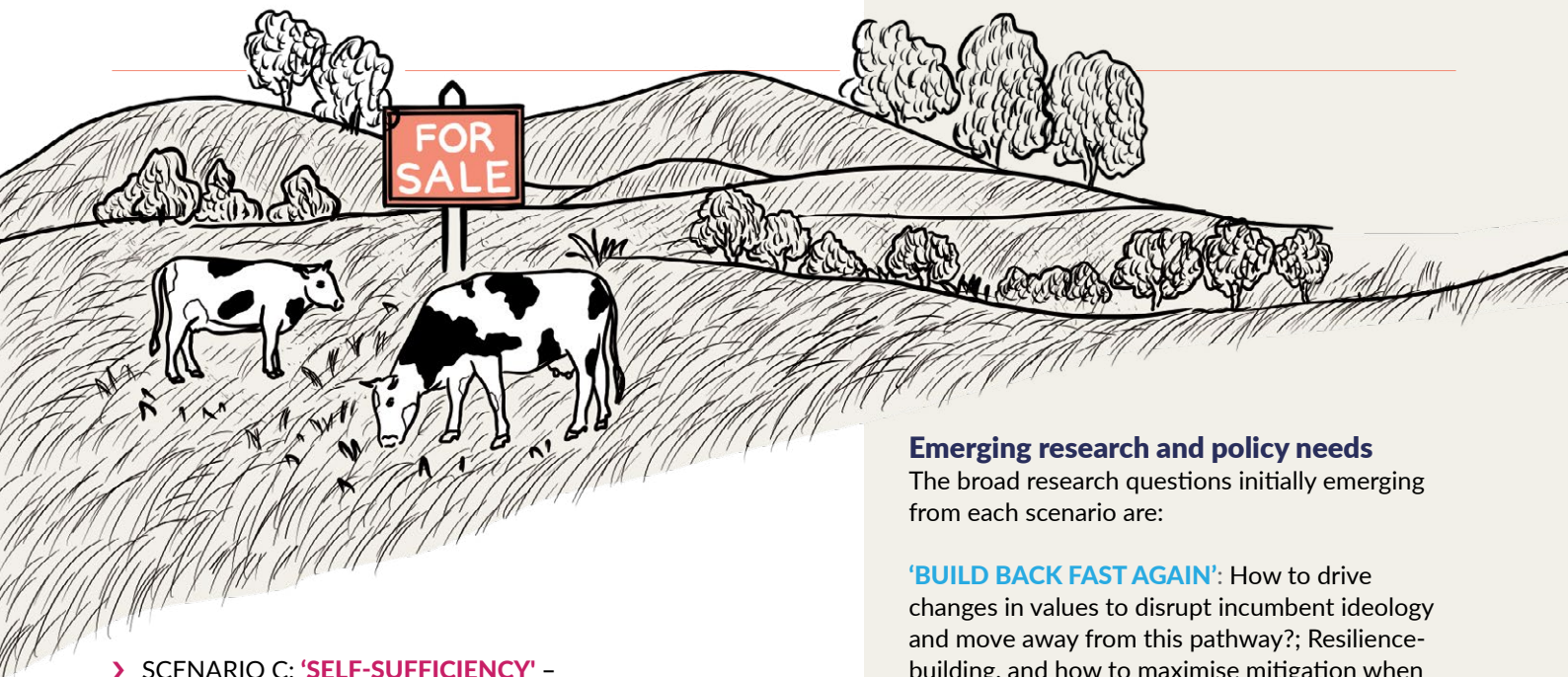
> SCENARIO C: **'SELF-SUFFICIENCY'** –
an unstable, regionalised world, where a
circular economy is driven by the need to save
resources.

The focus is resilience-building and efficiency;
life is hard with economic contraction and global
crises driving an 'island-fortress' mentality; food
security is high on agenda with agricultural
policy driven by the need to feed everyone; food
production is not technologically rich; mixed
farming prevails due to the cost and availability
of fertilisers; biomass and green composting
thrive; farmers focus on 'traditional' UK crops
best suited to the land, with some new crops
suited to a warming climate; meat becomes a
luxury for many; prices are high and people buy
less, consume less, waste less, travel less.

> SCENARIO D: **'THE RIGHT TO FOOD'** –
a geopolitically stable world, with a globalised
economy built on 'green growth'.

A high-tech, post-fossil fuel future, with diverse
food growing technologies (urban, vertical,
proteins), intensive and efficient agriculture;
more green fertilisers and biotechnology; more
ultra-processed food, but designed for better
nutrition; countries trade on comparative
advantage in fruit and veg; farming is based on
'sustainable intensification' and land sparing;
UK production is mainly horticulture, grains,
and much less red meat; ruminants farmed in
limited way to minimise pollution, using methane
inhibitors; pasture is focused on production of
heritage meat, rewilded, or used for feedstock
for protein extraction; inequality is lower than
Scenario A ('Build back fast again') and C ('Self-
sufficiency') as food is seen as a basic right.

Emerging research and policy needs
The broad research questions initially emerging
from each scenario are:

'BUILD BACK FAST AGAIN': How to drive
changes in values to disrupt incumbent ideology
and move away from this pathway?; Resilience-
building, and how to maximise mitigation when
developing adaptation strategies? What would
a land use strategy look like to ensure land is
used in the most useful way?; How can growing
food insecurity and inequality be mitigated by
producing cheaper food in crisis conditions?

'CIRCULAR WORLDS': How to drive changes
in social values to move towards this pathway?;
How might capacity be built to promote
significant new behaviours in lifestyles and
farming practice?; How can new, more diverse
and integrated mixed farming systems be
developed, including with new technologies, that
build-in circular and agro-ecological principles?

'SELF-SUFFICIENCY': How can capacity
be grown for urban and small-scale market
gardens and allotments and how can cooking
skills be enhanced and promoted?; How can
the development of lower-input, diverse and
circular farming systems be developed with green
manure replacing synthetic fertilisers?; How can
the UK science base help develop and spread
new technologies supporting legumes, protein
extraction from grass and crops for animal feeds;
What institutions are required to help ensure
nutritional security shapes local agricultural
production and producer-consumer relations?

'THE RIGHT TO FOOD': How to drive value
change to disrupt incumbent ideology and move
towards this pathway?; How can capacity be
grown for urban and small-scale market gardens
and allotments and how can cooking skills be
enhanced and promoted?; How best to maximise
yields in intensive land-sparing; how best to
develop green fertilisers and biological pest
control methods; how can carbon storage best be
developed on former pastureland?

Introduction
The net zero challenge and the UK agri-food system

The UK has committed to achieving 'net zero' by 2050. While strategies have been developed for key sectors such as energy and transport, there is no credible vision for the UK agri-food system's pathway to a net zero UK. This is significant since agriculture, land-use and food (processing and retail) account for almost a quarter of UK emissions. Land underpins the agri-food sector, but also provides the UK's terrestrial 'nature' and ecosystem services and is a key resource for increasing carbon sequestration. Our agri-food system also significantly impacts citizens' health. There is so much at stake, making a vision, and the science and research to underpin it, all the more pressing.

Why isn't there consensus on a vision?
Producing a vision is hampered by the complexity of agriculture, the relationships between local production and international trade, and contested issues such as the role of the market versus government. This is compounded by cultural values and the very personal nature of food. A net zero UK requires managing trade-offs between whether land should be providing food, carbon storage, habitats, or livelihoods. These trade-offs need to be actively managed, rather than left to 'the market'. What is most profitable for a land-owner to do is determined by demand-and-supply at a global, as well as domestic level. The profitability of land use options can, of course, be manipulated via tax, regulation and incentive schemes, but the policy frameworks underpinning these must be evidence-based and sufficiently stable to drive long-term commercial investment and commitment.

Creating incentives often requires a degree of certainty about the future. However, the last two decades have been a period of huge change – technologically, politically, socially and economically – and it is no-longer tenable to imagine the markets of 2050 will be a simple, smooth extrapolation of the past trends rooted in stability and cooperation. The events of 2022 have brought war, which is challenging control of an important European breadbasket, interacting with supply chain disruptions arising from a zoonotic disease, and with extreme weather made more likely by climate change. This new age of insecurity highlights the fragility of global markets.

A new uncertain world
If 2022 and 2023 are a taste of the future pressures on the global agri-food system, what will the market for the goods from land be in 2050 and how will this shape land use decision making in future? The unpredictability of future agri-food markets is summed up by the acronym 'TUNA': Turbulent, Uncertain, Novel, Ambiguous[1]. There is a strong argument that Business As Usual (BAU) – characterised by increasing land productivity to service increasing global demand, while externalising costs and undermining sustainability - is unsustainable. Economic and population growth drives consumption growth, which drives climate change that then undermines the potential for the trends to continue, while increasing the scale and cost of delayed restorative action.

Equally, in the long term, our fragile and complex socio-economic-environmental systems will increasingly be subject to shocks. Such shocks, like COVID-19, may be disruptive enough that they also shift 'business as usual' mindsets and provide opportunities for rapid system change. Given this, what might the future look like, and therefore how might it influence what is needed to shape the UK's agri-food and land-use system through the transition to net zero?

[1] Ramírez, R., & Wilkinson, A. (2016). *Strategic Reframing: The Oxford Scenario Planning Approach*: Oxford University Press

How scenarios can help decision making under uncertainty

Decisions about policy and research agendas made today and based on historical trends, may become less fit for purpose as the future diverges from the past. However, future scenarios can aid strategic decision making under such uncertainty when past trends cannot be extrapolated into the future with confidence. By examining a range of plausible futures, it is possible to think through the challenges that might be encountered and the opportunities that might arise. Using scenarios is less about 'betting on a future' and more about stress-testing plans to see whether decisions made now would remain 'fit for purpose' under alternative futures.

This paper describes four scenarios of how the world might look in 2050, and what sort of agri-food systems may exist, shaped by market forces, policies, politics, and social attitudes. These scenarios were developed by the AFN Network+ to support work among researchers, partners and stakeholders around the UK's net zero transition and the UK agri-food system. (See **Appendix I** for methodology). In all four scenarios, the UK reaches net zero emissions by 2050, but via alternative pathways and with very different implications.
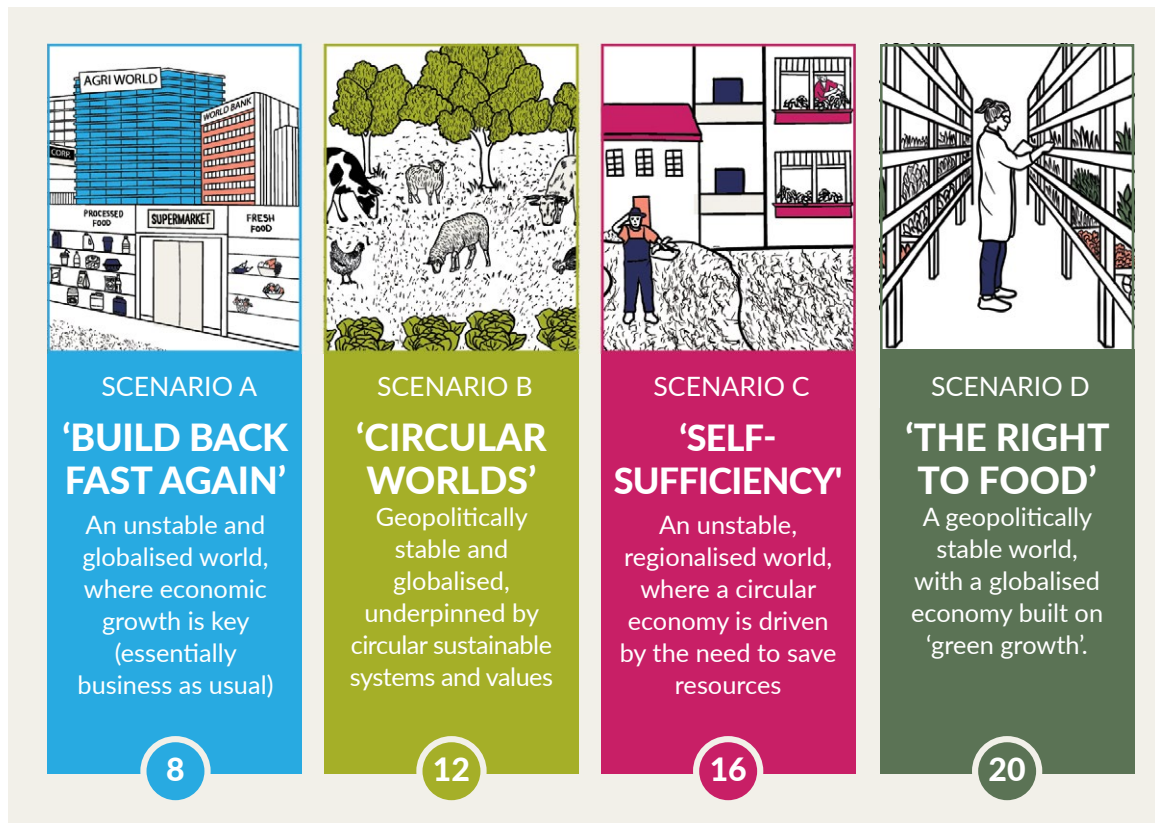
The Scenarios: Potential food system futures and how net zero may be achieved

The four scenarios outline futures which are influenced by three major uncertainties. The first concerns geopolitics and stability - will the world be more volatile, conflicted and contested, or return to a more calm, cooperative, rules-based situation? The second concerns economic development - will we move towards more regionalised, regulated and securitised markets, or rediscover open global
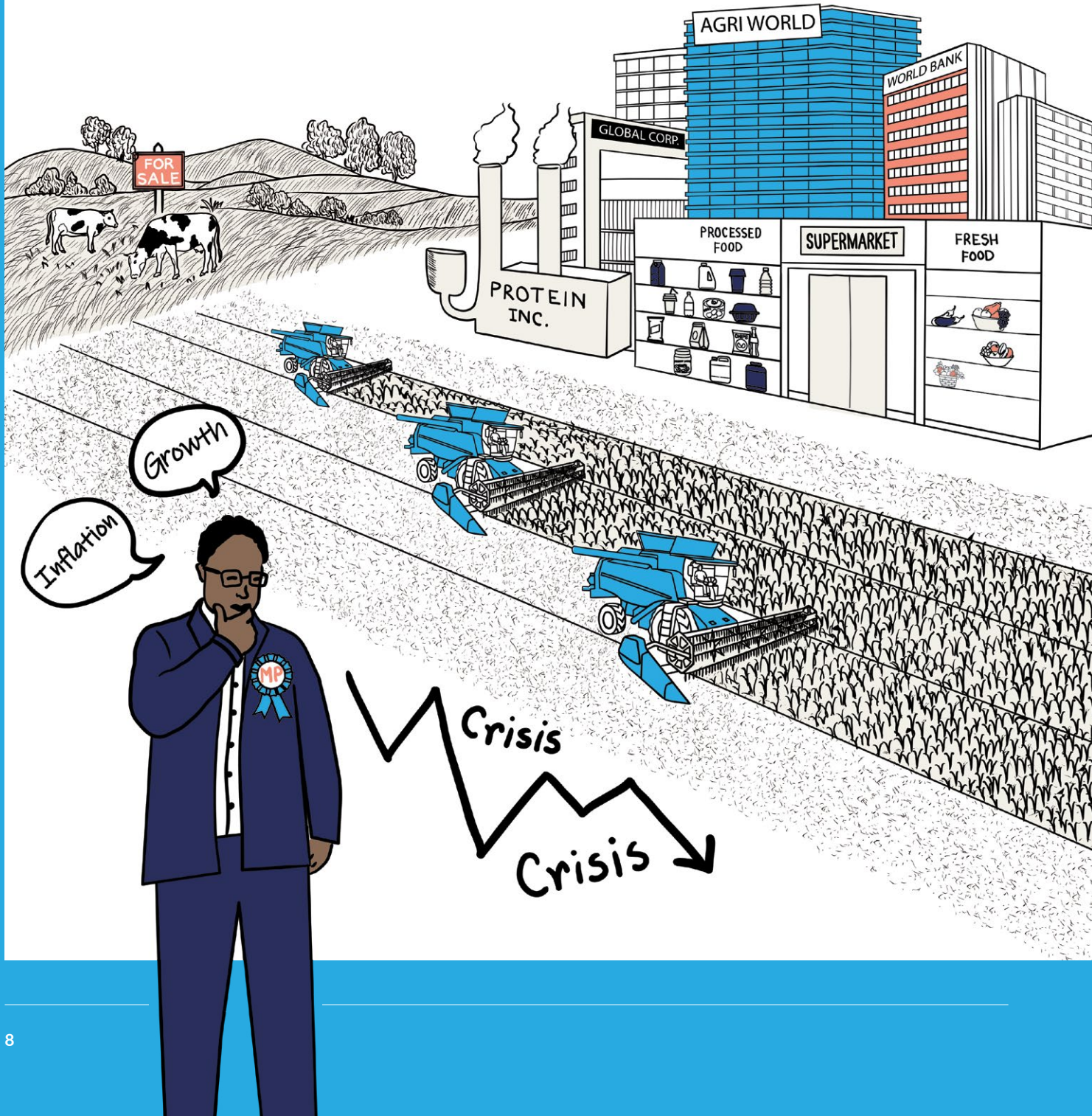
> ❝ *Decisions about policy and research agendas made today, may become less fit for purpose as the future diverges from the past.*

markets and drive back towards globalisation? The third uncertainty concerns demand and consumption - how will demand for the goods from land evolve? Will it grow unfettered, or will demand be shaped by; what is sustainable to supply; price signals; regulation; or innovation in the sector or system? The four scenarios were developed in a participatory exercise that explored these three 'axes of uncertainty' (figure 1).

FIGURE 1: THE FOUR SCENARIOS

SCENARIO A

'BUILD BACK FAST AGAIN'

An unstable and globalised world, where economic growth is key (essentially business as usual)

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SCENARIO B

'CIRCULAR WORLDS'

Geopolitically stable and globalised, underpinned by circular sustainable systems and values

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SCENARIO C

'SELF-SUFFICIENCY'

An unstable, regionalised world, where a circular economy is driven by the need to save resources

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SCENARIO D

'THE RIGHT TO FOOD'

A geopolitically stable world, with a globalised economy built on 'green growth'.

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SCENARIO A
'BUILD BACK FAST (AGAIN)'

Key features

> World view: individualistic, transactional, short-termist and market-driven

> Geopolitically unstable and crisis ridden (an extension of current trends)

> Globalisation is volatile, as are global supply chains (trade wars, climate). UK food supply is uncertain & nation state allies secure production and militarise trade routes

> Political focus is on economic growth (rebuilding fast after crises, not rebuilding better)

> Global corporations have more power and nation states are restricted by trade treaties

> Food production is intensive and centralised - mostly ultra-processed, with a focus on industrial protein and other foods from a few commodities for calories. Fresh food is often unavailable

> Big retailers still dominate, vertical farming is prospering

> 'Net zero' route is through technology and 'sustainable intensification'

> Large withdrawal of farmers from the land - areas abandoned to 'rewilding'

Scenario A is a world that might be thought of as 'present trends extended' – a world that is geo-politically unstable and crisis ridden. Climate-change and other forms of environmental disruptions amplify geopolitical tensions around resource security, creating greater volatility in global supply chains. Political leaders remain focussed on economic growth, but frequent crises mean periods of strong growth are rare, and instead the UK spends many years each decade 'building back fast' rather than attempting more transformative 'building back better'. The worldview of the UK in 2050 in this scenario can be characterised as individualistic, transactional, short-termist and market-driven.

PATHWAY TO 2050

The decade of the 2020s was one of particular volatility, as disruption was followed by yet more disruption. These included; pandemics; European and Asian wars; conflagration across the Sahel and civil wars in Latin America; food insecurity and civil unrest in a swathe of countries sparked by the 2024 El Niño; and inward-looking nationalism driven by large-scale movement of people and the 'put our country first' mentality epitomised by the re-election of President Trump in 2024. So many things happened, there was little time for the UK to get back on its feet each time, before the next challenge arose. By the mid 2030's the pretence of wanting to build back better was gone — and what matters now in 2050 is being able to build back fast, to ensure jobs and avoid recession.

This is a world where growth is always a political priority and is always just around the corner, and the onus on every worker and institution is to boost their productivity. Governments struggling with the world in perma-crisis of the 2020s and 2030s allowed corporations to step into the breach — but at a cost. Governments have given more and more licence to global corporations, who have managed to stack the deck even more in their favour. This is a globalised world of Charter Treaties and international trade agreements that restrict what national governments can do. What little public money exists is spent on permanently rebuilding from the last crisis, often sparked by the impacts of climate change.
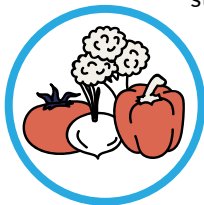
Globalisation persists but is very volatile. Local contests and trade wars, and supply chain disruptions from climate, mean the UK is never sure of what will be available, when, or at what price. To help manage food production, countries seek to secure production arrangements with allies, and trade routes are sometimes militarised through the increasing areas of global instability. Trade agreements are often also connected to deals on managing or restricting migration.

THE UK FOOD ENVIRONMENT

The food system is dominated by ultra-processed and fast foods, both at home and out of home, with more food consumed out of home. 'Real foods' still exist but are expensive and high-status, with most food being constructed from ingredients extracted in highly industrialised processes from a few key commodity crops. Depending on the crisis, fresh food is often unavailable. The big supermarkets still dominate the retail landscape, although we also see more local vending machines and the 'Uberisation' of food. There are more takeaways and fewer restaurants.

AGRICULTURAL PRODUCTION

There is deregulated precision-breeding of both plants and animals. Vertical farming is prospering, and uses heat from data centres and an energy system underpinned by a fleet of the new small Advanced Modular Nuclear Reactors, along with renewables that provide low-cost energy during much of the year. Food production is intensive and centralised, with rewilding occurring on abandoned grazing land. Due to eternal volatility, food prices have risen, while intensification has boosted yields, providing the basic commodities at volume that underpin calorific-security. Given prices and volatility, 'real meat' is rare and expensive. Most food comes in packets with meat analogues in the form of meat-like alternative proteins more common.

SOCIAL VALUES

Everyday life is fragmented and polarised. The lack of significant economic growth (due to forever 'building back fast' from the last crisis) means that social safety nets have become more threadbare. Companies provide social insurance to attract staff, and religious and community groups fill local gaps in their neighbourhoods. The high level of corporate regulatory control means that there is little transparency, although rumours and alternative perspectives are shared on private, secure, alternative networks.
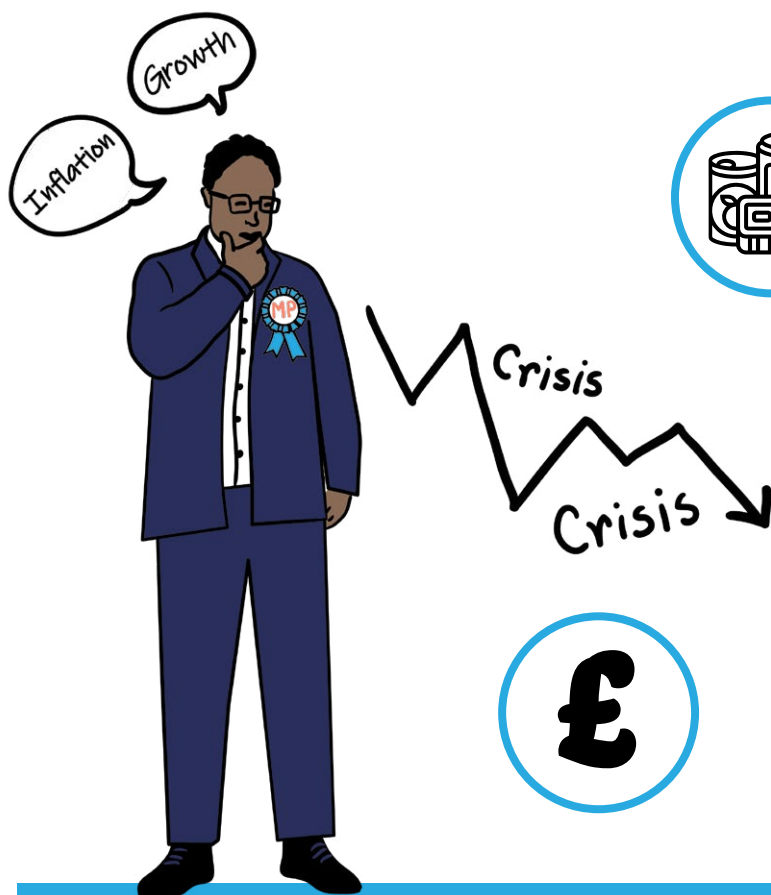
NET ZERO?

The route to net zero in this world is believed to be through technology, some of which works and some of which is little more than 'greenwashed' magic bullet solutions that bring their own problems. Companies publish statements about their carbon policies and activities, but these are effectively impossible to verify. There is certainly some double-counting going on. However, in many sectors now the most competitive business models are those based on low-to-no emissions production.

Net zero in the UK is achieved by 'sustainable intensification' of crop commodity production on the one hand, and the large-scale withdrawal of agriculture from marginal pasture land, allowing afforestation and 'rewilding'. Demand-side changes in dietary composition (particularly less meat due to the cost of animal feed) also reduce agri-food emissions.

Summary of implications for the UK agri-food system

› Climate and trade volatility is significant: Resilience-building is key for households, supply chains and agriculture.

› Volatility in the world (climate, geopolitics and trade) means input supplies for agriculture are variable: Some parts of agriculture hedge towards alternative sources of nutrients (compost, sewerage, some mixed farmscapes integrating livestock into arable).

› Due to permanent economic crisis there is not a lot of public money available, either for agricultural support or for social safety nets. Inequality increases.

› The answer is always sold as being in technology: There is lots of investment in biotechnology, vertical farming and alternative proteins, but while new technologies are deployed, the challenges always seem to remain.

› Food is largely derived from commodity crops grown at scale and intensity: 'Real food', as it is quaintly termed, is rather niche and expensive.

› The focus on ultra-processed foods has changed the balance of land use so that areas of intensive land use but also agricultural abandonment ('rewilding') characterise the UK landscape.

› There is strong corporate control of food and farming: Agricultural margins are wafer thin and farmers bear the risks, but have little autonomy in decision making. Farmers are keen to build resilience where they can, but only if it saves them money. Increasing efficiency and improving soil carbon are adopted at scale.

› There is a lack of transparency about progress towards net-zero, with lots of techno 'false profit' solutions. Most progress emerges from technology (efficiency), improving soils (to build resilience), and carbon storage in abandoned agricultural land.

SCENARIO B
'CIRCULAR WORLDS'
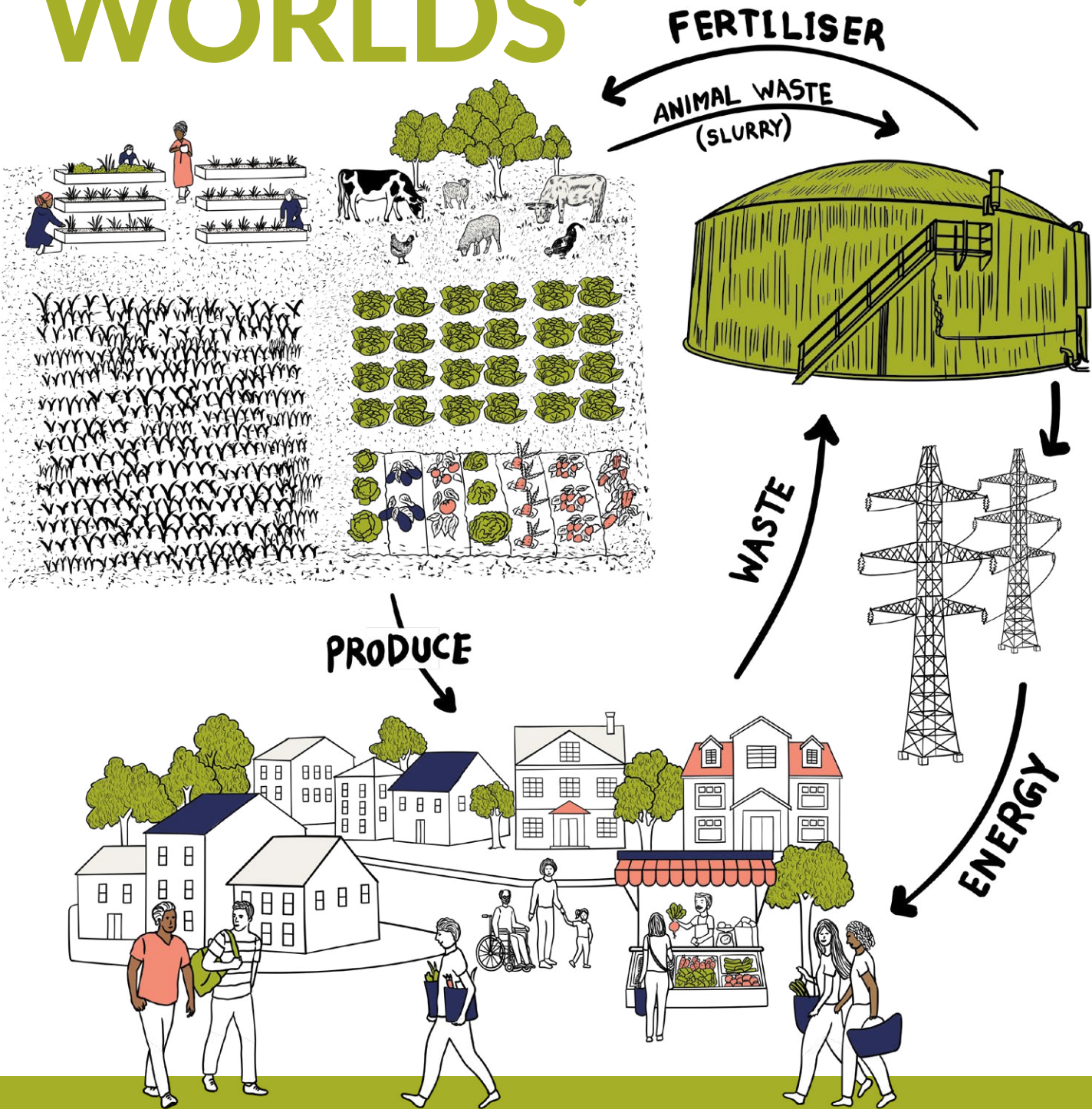
Key features

› World view: Shared, systemic, well-being-oriented, intergenerational fairness

› Millennial and GenZ new global order based on sustainability, climate action, circular economies, co-operation and well-being

› Agriculture produces less, is more diverse, mixed, circular, low input, with improved carbon storage. Horticulture is common in peri-urban/ urban areas

› Food and farmers are more highly valued. Farmers' focus on producing 'less but better' and margins are higher

› Sustainable diets are new normal, meat is occasional. Food is more expensive. People cook more, eat greater variety, consume less, waste less, buy from variety of suppliers

› Far fewer livestock frees up land for nature and carbon storage. Carbon credits and nature credits internalise externalities. Renewables mean energy is cheap

› Cooperative trade buffers climate related regional/ national impacts. Carbon taxes on food imports increases costs
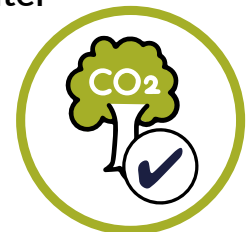
In Scenario B, a new global geopolitical order develops based on sustainability, climate action, and shared values of circular economies, system co-ordination and co-operation, and wellbeing-oriented public policies. The worldview of the UK in 2050 is characterised as shared, systemic and well-being-oriented.

PATHWAY TO 2050

The solutions to the crises of the 2020s were always out there. The problem was people were too entrenched in their existing lifestyles to act on them. However, the generational values espoused by Millennials and GenZ lead to widespread middle-class revolt about inaction — climate's '1848 moment'[2] — and opened the door to a surging set of transformational social movements.

Wrapped up in the same story was a growing realisation that enough is enough; that work, consumption for consumption's sake, and a lack of time, were at the heart of the malaise of the 'Millennium Decline' in the first decades of the century. Social norms switched from valuing wealth accumulation and consumption to valuing time and wellbeing, and the role that social cohesion and a sustainable environment plays within this. This led to a transition to a more sustainable, circular economy, based on lower primary consumption, and where wellbeing metrics shape economic policy, not GDP.

As a result of the transformation in social norms and values, the third generation of Sustainable Development Goals have mostly been achieved, even if this is about 20 years later than intended when the 2030 agenda was put in place. In most countries the UN's Human Development Index is getting better. The losers here have been the world's wealthy – and they are bad losers, constantly using media outlets and paid-for policy think-tanks to whip up complaints.

The transformation has been funded in a range of ways, including the redistribution of wealth to improve equality, the use of carbon credits and nature credits to internalise externalities from industry (including farming and food), and a shift away from subsidising the fossil fuel economy. A wholesale shift to renewable energy means energy is cheap and circular economic production (and circular trade) create a more efficient economy than the old extractive linear economy ('reduce waste, reuse, repair, recycle' replaces 'take, make, discard').

However, while broadly on target for the Paris goals (about 1.7 degrees of global warming), the impacts of changing weather patterns continue to grow. This creates frequent regional or national problems – but in a cooperative world with rules-based intergovernmental cooperation, trade works to buffer many of the impacts.

THE UK FOOD ENVIRONMENT

Food and hence farmers and producers, have become more valued in society. Food diversity has improved, as have cooking skills, partly because people now have more time, as many now work a 4-day week. Consumer preferences have also changed – meat has become restricted to an occasional guilty pleasure, as sustainable diets are the new normal.

People buy from a variety of suppliers, partly enabled through online communities, including buying directly from farmers and producer co-operatives. Box schemes and community supported agriculture are promoted by the Community Farm Movement and new intermediaries. Retailers routinely enable refills, and Masterchef, now in its 38th season, celebrates the pleasures of cooking with a whole range of alternative proteins. Social values mean communal eating (family meals and shared meals) are more common than in the 2020s, and left-overs are often offered through the FeedSomeoneForFree App.

[2] In 1848, the "Springtime of the Peoples" a series of revolutions affected over 50 countries in Europe, driven by demands for more democratic processes, press freedom, economic rights and food security.

> **As people eat less, waste less, but eat more whole foods, farmers focus on producing 'less but better', and more diversity.**

AGRICULTURAL PRODUCTION

Farmers have been reinvigorated by the new emphasis on food and the better margins that they get from selling more directly. As people eat less, waste less, but eat more whole foods, farmers focus on producing 'less but better', and more diversity than the old-fashioned commodity crops. People volunteer for local gardening co-operatives because they know it's good for their psychological health and because they have more time. Farming, like other aspects of the economy, is more circular and less linear. Mixed farming and mixed landscapes are more common, and horticulture is commonplace in peri-urban (market gardens) and urban settings (vertical farming, allotments and community gardens).

SOCIAL VALUES

This world is underpinned by values that are around universalism, but there is also a deep respect for conserving and for recovering traditional skills. Community matters, as does intergenerational fairness.

NET ZERO?

The driver of this transformation was a political revolt driven by fears of climate change after a series of terrible weather events in the 2020s. So, net zero is at the heart of the politics of this world. Artists have been paid to design public campaigns on the theme that 'careless consumption costs lives', and 'waste not, want not'. This is true internationally as well as in the UK. As well as carbon payments, nature credits have underwritten the protection of forests, both rain- and temperate.

Net zero is achieved through producing less (but more diverse, and nutritionally efficient) output from agricultural land, with less intensive agriculture, but more diverse, mixed, farming systems enhancing carbon storage on-farm. Eating less ruminant meat releases land for nature and carbon storage. A change in attitudes underpins acceptance of shifts in diets and UK food security is underwritten through ethical trade in which offshored emissions are minimised and/ or offset.

Summary of implications for the UK agri-food system

More diversified farming systems, mixed farms and landscapes, trees integrated into farms, local 'market gardens', emphasis on land sharing than sparing. New technologies for smaller-scale, mixed, farming systems are developed.

› Sustainability and wellbeing are at the core of this future, with less focus on economic growth. Lower yields, due to fewer inputs (pesticides, synthetic fertilisers) are widely accepted. Technologies to maximise yields in regenerative and agro-ecological systems have had to be developed.

› There is more cooking from 'whole foods', and less consumption of convenience or ultra-processed foods. New social norms mean widespread acceptance of flexitarian diets.

› People are more local and community minded and have more time to engage. There are more local food networks, and most farmers do direct selling to consumers.

› System efficiency is at the heart of the circular economy – systems are designed to be low-waste, repairable and recyclable, and this applies to farming (e.g. circular farming systems, green fertiliser, on-farm energy systems, nutrient cycling through livestock and complex rotations) and food (low waste, use of left-overs, meal planning).

› Trade occurs (whether some tropical produce, like bananas, or agricultural inputs), but carbon-border adjustments mean costs of importing are high. Agricultural nutrients that are locally-derived from organic sources are often cheaper.

› Higher prices of many foods (due to producing 'less but better') are offset at the household level by (a) less convenience food and more home preparation of raw ingredients; (b) less food waste; and (c) a shift in dietary composition (eating less meat due to its relatively greater price). Higher farm-gate prices provide better livelihoods for farmers, and there are more labour opportunities in the rural environment. Farmers often have dual careers, a regular job in their virtual office, enabled by universal high-speed broadband, shared with part-time work on a farm.

SCENARIO C
'SELF-SUFFICIENCY FOR SECURITY'
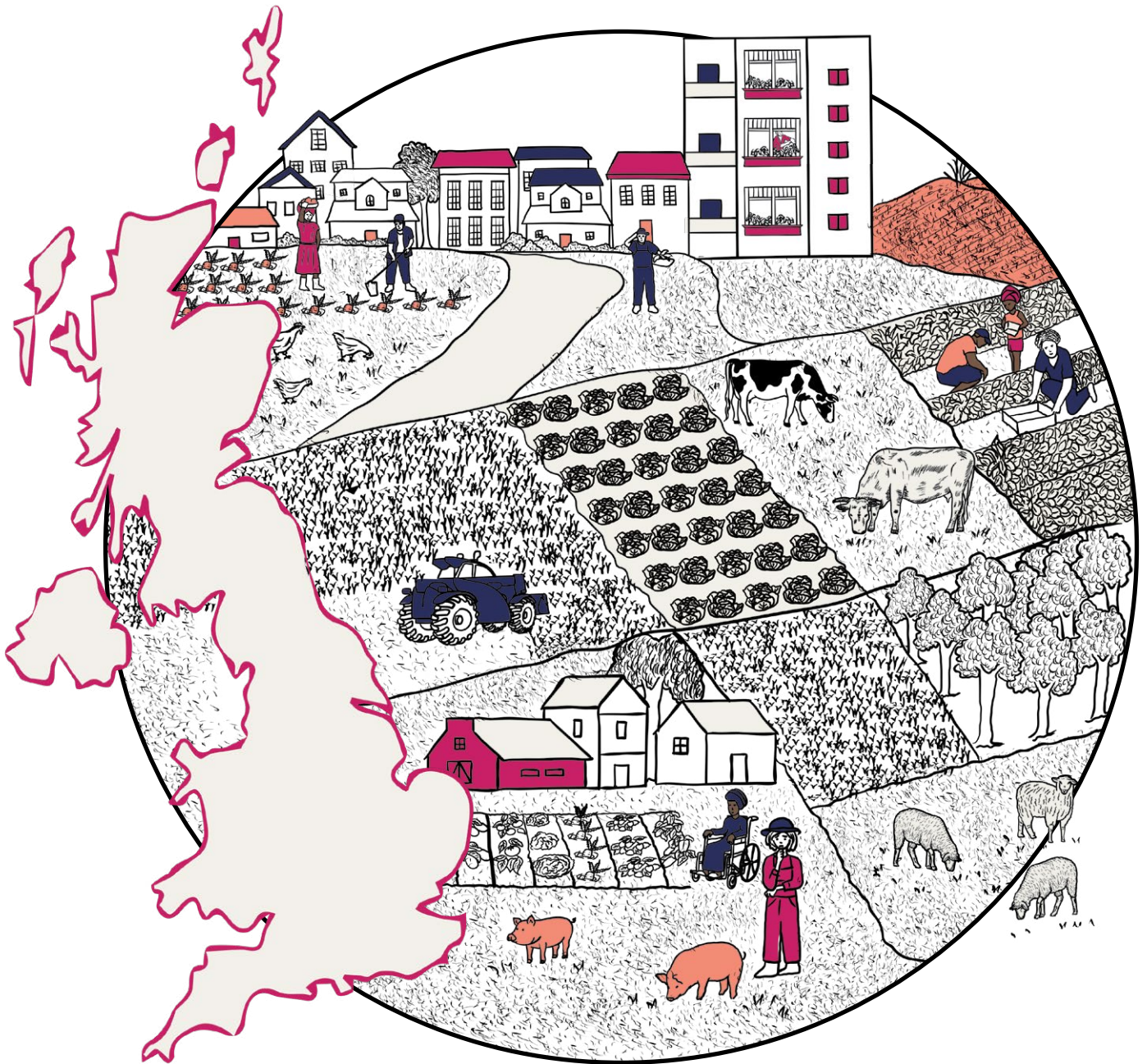
Key features

› World view: security-focussed, self-reliant, and about 'making do'

› Fractured, multi-polar world, full of conflict. Security of supply is key. Countries increase self sufficiency of food and trade with nearby allies

› Poorer world: People buy less, source more locally, consume less, grow at home. There are unofficial markets, and lower food safety standards

› Circular economy born out of need to save resources/not rely on imports

› Security of nutrition is core government food/agricultural policy: Farmers incentivised to grow crops for public health needs, rather than market demand. More focus on fruit, vegetables, high yielding traditional crops, plus some new ones adapted to new climate

› Food consumption is more regional and seasonal. Less meat consumption as ensuring enough food to feed the human population has risen in importance

› Trade decline means fertilisers are less available/ more expensive. More green fertilisers and mixed farming systems with rotations as a result. More small-scale farming systems. Some grazing land abandoned, afforestation increased

› Focus increasingly on adaptation rather than mitigation

In Scenario C the geopolitical tensions arising in the 2020s have created a fractured, multipolar, world, full of contestation and conflicts. There is more of a siege mentality, where the security of supply becomes key. Countries increase their self-sufficiency, trade with nearby key allies and develop a circular economy to reduce reliance on imports. The worldview of the UK in 2050 can be characterised as security-focussed, self-reliant, and about 'making do'.

PATHWAY TO 2050

There were major wars and civil unrest in the 2020s, including in Ukraine, Taiwan, Central and Latin America, Sudan and the wider Sahel, plus migration amplified by the 2024 El Niño's impacts and passing 1.5 degrees of warming. This caused the world to fragment into a multi-polar one of regional blocks, but even within these, climatic impacts made trade uncertain. The weather effects of climate change and the fragmentation of international relations meant that both the production of food, and its distribution, were disrupted. To underpin food availability – and thus national security – countries increased self-sufficiency and began trading more with near neighbours and allies.

The security of nutrition becomes a much more central orientating principle in public policy, defining agricultural policy. Food consumption is more regional and more seasonal. Countries need to grow more of their own food, and those with fewer resources need to develop good relationships with neighbours. Within countries there are variations between regions, and supply is erratic, so food storage also matters. Migration has increased globally as a result of the disruptions, but the UK's borders have hardened and only those with provable skills are welcomed.

It is a poorer world, with significantly lower levels of disposable incomes, thanks to the economic contraction of regionalisation in an era of global instability.

Climate change is still being addressed by governments, but the Paris Agreement has lapsed due to the breakdown of multilateralism. The focus is increasingly on adaptation driven by 'efficiency' and 'resilience-building' measures (such as soil improvement) while mitigation is more a by-product than an aim as we pass two degrees.
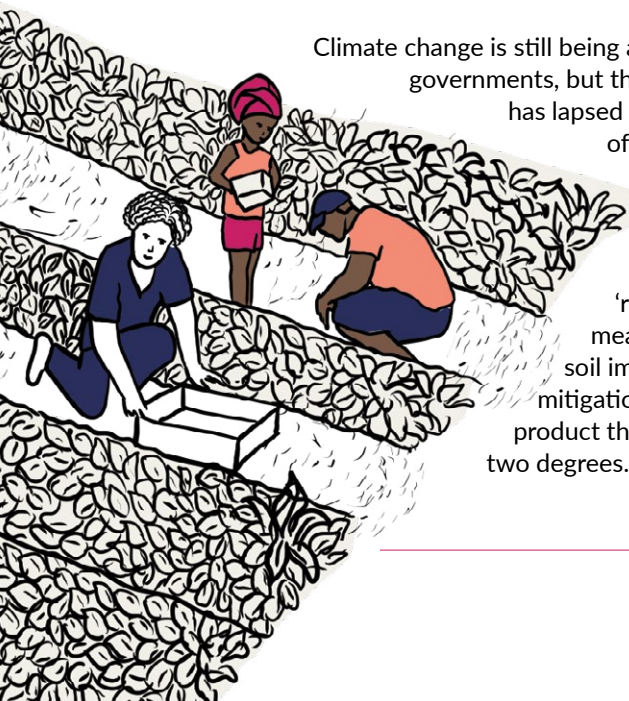
THE UK FOOD ENVIRONMENT

Food security is a central part of public policy. Farmers are incentivised to grow a range of crops based on public health needs, rather than simply responding to market demand. People have got used to the idea that food is more expensive, but they all know that the alternative is shortages and empty shelves. And that means that people also grow their own food when they can — in gardens or community spaces.

There is less meat consumption: The supply of feed for livestock has contracted as food for people has risen in importance, so meat production is primarily from grass-fed livestock or monogastric animals (e.g. chickens and pigs) fed on recycled organic matter, such as food waste and alternative sources of protein, including farmed insects. Food poverty is common, especially in urban environments. There are unofficial markets and food safety standards have declined.

AGRICULTURAL PRODUCTION

Production focuses less on producing goods for a global market, and more on producing what can be produced locally for local consumption. This includes more focus on fruit and vegetables, with high yielding traditional crops suitable to local conditions, coupled with some new ones adapted to the new climate (e.g. sunflowers, grapes, apricots). Those that have multiple uses – like potatoes – are grown more extensively.

The decline in trade means that commercial fertiliser is less available, and more expensive – so extensive development and use of green fertilisers has occurred, and livestock are also integrated back into complex rotations within diverse, mixed farming. Overall, there is less livestock production by farmers, but also more informal production. More households keep hens — and there are some illicit pigs as well – especially in rural gardens.

> ❝ *It is a poorer world, with significantly lower levels of disposable incomes. Mixed farming prevails, due to the cost and lack of availability of synthetic fertiliser.*

This is an economically poorer world than that of the 2020s. People look after their neighbours because it is always possible that you will, at some point, need your neighbours to look after you. There is, therefore, some sharing of skills, which have been rebuilt slowly out of need rather than any kind of plan.

Companies have become weaker because of a long run of poor profitability, which means that many have been broken up for value by opportunistic investors and because multinational companies have less reach in a non-globalised world. The world feels like it has gone backwards. Consumption levels have fallen to more sustainable levels, but those old enough to remember the 'kid in the sweetshop' feeling of mindless consumption at the start of the millennium feel something is now missing.

NET ZERO?

Net zero is less central to policy in this future, where the focus is on adaptation, but this is a world where people buy less, sourced more locally, and consume less – and thus, emit less. There's less opportunity for travel as well and most holidays are within the UK. No one wants to risk being abroad when another crisis hits and borders close.

Net zero, however, is arrived at due to economic contraction and the circularity that reduced inward flow of goods necessitates. Resilience, efficiency and circularity are the key policy aims, and in the land sector this translates into more mixed, diverse and small-scale farming systems, with some grazing land abandoned and afforestation increasing.

Summary of implications for the UK agri-food system

> This is an uncomfortable world where everything is hard work driven by a world in crisis. There is economic contraction from the mid-2020s, as the contested and conflicted world drives inward-looking island-fortress mentality.

> Food and nutritional security are high up the policy agenda, and agricultural policy is driven by the need to feed everyone.

> This is not a technology-rich future. Technological development is not a shared international endeavour in this contested world, so innovation relies on those R&D budgets the shrunken economy and public purse can afford. That being said, there is much 'informal' technological development arising from informal knowledge and innovation systems (especially small scale, on-farm, trial-and-error, and farmer peer-to-peer learning).

> Mixed farming prevails due to the cost of synthetic fertiliser (and lack of availability). The circularity of the economy has also allowed

more biomass (from animal and human manure, from food and industrial organic waste) to be developed into green compost.

> The agricultural focus is on what is best suited to grow: Wheat and barley, root vegetables, brassicas and beans, plus apples, pears and some berries, with a range of new crops to suit the new climatic conditions (apricots and sunflowers, for example). Allotments and small-scale peri-urban farms supply chicken and pigs. Grazing ruminants (and some pigs) come from mixed farming systems, but meat is a luxury for many.

> Prices are relatively high: people buy less, waste less and consume less; they also travel less.

> Resilience building (to cope with climate volatility) and efficiency (in the circular economy) are the focus of effort. Net zero largely arises from lower consumption, from increasing adaptation (e.g. improved soil carbon to build soil fertility) and reducing waste.

SCENARIO D
'THE RIGHT TO FOOD'

Key features

› World view: Innovation, inclusiveness and social purpose

› Globalised, cooperative, multilateral. Sustainable 'green growth' is political goal

› The 'right to food' is part of the social contract - ultra-processed (but healthy and sustainable) food supplied as part of Universal Basic Income. Food is cheap, people eat less, more healthily, waste less

› Technological development is significant. A well-developed alternative protein market has changed consumer tastes

› Small-scale, alternative, producers of new foods flourish. Global companies are broken up, more B-Corps and social enterprises exist

› Mixed economy of food production. Decline in livestock production (carbon taxes, emissions issues), but more focus on fruit and vegetable production, local production (greenhouses, vertical farming, closed, hydroponic systems)

› Agriculture is primarily 'sustainably intensive' – composts, bio-pesticides, regenerative, agro-ecological systems. Land spared for rewilding/carbon storage.

Scenario D describes a world which is globalised, cooperative, and where sustainable growth is the political goal. In this world, the 'right to food' — meaning, the right to nutritious, affordable, and accessible food — has become part of the social contract, as has a stronger commitment to sustainability, framed within the 'green growth' paradigm. The worldview is one of innovation, inclusiveness and social purpose.

PATHWAY TO 2050

The disruptions in the 2020s created the conditions for a rapid tipping point in social attitudes that created the space for a new sort of politics. In effect, the richer world woke up to the unsustainability of its continued focus on economic growth, fuelled by consumption. 'There is no point in being rich on a dead planet' was a maxim at the time from a global movement driven by the more socially and environmentally conscious Millennials and GenX.

This shift in social norms created the conditions for more systemic approaches to policy making, and for a reinvigoration of multilateralism. There is a significant reformulation of the multilateral architecture of cooperation, making institutions like the UN, World Bank and World Trade Organisation more inclusive and with a greater focus on enabling equitable and sustainable development.
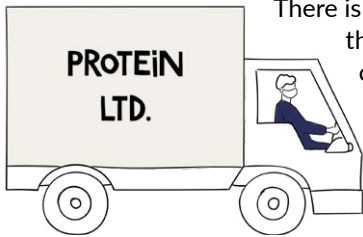
The wider costs of processed foods on health, the environment, and social equity, have become more central to public policy. Policies that started with free school meals (in richer countries) evolved into the right to affordable, accessible, nutritional food, funded by carbon taxes, at least in the short term. 'The right to food' slogan is understood globally, even if it is still a campaign rather than a norm in some countries, while in others it is part of a 'universal basic service' safety net.

These social values also meant that most of the global food companies have been broken up by more effective anti-trust or anti-monopoly legislation, even if their individual divisions are still recognisable in the corporate world. B-Corps (companies certified as meeting high standards of social and environmental performance and transparency) and social enterprises have become more commonplace. The economy is one of 'a thousand flowers blooming' rather than consolidated 'Big Business'.

Economic growth remains the central ideology, but in the guise of green growth. If there is a trade-off between sustainability and economic growth, the presumption is the former takes precedence, very unlike the early decades of this century. Markets are structured (regulated and incentivised via taxes, subsidies and trade-rules) to ensure this, and profits arise from businesses with a social purpose. This is Donut Economics in action[3].

Technological development is very significant within this world, and R&D innovation is providing many new solutions to old challenges to allow us to prosper within planetary boundaries.

THE UK FOOD ENVIRONMENT

Much of the improvement in access to nutritional diets was first driven by public procurement. Building alternative protein markets – shaped by procurement policies that wanted to limit the long-term health and environmental costs of cheaper foods - created new suppliers and helped to change consumer tastes. Publicly supplied food (part of a universal basic income) is healthy, and its innovative production methods mean it is affectionately described as 'astronaut food'.

Strong anti-trust policies also mean that there is less 'catch and kill' by consolidated business squashing new innovative systems. As a result, there is a flowering of small-scale, alternative, producers of new foods, whether alternative proteins from cells, insects, or industrial biotechnology. Ultra-processed foods (a dirty phrase a few decades ago) are now seen as healthy and sustainable. Food is cheap on the whole, but the cultural norms of health and sustainability, mean people are happy to eat less, eat more healthily and waste less.

[3] Raworth, K. (2017). Doughnut Economics: Seven Ways to Think Like a 21st-Century Economist. Chelsea Green Publishing.

> ❝ *Food is a basic right — so a nutritious diet, though perhaps dull 'astronaut food' — is at least available and affordable.*

This is a world in which sustainability matters along with social purpose. Values-driven businesses are welcomed as partners in helping to make change happen. However, there is always a tension between the imperative for (green) growth through effective business innovation and the anti-trust competition policies that are designed to limit size.

AGRICULTURAL PRODUCTION

This is a mixed economy of food production. A decline in livestock production (partly priced out by carbon taxes, partly due to manure management difficulties) means there is more focus on fruit and vegetable production, and 'sustainable' local production (greenhouses, vertical farming, closed hydroponic systems) are common in every town. This is a technically innovative world. All sorts of bio-production processes have scaled up, sometimes supported by public investment — from cultured 'meat' to solar proteins.

Agriculture is primarily intensive, allowing land to be 'spared' for rewilding and carbon storage. However, unlike the 'sustainable intensification' of the old days, the intensification here is 'really sustainable' based on composts, bio-pesticides, regenerative and agro-ecological systems.

NET ZERO?

This is a world of inclusive values, driven by a generation of Millennial and GenZ managers who have strong values of sustainability, diversity and autonomy. Net zero matters to them, and one of the drivers of the anti-monopoly campaigns of the 2030s was a strong sense that the world's corporations were still not committed enough to climate change action. Carbon taxes and related measures mean that post-fossil business models have been kickstarted.

We are almost aligned to the Paris Agreement, thanks to green growth fuelled by technology, and no fear of reduced consumption if it is needed for lower emissions. Sustainability is built into trade, but Carbon Border Adjustments, forest-free supply chains, and increased transport costs, mean trade is less the engine of growth than in the 2020s and 2030s.

In the land sector, emissions reductions arise from 'really sustainable' intensification and land sparing, coupled with a reduction in ruminant consumption and waste driven by attitudinal changes.

Summary of implications for the UK agri-food system

> This is a high-tech future, with intensive agriculture and high agricultural efficiency in a post fossil-fuel economy.

> 'Sustainable fertilisers' (composted waste, human waste, animal waste) coupled with biotechnology are widely used to increase nutrient use efficiency.

> There is diverse development of technologies, including urban, vertical and alternative proteins.

> Diets have a large component of ultra-processed food with nutrition often engineered through biofortification and fortification.

> It's a global world — lots of trade based on comparative advantage — particularly in fruit and vegetables. But the social values of sustainability also see 'local as good', so greenhouses and hydroponic vertical farms are common in urban environments.

> UK farmscape and net zero are based around sustainable intensification and land sparing. UK production is focussed primarily on horticulture and grains, much less red meat, though ruminants are still farmed in a limited way. (Methane inhibitors partly deal with climate impact, but the pollution from manure affecting land, air and water quality, and biodiversity, was enough for Millennials to regard widespread livestock production as 'unsustainable').

> Pastureland is focussed on production of 'heritage meat', rewilded, or used for feedstock production (e.g. grass proteins extracted for non-ruminants).

> Social inequality is lower in this scenario than Scenarios A ('Build back fast') and C ('Circular worlds'): Food is a basic right — so a nutritious diet, though perhaps dull 'astronaut food'— is at least available and affordable.

Conclusions:
Implications for planning and decision-making

The four scenarios are based on different forward projections of what has already been happening and all have roots in today's world. Of course, if disruptive events of the last few years intensify, this could lead to still different futures with different politics, attitudes and resultant food systems. The scenarios are an attempt to sample the range of plausible futures – and none should be taken as a prediction. Instead, they are attempts to create internally consistent and contrasting storylines to help inform current planning for agri-food systems through the net zero transition.

Implicit in this analysis are two basic ideas. First, the future is increasingly difficult to predict: It is turbulent, novel and ambiguous. The mega-trends that have shaped today's world are changing. Economic and political power is shifting from West to East, and the multilateral cooperative world that has underpinned globalisation is coming under strain. There is increasing inequality, a fracturing of global markets, and competition between states. This all suggests the world of the future is less likely to be a predictable extrapolation of past trends towards globalisation.

The second basic idea is that new drivers of future change might emerge that are likely to be important but are not currently predictable. These might involve dietary changes, a shift in the geopolitical 'polarity' of the world, climate risks, de-globalisation or access to markets and technology. Such a range of alternative, plausible, futures raises two questions:

First, if business-as-usual is unlikely, what will the future look like? Given that the emerging drivers of the global and regional economies differ from the past, and yet the future is increasingly uncertain, how is it best to think about designing today's policies? Decisions made today may become less fit for purpose as the future diverges from the past. Thinking about alternative futures in this way is a route to challenging simple extrapolations of the past that simple extrapolations of the past that may not be relevant or useful.

Second, if 'black swan' events are likely to happen, will that shift us towards a different future? Today's economies often seem impossible to change, because there is so much personal, political and financial capital invested in today's systems. Lower income countries are invested in replicating pathways to development that have allowed higher-income countries to achieve their economic success. However, as COVID-19 and the Ukraine war have shown, 'business-as-usual' thinking about development can be undermined by events. While disruptions can be painful, they can also undermine how the system is locked-in to its current trajectory. In some circumstances, such events can drive structural change sufficiently to change the direction of travel. Recognition that such events occur, and will occur more frequently, reduces the risk that decision-makers are locked-in, or constrained, into believing the future is a simple linear development of the past.

In particular, the research and innovation needs of the very different worlds in 2050 require careful thought. Given that research, development and innovation may take decades to deploy at scale,

> " *Given that research, development and innovation may take decades to deploy, the technologies needed in 2050 should be being developed now.*

the technologies needed in 2050 should be being developed within the next few years. Equally, the research undertaken today is primarily built on a vision of the 2050 world arising from broadly, business-as-usual thinking. There is no guarantee that BAU will continue, given the way the world is currently evolving, and today's investments risk creating a locked-in path-dependency that prevents us investing in alternative innovation needs for alternative futures.

The research needs for the different scenarios are summarised below. What is striking is that for three of them agriculture is quite different from today's predominantly intensive model. It is agro-ecologically intensive in Scenario D ('The right to food') and features smaller, more diverse, mixed, low-synthetic-input systems in Scenarios B ('Circular worlds') and C ('Self-sufficiency for security'). All also have increased circularity.

Should we be preparing, through funding our R&D and innovation ecosystems, for different forms of agriculture (different crops, grown in different ways, within different farming systems, in different amounts) to ensure we are 'future-ready', whatever the future holds?

Equally, some of the plausible futures are in a normative sense likely to be better social futures. Are we investing enough in understanding and unlocking system transformation from the more dysfunctional futures (Scenarios A, C) to the more equitable ones (B and D). In the midst of this, how can we prioritise pathways that maximise co-benefits for human health and biodiversity? Systems change is always a challenge, because complex systems by their nature develop internal resilience to change (they become locked-in). It is also worth considering that to achieve net-zero is one goal, but to achieve net-zero in a more socially just world, is even better.

The broad research questions initially emerging from each scenario are:
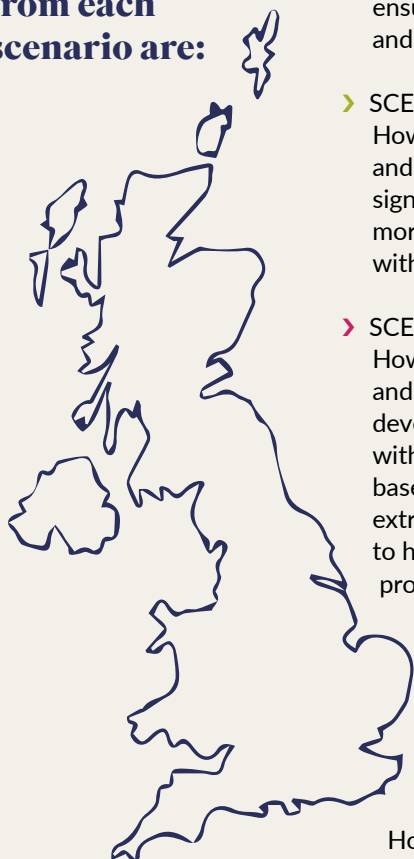
> SCENARIO A: **'BUILD BACK FAST AGAIN'**
How can we drive changes in social values to disrupt incumbent ideology and move away from this pathway?; How can we build resilience and maximise mitigation when developing adaptation strategies? What would a land use strategy look like to ensure land is used in the most useful way?; How can growing food insecurity and inequality be mitigated by producing cheaper food in crisis conditions?

> SCENARIO B: **'CIRCULAR WORLDS'**
How can we drive changes in social values to disrupt incumbent ideology and move towards this pathway?; How might capacity be built to promote significant new behaviours in lifestyles and farming practice?; How can new, more diverse and integrated mixed farming systems be developed, including with new technologies, that build in circular and agro-ecological principles?

> SCENARIO C: **'SELF-SUFFICIENCY'**
How can capacity be grown for urban and small-scale market gardens and allotments and cooking skills enhanced and promoted?; How can the development of lower-input, diverse and circular farming systems be developed with green manure replacing synthetic fertilisers?; How can the UK science base help develop and spread new technologies supporting legumes, protein extraction from grass and crops for animal feeds; What institutions are required to help ensure nutritional security shapes local agricultural production and producer-consumer relations?

> SCENARIO D: **'THE RIGHT TO FOOD'**
How can we drive changes in social values to disrupt incumbent ideology and move towards this pathway?; How can capacity be grown for urban and small-scale market gardens and allotments and cooking skills enhanced and promoted?; How best to maximise yields in intensive land-sparing; How best to develop green fertilisers and biological pest control methods; How can carbon storage best be developed on former pastureland?

APPENDICES

APPENDIX I - METHODOLOGY

The scenarios were built up from considering key uncertainties[4] which centred on three questions.

› **Geopolitics and stability**: Will the world be more volatile, conflicted and contested or return to cooperative, rules-based and calmer?
› **Economics**: Will we rediscover open, global markets and drive back towards globalisation, or move towards more regionalised, regulated and securitized markets?
› **Demand -consumption-based growth or more sustainability**: How will demand for the goods from land evolve? Will it grow unfettered, or will it decouple from resource demand, through price signals and sector or system innovation?

An initial '2 x 2 x 2' framing generated eight scenarios. These were reduced to four through a process that ensured that the set; was sufficiently future oriented; focussed on the external context; had a narrative description; were plausibly possible; provided a systematised set; and the scenarios are comparatively different.[5] The question about 'plausibly possible' was used as a test of internal coherence: Does each scenario represent a plausible set of relationships between actors and have a credible set of outcomes? The question about 'comparatively different' was used to ensure that the initial set of scenarios did represent distinctively different versions of the future, given the range of uncertainties. The four draft scenarios that emerged were taken into three workshops in Spring 2023. The first, at Chatham House, with a mix of in-person and online attendees, included participants with knowledge of international trade and finance, and geopolitics, as well as food and sustainability. It was designed to create a picture of the scenarios at an international level. The second, held online, was designed to translate the scenarios from an international context into the UK. This was an 'incasting' workshop, in which participants "articulate the implications of given alternative futures".[6] This was pursued using a set of futures questions developed by Lum and Bowman.[7] The third workshop, also held online, used a Three Horizons framework to identify the pattern and nature of systemic change between the present and a possible future patterns of transition within each scenario.[8]

The four scenarios that emerged each represent a different version of the future seen from the present. Clearly, they share that present, so they have different transition paths. 'Predetermined' elements refer to those elements of the future that effectively have been predetermined by prior systemic changes described by Drucker as "the future that has already happened ".[9] They are likely to be found in all scenarios. Predetermined elements included:

› Continuing climate change deterioration, including more extreme weather events;
› Continuing deterioration of biodiversity in the medium term, even in scenarios where people choose to act on this;
› Continuing increase in global population numbers, certainly in the medium term and likely for the full quarter of a century of the scenarios;
› An energy market in which renewables are the cheapest means to produce energy;
› Downward pressure on productivity and growth because of resource constraints, certainly in the medium term;
› Generational values will evolve and will differ by generation;
› Over the next quarter of a century we are extremely unlikely to see a return to a single hegemonic global power; and
› Politics will continue to be shaped over the next generation, by responses to the global financial crisis and its aftermath.

APPENDIX II - PARTICIPANTS AT SCENARIO WORKSHOPS

Participants at each of the scenario workshops varied, but included the following:
Network+ Team
Andrew Curry (School of International Futures)
Tim Benton (Chatham House/University of Leeds)
Sarah Bridle (University of York)
Stefan Kepinksi (University of Leeds)
Angelina Sanderson Bellamy (University of West of England)
Neil Ward (University of East Anglia)
Tom MacMillan (Royal Agricultural University)
Simon Pearson (University of Lincoln)
Jez Fredenburgh (University of East Anglia)
Sophie Constant (AFN Network+ Team)
Jess Nuttall (AFN Network+ Team)
Claire Pickerden (AFN Network+ Team)

Network+ Champions
India Langley (LettUs Grow)
Anna Macready (University of Reading)
Simon Willcock (Rothamsted Research)
Jacquie McGlade (University College London)
Bob Costanza (University College London)

Network+ Early Career Board Members
Saher Hasnain (University of Oxford)
David Baldrin (James Hutton Institute)
Joanna Ferreira (Scottish Rural College - SRUC)
Zainab Oyetende-Usman (Rothamsted Research)

Those directly involved in the Network+ were joined at the workshops by around 40 other individuals drawn from a wide range of organisations including: UK universities and research institutes; central government departments and agencies involved in food, health and environment; international development agencies such as the UN; national and local farming groups covering both conventional agriculture and environmentally-progressive production systems; environmental organisations; international commodity trading organisations; the security and diplomatic services; commercial organisations; international financial services including national banks. Participants contributed as individuals and not as representatives of their organisations.

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[8] Curry, A. and Hodgson, A. (2020). 'Seeing in multiple horizons: connecting futures to vision and strategy'. In Slaughter R., and Hines, A. (eds), *Knowledge Base of Futures Studies*. Houston: Association of Professional Futurists.
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