STFC Food Network+

University of York

UKRI Science and Technology Facilities Council

The UK Food Systems in 2050: Trends, Roadmaps, and Future Research Needs

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- Dr Stephen Mackenzie, Sustainability Specialist (GHGs in Food Systems), WRAP
- Prof Dominic Moran, Professor of Agricultural and Resource Economics, University of Edinburgh
- Prof Judith Evans, London South Bank University, UK
- Prof Ilias Kyriazakis, School of Biological Sciences, Queen University Belfast.
- Prof Richard Napier, School of Life Sciences, University of Warwick.
- Pete Robertson, Chief Executive, Food & Drink Federation Wales.
- Cathrine Baungaard, Food Service Sustainability Advisor, WWF.
- Alice Garvey, Sustainability Research Institute, School of Earth and Environment, University of Leeds.
- Dr Luana Swensson, Policy Analyst for Sustainable Public Procurement, Food and Agriculture Organisation of the United Nations (FAO).
- Prof Tony Heron, Profesor of International Political Economy, University of York.
- Prof Matt Lobley, Professor of Rural Resource Management, University of Exeter.
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Executive Summary

Since mid-2019 the UK has legally committed itself to be one of the first countries to reach Net Zero greenhouse gas emissions by 2050. We are less than three decades from that deadline, and a multiplicity of strategies and pathways, emerging constantly, is adding further complexity to urgent decision-making. At the STFC Food Network+, we aim to contribute to reaching such an ambitious goal, by providing agri-food researchers and stakeholders with a plural and diverse forum to re-imagine and re-design the UK food system for it to be Net Zero. **This report is based on the April 28th, 2022, online panel discussion and participatory workshop entitled 'The UK Food Systems in 2050: Trends, Roadmaps, and Future Research Need' as well as on follow-up consultations with UK food system stakeholders.** Hence, it constitutes a piece of collective thinking from researchers and stakeholders already working towards the decarbonisation of the UK food system.

Our goals for the April workshop and follow-up consultations were to:

1. Collectively forecast the UK Food System of 2050.
2. Identify current challenges and future research directions.
3. Discuss what is needed for designing sector-specific roadmaps.
4. Identify challenges and opportunities on how Net Zero can be assessed and measured.

In our 2022 workshop, the opening talk by Professor Toby Peters shed light on the current system-level challenges. **Peters pointed out the limitations of reductionist approaches, and how the lack of interconnectivity amongst stakeholders' roadmaps is hindering the potential for a speedy and steady transition.** Participants and speakers explored the ongoing situation in which short-term fixes are far from useful, **stakeholders' data continues to be contested and the complexity around extant metrics makes decision-making difficult.** Acknowledging these challenges all participants were invited to forecast the UK 2050 food system and these are some of the features that we wish will describe it when the time comes:

What is a resilient and Net Zero Food System?

- Respects planet boundaries
- Intergenerational equalitarian
- Waste free
- Socially inclusive
- Transparent footprints
- Environmental externalities are internalised

The workshop continued with a set of insightful presentations by a group of experts for each of the following sectors: primary production, food manufacturing, retail and consumers, the public sector, and food trade. For each one, speakers and participants discussed key roadmaps and scrutinized their feasibility given present technological, societal, and economical endeavours. Rich discussions were essential to come up with specific ideas on how we expect each sector to look in a 2050 Net Zero scenario and which questions must be properly addressed as of now. The expertise of researchers, practitioners, and stakeholders led to significant topics emerging and a fruitful exchange of ideas. You can find a collection of them below.

• Primary production	• We will have a different conception of what farming means. • There will probably be more focus on alternative proteins as well as a focus on circularity. • It is likely that for the UK there will be a reduction in the size of the livestock sector and that farming will be regenerative.
• Food manufacturing	• Will supermarkets exist in the future? Or will food delivery be the norm?
• Retail and consumers	• We will achieve a shift to alternative proteins, in Europe and the UK non-meat will be normalised, for instance, insects. • Market competition will lead to decreasing prices and higher availability of meat substitutes.
• Public procurement and food trade	• Tendering processes and other public procurement mechanisms will be aligned with Net Zero agendas. • Public procurement contracts will be specific and target NZ goals. • Tendering approaches will be flexible and adaptable for NZ purposes.

Five future research areas

During the two final sessions of our workshop participants were asked to identify the main food system conflicts they think are hindering the Net Zero transformation of the UK food system. Whilst doing so, participants observed progress regarding available assessments and measurements of emissions generated when producing, manufacturing, buying, consuming and regulating food. When consulting stakeholders, we asked them to contribute to identifying the most relevant areas for research based on our workshop discussions and their expertise. Collectively five main areas were established, and a detailed description of each one can be found in the final sections of this report. We encourage our fellow academics, researchers, food system stakeholders, and public policy practitioners to read the full report for a deeper understanding of the work behind it.

Research needs

Biodiversity and nature recovery	• Comprehensive and robust analysis on current and future Environmental Land Management Schemes (ELMs), particularly their unintended consequences for farmers' livelihoods and biodiversity. • Linking bioeconomy for food system transformation • Nature positive net zero food systems
Technology and modelling system-of-systems transitions	• Development and analysis of comprehensive measures and robust models for tracking GHG emissions across Scopes 1, 2, and 3. • Analysis of appropriate mixes of technologies to facilitate emissions reductions. • System of systems approaches to develop pathways towards Net Zero commitments.
Governance mechanisms and the need for diverse transition approaches	• Design and development of hybrid governance mechanisms for collaboration, and to improve and ensure data sharing, investment, joint decision-making, and net zero policy development. • Estimating potential carbon abatement from complementary approaches to Net Zero.
Reforming our carbon pricing policies	• Robust models of abatement potential. • Analysis for potential transformations of the current carbon pricing system. • Design and development of governance framework(s) to ensure all stakeholders are considered.
Public procurement transformation	• Analysis of public procurement mechanisms to trade in residual carbon that is not avoided by net zero policies. • Development of complementary approaches to facilitate private and regulated markets for trading agri-food system carbon prices for negative emissions.

INTRODUCTION

Achieving a UK Net Zero food system(s) in less than three decades is one of the most challenging tasks British society is facing. From farming to waste, management stakeholders are mostly on board, yet the 'how' question is yet to be answered. Whilst there is a shared understanding of the urgency to decarbonise the way we produce, process, package, store, distribute, retail, and consume food, there are several uncertainties regarding which technologies, policies, interactions, and strategies will ensure that the goals are met on time.

In mid-April 2022 the STFC Food Network+ made a call for academics, industry, government, civil society, and interest groups to participate in an online panel discussion and participatory workshop entitled **'The UK Food Systems in 2050: Trends, Roadmaps, and Future Research Need'.** The workshop was held on April 28th and its main goal was to collectively assess, identify and discuss research and the overarching needs for one of the most pressing issues for the British food system: how to delink it from carbon emissions? The goals of the workshop were:

- Collectively forecast the UK Food System of 2050.
- Identify current challenges, sector misalignments, and future research directions.
- Discuss what is needed for designing sector-specific roadmaps.
- Identify challenges and opportunities in how Net Zero can be assessed and measured.

In order to best utilise the wide-ranging expertise, the workshop combined key speakers' contributions, panel discussions, and participatory spaces for discussion. This report details the workshop proceedings and includes contributions from follow-up consultations with experts and stakeholders.

NET ZERO FOOD SYSTEMS: THE BIG PICTURE

The first section of the workshop revolved around the ongoing system-level challenges, the future research needs, and the disconnection between Climate Change and sustainable food systems research.

Professor Toby Peters presented his take on the current system-level challenges, underscoring the main sources of emissions within the British food system and sharing his opinion on the reductionist approaches to decarbonisation that have been developed so far. Furthermore, Peters stressed the lack of interconnectivity amongst ongoing potential Net Zero sectoral and stakeholder roadmaps.

To conclude, Professor Peters sent a strong message around three key ideas:

Urgency for quantifying the real value of Net Zero food systems.

Analyse ongoing changing trends and how this is leading stakeholders to rethink their business model.

Planning with a bottom-up approach and with flexibility.

UK FOOD AND DRINK INDUSTRY EMISSIONS

Presenting the topic of Future Research Directions, **Stephen Mackenzie, Sustainability Specialist for WRAP**, shared with the workshop audience what WRAP has recently identified while working with UK food business representatives and other stakeholders signatories of The Courtauld Commitment 2030.

Food GHG emissions...

- Globally, food systems are responsible for around one-third of total emissions.[1]
- In the UK: In 2019, total food system emissions were estimated to be 158 Mt CO2e.[2]
- **UK food waste only**: 36MT of emissions are associated with food waste and are equivalent to 23% of total UK's food system emissions.[2]

Not as speedy as we need!

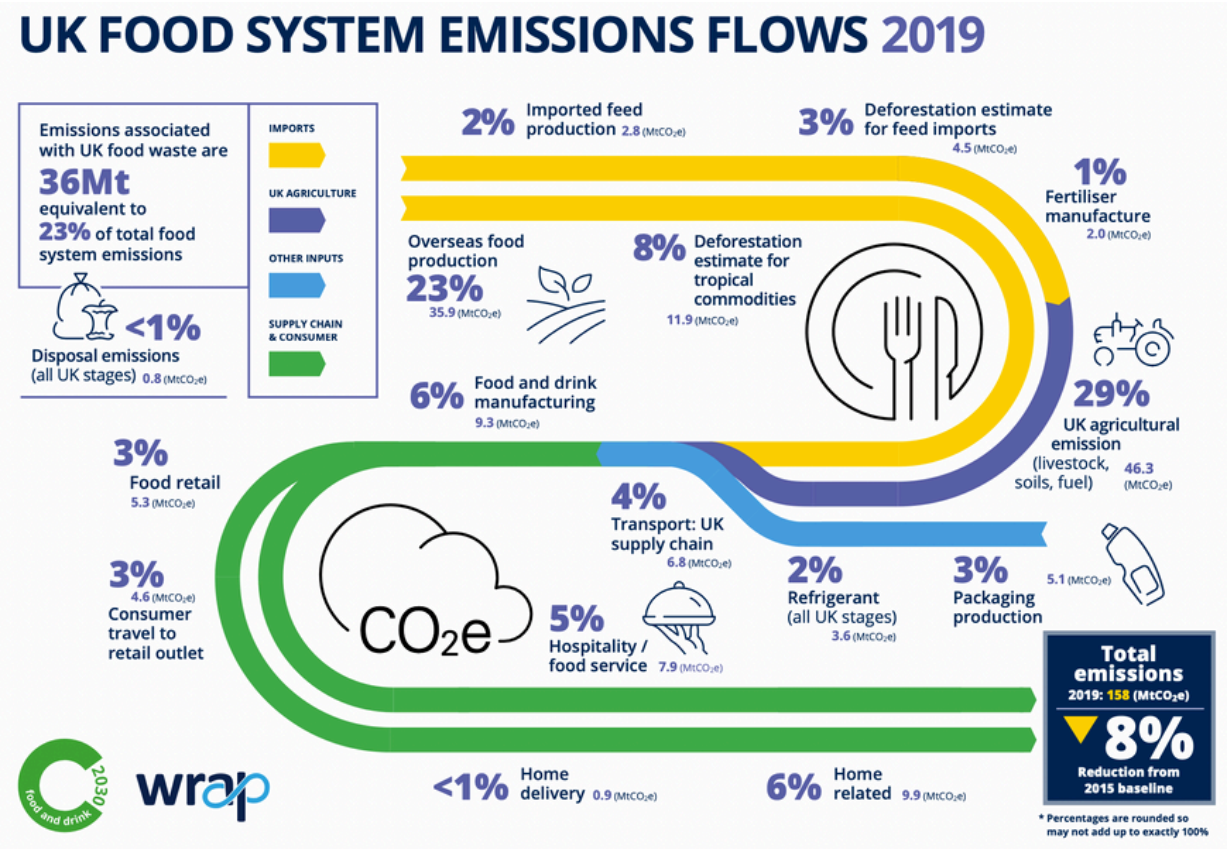
- Emissions' reductions are not at the speed needed as time runs out.

Reliable data is urgent.

- Across food stakeholders data on emissions and other footprints is really contested, it is of the utmost importance to build and deliver consistent and transparent data.

UK FOOD AND DRINK INDUSTRY EMISSIONS

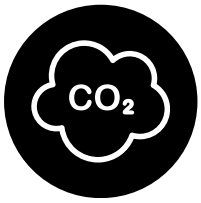
Overall, Mackenzie portrayed a British food industry willing to participate in decarbonising businesses, yet still working with short-term fixes, and with many areas for improvement regarding data generation, sharing, and management.



Pathway 2030: Delivering a 50% reduction in the GHG footprint of UK food and drink. WRAP 2021. [3]

CLIMATE CHANGE RESEARCH PRIORITIES FOR SUSTAINABLE FOOD SYSTEMS

For this section, Professor Dominic Moran presented his talk on Sustainability metrics and policy/governance. Professor Moran's talk shed light on the current complexity of available metrics for sustainability across food systems. For one thing, solely for the farm sector, Moran and collaborators have identified around 180+ mitigation measures already available. However, regarding the consumption sector, Moran suggests there is space to use the price system via taxation, but an evaluation of potential outcomes is urgently needed. Finally, Moran shared three essential points for being on track to make Net Zero food systems a reality:



No. 01 — Carbon budgets

Define carbon budgets for each sector, by subtracting cost-effective abatement potential from emissions projections.

No. 02 — Potencials

Ask the difficult questions, for instance: do we have full technical potential? Economic, feasible (behavioural) and policy potentials?

No. 03 — Policy bodies

An overarching governance structure is needed for relevant policy bodies. How do we work this out?

Defining a resilient and NZ food system in 2050?

What is it?

- Respects planet boundaries
- Intergenerational equalitarian
- Waste free
- Socially inclusive
- Transparent footprints
- Environmental externalities are internalised

What are the present challenges?

- Data generation, disclosure and homogenisation.
- Consumer literacy needs significant improvement.
- Ethical and environmental consumer gap.
- Responsibilities are not defined.
- The role of the Government is unclear.
- The governance of the processes for transitioning towards Net Zero has no leading actor.
- Producing cheap food might be impeding the conformation of networks and collaboration.
- The UK relies on a significant amount of imported food that comes with imported CO2.

SECTOR SPECIFIC ROADMAPS

The second section of the workshop revolved around the current state of sectoral Net Zero roadmaps and the identification of potential conflicts amongst sectoral goals. **Professor Judith Evans and Dr Stephen Mackenzie** co-chaired the session. The sectors and speakers are listed below.

1. **UK Primary Production:** Prof Ilias Kyriazakis, School of Biological Sciences, Queen University Belfast.
2. **UK Food Manufacturing:** Pete Robertson, Chief Executive, Food & Drink Federation Wales.
3. **UK NGOs / Retailers:** Cathrine Baungaard, Food Service Sustainability Advisor, WWF.
4. **UK Consumption:** Alice Garvey, Sustainability Research Institute, School of Earth and Environment, University of Leeds.
5. **Public Sector Procurement:** Dr Luana Swensson, Policy Analyst for Sustainable Public Procurement, Food and Agriculture Organisation of the United Nations (FAO).
6. **UK Food Trade:** Prof Tony Heron, Prof of International Political Economy, University of York.

Once the overall picture was presented by the key speakers, participants were asked to collectively and actively contribute by responding to three main questions for each sector: What will this sector look like in 2050? How do we get there? And what are some of the big questions we need to ask now? Breakout rooms were set up according to participants' affiliations when registering. The results of the discussions and keynotes from the speakers are condensed over the following pages.

PRIMARY PRODUCTION

Discussed roadmap:
The Centre for Innovation Excellence in Livestock (CIEL) recently published its '**Net Zero & Livestock. How can farmers reduce emissions?**' report (April 2022).[4]

Main challenges:

- Livestock accounts for circa 7% of total GHG emissions in the UK.
- Enteric fermentation and manure management are the top contributors.
- Estimations, targets, and deadlines for reducing emissions are diverse.

Potential reductions:

- Up to 23% of emissions could be reduced if CIEL report recommendations are followed.
- CIEL suggests improving efficiency as the main strategy for action.
- There is research and data available to reduce emissions in this sector.

Livestock accounts for circa 7% of total GHG emissions in the UK. [4]

PRIMARY PRODUCTION

What will this sector look like in 2050?

- We will have a different conception of what farming means.
- There will probably be more focus on alternative proteins as well as focus on circularity.
- It is likely that for the UK there will be a reduction in the size of the livestock sector, and that regenerative farming practices will be in place.
- We see a potential for segmentation of the market, one focusing on cheap food and the other on what we could call 'luxury' production, e.g. food items with sustainable qualities.

How do we get there?

- Make sure there is a fair share of responsibilities amongst producers, manufacturers, retailers, and government, through collaborative multi-stakeholder governance.
- Do not treat all livestock sectors as homogenous and recognise different systems.

What are some of the big questions we need to ask now?

- How to capture potassium and nitrogen so they stop being the main waste coming from the food system?
- What role is regenerative livestock farming playing?
- How to assess Life Cycle Analysis(LCA) for different systems? And how do we make it transparent, transferable, and scalable?
- How to move beyond GHG emissions and include micronutrient deficiency, and livelihood stresses?
- What complexities and path dependencies and power dynamics need to be considered to avoid exclusively focusing on techno-fixes as silver-bullet solutions? For instance, plant-based diets are often presented as singular standardised options but there are different crops and processes that have different impacts. How can these be incorporated into these models?
- How can culture be integrated into these recommendations? Especially as much research is done through a Global North lens.

FOOD MANUFACTURING

Discussed roadmap:
The Food and Drink Federation (FDF) Net Zero Handbook (November 2021).[5] FDF's handbook relies on looking at scope 1, 2, and 3 emissions across the UK food and drink supply chain.

Main challenges:

- 34% of UK food and drinks' emissions come from ingredients, out of that 32% are generated by imported ingredients.
- Feed production (for livestock) is one of the top energy-intensive sectors in the supply chain.
- Around 20% of UK food emissions are outside the manufacturing sector and are generated during consumption.
- To effectively abate emissions, manufacturers and brand owners need to act in unison, yet many are launching their own ambitious commitments and programs.
- Methodologies and data measurements are diverse and, as a result, are increasing the complexity of the shared task.
- A change of culture is needed in order to find a balance between collaboration and competition amongst all food and drink stakeholders.

34% of UK food and drinks' emissions come from the ingredients, out of that 32% are generated by imported ingredients.[5]

FOOD MANUFACTURING

What will this sector look like in 2050?

- We expect the sector to look very different, yet there are many unknowns and non-considered factors.
- Will the supermarkets still exist in the future? Or will food delivery be the norm?

How do we get there?

- Building alignment and agreement between stakeholders, e.g., supermarkets and their roadmaps and commitments.
- Assessing the opportunities for integration as a way of sharing resources. Use modelling tools to achieve integration of resources across supply chains.
- Assess the need for an overarching organisation that leads the progress and organisation of the transition so that alignment of goals is achieved.

What are some of the big questions we need to ask now?

- What are the actions being taken to engage micro and SMEs in net-zero discussions and commitments? In the short term, most SMEs face economic challenges that often disincentivise actions to reduce their emissions.
- Are we doing research on the labour and skills issues along the food supply chain?
- What innovation skills do manufacturers and retailers need and how should these be implemented
- How to overcome the food security issues that the UK faces?

RETAIL AND CONSUMERS

Discussed roadmaps:

1. The WWF Basket[6] initiative. The Basket lays out seven priorities for UK food retailers to tackle the climate and nature crises: deforestation and conversion, climate, diets, agriculture, marine, food waste, and packaging.
2. 'Reducing the UK's food footprint: Demand-side action for more palatable food emissions' (CREDS, 2021).[7]

Main challenges:

- There is a research gap in terms of defining what ratio of plant and animal proteins should be in place to achieve Net Zero targets. These must be realistic and consider the carbon footprint of animal protein replacements.
- Similarly, when should we set the deadline for retailers and food service providers to fulfill these protein splits ?
- More research is needed around behavioural change and consumer engagement with eco-labels.
- Consumers are not the sole ones responsible for the change we need, policy must back up this transformation.
- Policy incoherence amongst government departments involved in UK food and Net Zero policies.

Potential reductions:

- Foodservice businesses to work on plant-forward menus.
- Many companies are converting their animal protein reduction strategies into tangible metrics and publicly disclosing their commitments.
- Using regulation to mainstream flexitarianism and carbon footprint labelling.

'Demand-side action on consumption should not be assumed as the sole responsibility of consumers.'[7]

RETAIL AND CONSUMERS

What will this sector look like in 2050?

- We will achieve a shift to alternative proteins, in Europe and the UK non-meat will be normalised, for instance, insects.
- Market competition will lead to decreasing prices and higher availability of meat substitutes.
- We envision structural changes as it would be a system with more digitalisation, more online shopping, and integrating of carbon data information on consumption. Similarly, changes to the structure of agriculture, through closer interaction with farmers, potentially via AI in farms.
- Consumers will likely engage in production at local and urban scale. This will have implications for reducing food insecurity and contributing to local employment.
- As a countershift, there could be a new social stigma out of the non-net zero diets, or meat-based diets.

How do we get there?

- Work on consumer literacy and promote a substantial degree of consumer mobilisation.
- Prioritise local and regional food production.
- Use existing local initiatives that have developed a carbon plan.
- Develop initiatives to retain value in the local area.
- A mixture of push and pull strategies is needed, including regulation. Some of these changes will occur organically, thus achieving the Net Zero deadline might not be the case.

What are some of the big questions we need to ask now?

- What about the systemic challenges as it is the asymmetric power relationship between big players, e.g. supermarkets and consumers?

PUBLIC SECTOR AND FOOD TRADE

Discussed roadmap:
Public food procurement as a game-changer for food system transformation (Swensson et al., 2021).[8]

Main challenges:

- Governments must capture and analyse the data regarding from whom we are buying food and how to reduce its footprint.
- Difficult questions to ask: which production practices are we supporting? Which vulnerable groups are we overlooking?
- Public food procurement must be analysed from a global perspective.
- Data for impact evaluation of public procurement initiatives targeting food systems transformation is not available yet.
- In international trade, most of the carbon emissions come from the point of production, not from transport.

Potential reductions:

- Public procurements have the potential to send signals to the food systems' directions.

Which production practices are we supporting?
Which vulnerable groups are we overlooking?

PUBLIC SECTOR AND FOOD TRADE

What will this sector look like in 2050?

- Tendering processes and other public procurement mechanisms will be aligned with Net Zero agendas.
- Public procurement contracts will be specific and target NZ goals.
- Tendering approaches will be flexible and adaptable for NZ purposes.
- Public procurement organisations will be the ones that work to design NZ-sensitive contracts.

How do we get there?

- Assess our public procurement practices and legal constraints, so they can be transformed.
- Assess our carbon leakage and importing carbon through the international food trade.

What are some of the big questions we need to ask now?

- Who will be responsible for implementing NZ public procurement contracts and regulations?
- How to reconcile the political mandate and aim of diversifying the UK trade relationships with decarbonisation?
- WTO rules on non-discrimination impede members' ability to discriminate between trade partners on the basis of how their goods are produced. How then to decide whom we trade with and align the decisions with the carbon emissions reductions targets?
- How are we decarbonising international trade transport, e.g., marine transport versus last-mile transport?

FOOD SYSTEMS CONFLICTS

For session two **Professor Matt Lobley, Professor of Rural Resource Management at the University of Exeter** shared his expertise on understanding British farmers and their challenges. Lobley highlighted that whilst there are some primary producers obtaining high profits, most face severe and profound challenges which must be considered when considering how to bring the sector into transition to an NZ food system. Specifically, Professor Lobley referred to the **aging age structure of farms' legal holders, sometimes low education and literacy levels amongst the older generation, and poor mental health, including high levels of stress and anxiety. If these pressuring factors are not incorporated when designing NZ agricultural policies they would be overlooking the stark reality of British farming.** Furthermore, in the UK farming is performed by family businesses who were heavily dependent on the Common Agriculture Policy (CAP). To illustrate, around 40% would have made a loss if they hadn't received the basic payment, and most were making either a low or a very low profit.

Hence, prior to incorporating the NZ agenda into agricultural and food systems policies, in Lobley's perspective, we ought to comprehend that any further requirement represents extra layers of demand for primary producers. **Particularly difficult is the situation of livestock farmers who are facing the most challenging and demanding policy transformations,** in terms of demanding from them the environment, water, biodiversity, clean air, and clean water. In short, when applying the narrative of public money for the public good to basic payments schemes, it is fundamental to ask: how are we supporting farmers so they move towards the NZ transition? The audience was invited to pose questions and comments in response to Professor Lobley, among which we selected:

- Is it profitable to be a farmer in the UK today?
- What could farmers change in the way they work today to be financially better off?
- What unequal power distributions are there across value chains and what are their implications for farmers' profits?
- The British farming sector benefits from training and co-learning schemes, and we are in need of more work in this area of action.

NZ Food Systems Assessment and Measurements

What needs?
What measurements?

- The final session of the workshop delved into the discussion around needs and how we assess and measure NZ? In response, workshop participants, including academics, industry, government, and NGO representatives contributed by providing comments mainly related to the key priorities listed below.

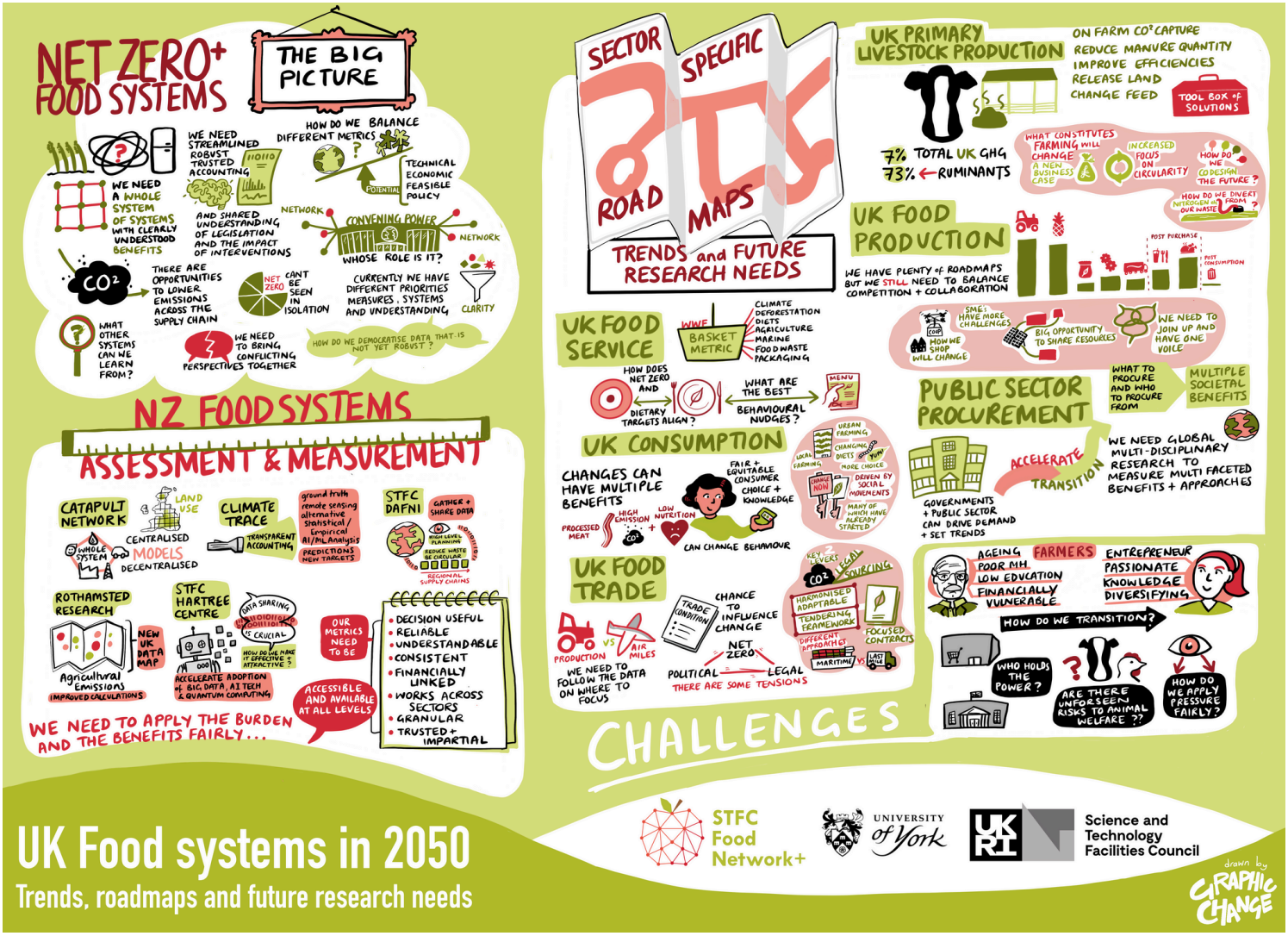
Priorities

- We are in urgent need of generating reliable, transparent and non-biased data;
- It is fundamental to develop tools for the homogenisation of footprints metrics;
- All sectors and stakeholders will benefit by ensuring data accessibility and availability.
- Using independent sources of data is of utmost importance.
- Developing skills and technology for tracking and sharing data is one of the biggest areas for improvement across the UK food system.

For the reunited group of experts, there was consensus that **we are still not where we should be to speed up the transitions we urgently need. Especially, there is an urgent need for building useful metrics for decision-making, reliable, understandable, and consistent for all food system actors.** Missing this essential step would undoubtedly impede further progress toward zero carbon emissions for the UK food system.

Two features for data to be useful were underscored by several stakeholders. On the one hand, **data must achieve higher levels of granularity.** On the other hand, **data should always be trusted and impartial** if the food system is aiming to be, not only carbon-free but socially just.

Graphic Change witnessed the entire workshop and a visual recording was created.



Future Research Areas

Biodiversity and nature recovery

Participants discussed:	• Net zero, food, and nature are all linked, and landscapes need to deliver on all components for a sustainable food system. Currently, participants spotted a lot of unknowns around, for instance, Environmental Land Management Schemes(ELMs), and how/if they will deliver better for biodiversity than current agricultural-environment schemes. • From a biodiversity perspective, there are concerns that any changes in yields and production may have leakage effects, leading to increased imports of food produced elsewhere with poor sustainability credentials.
Future research areas	• Comprehensive and robust analysis of Environmental Land Management Schemes(ELMs). • Interactions and considerations on nature recovery commitments linked to the food system. • Linking bio-economy for food system transformation. • Nature positive net-zero food systems

Governance mechanisms and diverse transition approaches

Participants discussed:

- Viable net-zero pathways for the UK food system ideally encompass land, water, and energy decarbonization pathways and are co-developed by a cross-industry coalition of public and private stakeholders and investors with a clear framework, methodology, and metrics for assessing the value and viability of potential net zero pathways, including technology maturity, behavioural factors, change readiness and cost of asset deployment.
- Other net-zero transition approaches (beyond technology and energy innovations) are relevant and needed. For instance, climate adaptation, deceleration, co-evolution, and policies that incentivise behavioural change.
- Different stakeholders are constrained by different forms of carbon lock-ins that may prolong, defer, or prevent smooth and coordinated transitions to low-carbon food production and consumption alternatives in the absence of a governing framework.

Future research areas

- Design and development of hybrid governance mechanisms for collaboration to improve and ensure data sharing, investment, joint decision-making, and net-zero policy development between large, medium, and small-scale food businesses, and the public and civil sectors.
- Estimating potential carbon abatement from complementary approaches to net zero such as discontinuation, phase-out, divestment, and destabilization.

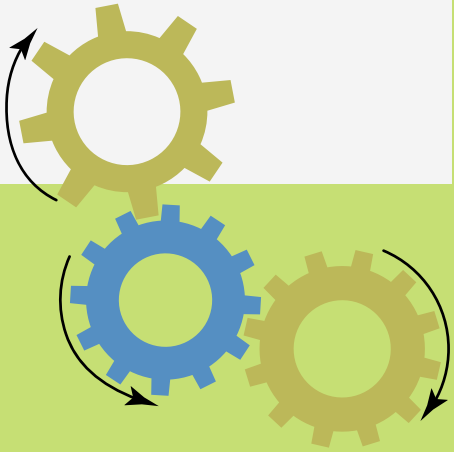
Technology, modelling and system-of-systems transitions

Participants discussed:

- The role of advanced precision agriculture, data capture and analytics technologies in improving point-of-source measurement of emissions.
- Developments in net-zero initiatives with negative costs, particularly those related to energy efficiency, process optimisation, and land management having longer-term economic returns. Other more expensive options currently considered include low-carbon energy (electrification) using solar, wind, nuclear, biofuels and carbon capture and storage (CCS).
- The government net-zero policies and investments currently centre on energy and technology transitions (biofuels, EV, hydrogen) and most deep decarbonization pathways that have been proposed do not account for the system-of-system impacts of energy transitions on food industry stakeholders, other sectors, and incumbent extractive industries.

Future research areas

- Comprehensive measures and robust models for tracking major GHG emissions across Scope 1, 2, and 3 emissions.
- Appropriate mixes of technologies (data capture, modelling, automation, and digital transformation) to facilitate emissions reductions and meet stakeholders' market and operational requirements (availability, safety, ethics, equity) within a carbon budget.



Reforming our carbon pricing policies

Participants discussed:

- The need for reforms around carbon pricing policies, in order to create a complementary mechanism for charging polluters and selling negative emissions based on robust models of abatement potential of different actors in the food chain.
- Some advocated for a medium-level, sector-specific carbon pricing system to be implemented and supported by clear guidelines, regulations, technology investments, and incentives to stakeholders for negative emissions.
- The need for stakeholders to run joint trade-off assessments of competing abatement costs and potentials across the food chain. This need comes from the fact that some cost-effective options may have small total abatement potential, while other more expensive ones could provide greater collective and cross-sectorial negative emissions.
- Regarding the production stage, participants advocated for a governance framework to unify and standardise existing metrics and methodologies for defining, abstracting, modelling, and analysing the system-of-systems problems of net zero accounting and reporting.

Future research areas

- Robust models of abatement potential
- Analysis for potential transformations of the current carbon pricing system
- Design and development of governance framework(s). A novel governance framework would be required to bring together all relevant stakeholders to ensure that abatement potentials and costs of different NZ pathways for producers, processors, retailers, and distributors are adequately assessed and weighted. Such a governance framework could focus on multiple net zero objectives (ecological, market, fiscal, technical, behavioural).

Public procurement

Participants discussed:	• The recently published series of governmental guidelines, and Carbon Reduction Plans for procurement of major government contracts; participants noted the requirements only apply to tenders by Central Government, executive agencies, and non-departmental public organisations. • The government's commitment to green procurement, and the proposed pathways to net zero. Participants suggested there is a need for evidence and clear sector-specific metrics for low-carbon products. Similarly, a clear and urgent need to incentivise stakeholders to introduce voluntary labels and standards for net zero procurement was discussed and reflected on the ideal timing, which could be as early as 2025, according to the Treasury's recent Net Zero Review. [9]
Future research areas	• Public procurement mechanisms to trade in residual carbon that is not avoided by net zero policies using revenues generated from carbon pricing. • Development of complementary approaches to facilitate private and regulated markets for trading agri-food system carbon prices for negative emissions and facilitate carbon subsidies using carbon tax revenues.

CONCLUSIONS

At present, in the UK the carbon footprint of food and drink (including imported emissions) is equivalent to around 35% of total GHG emissions (WRAP, 2021), and as our participants and consulted experts expressed, we are not moving quickly enough to meet the Net Zero target by the set deadline. Moreover, isolated short-term fixes are not getting us where we ought to be, hence teamwork in the form of multistakeholder governance and policy coherence are fundamental. Yet, through our April workshop and following-up consultations, we envision a food system operating purely on clean energy (or when needed offsetting any remnant carbon emission), animal proteins represent 50% or less of consumed proteins, land-use change in the Tropics is no longer linked to food consumed in the UK, circularity is the norm and not the exception. However, to achieve such a food system, major technological, scientific, and political changes need to be made in record time. We list below a group of top priorities for all stakeholders to work on speedily, if we aim to reach our goal by mid-century:

- Improve sectoral emissions data quality, availability, and shareability.
- Estimate the economic opportunity that NZ food systems represent so we can seize it.
- Understand how businesses models are evolving due to ongoing trends
- Enforce responsibilities on data generation and disclosure.
- Assess UK farmers' current needs and how to fairly co-design NZ farming practices across the country.

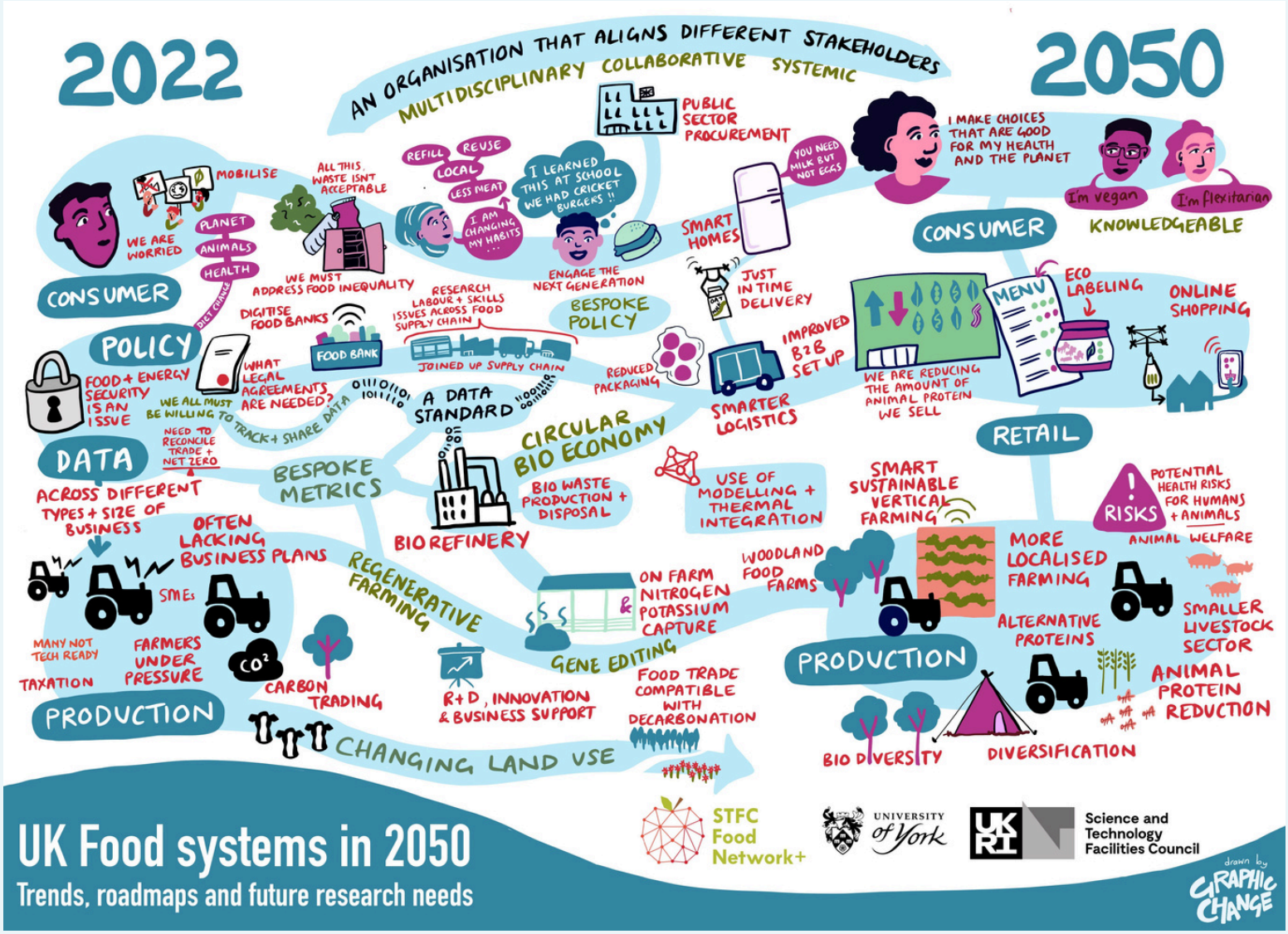
Additionally, workshop participants and consulted experts were invited to share their ideas on specific research needs, we share below a selection of them:

- On farming: understand how to reconcile environmental conservation and farming through bottom-up approaches.
- On food manufacturing: opportunities for connecting interventions aiming to tackle emissions.
- On consumers: consumer literacy and overcoming the ethical and sustainable gap.
- On retailing: estimate the ratio of plant and animal proteins at retailers and food service points.
- On public sector and food trade: development of data for transforming public procurement to NZ goals.

Plenty of work remains to be done and with urgency, yet we find space for optimism seeing an increased engagement and level of commitment across the food system stakeholders.

A summary of future research for transforming the UK food systems

ROADMAPS



+ 100

Over 100 participants and stakeholders discussed and participated in providing ideas around designing feasible and just roadmaps for achieving a UK Net Zero food system by 2050!

List of chairs, co-chairs and speakers

We would like to acknowledge the following individuals and organisations whose contributions made the workshop possible and fruitful.

Net Zero+ Food Systems: The Big Picture
Chairs:

- Prof Sonal Choudhary, Professor of Sustainable Management, University of York,
- Prof Toby Peters, Professor in Cold Economy, University of Birmingham.

Speakers:

- Prof Toby Peters, Professor in Cold Economy, University of Birmingham
- Dr Stephen Mackenzie, Sustainability Specialist (GHGs in Food Systems), WRAP
- Prof Dominic Moran, Professor of Agricultural and Resource Economics, University of Edinburgh

Sector Specific Roadmaps
Chairs:

- Prof Judith Evans, London South Bank University, UK
- Dr Stephen Mackenzie, Sustainability Specialist (GHGs in Food Systems), WRAP

Speakers and breakout rooms co-chairs:

- UK Primary Production: Prof Ilias Kyriazakis, School of Biological Sciences, Queen University Belfast. Co-chair: Prof Richard Napier, School of Life Sciences, University of Warwick.
- UK Food Manufacturing: Pete Robertson, Chief Executive, Food & Drink Federation Wales.
- UK NGOs / Retailers: Cathrine Baungaard, Food Service Sustainability Advisor, WWF.
- UK Consumption: Alice Garvey, Sustainability Research Institute, School of Earth and Environment, University of Leeds.
- Public Sector Procurement: Dr Luana Swensson, Policy Analyst for Sustainable Public Procurement, Food and Agriculture Organisation of the United Nations (FAO).
- UK Food Trade: Prof Tony Heron, Prof of International Political Economy, University of York.

List of chairs, co-chairs and speakers

Food Systems Conflicts
Chair:

- Dr Christian Reynolds, Senior Lecturer, The Centre for Food Policy, City University, London

Speaker:

- Prof Matt Lobley, Professor of Rural Resource Management, University of Exeter

NZ Food Systems Assessment and Measurements
Chairs:

- Prof Sonal Choudhary, Professor of Sustainable Management, University of York,
- Dr Raymond Obayi, Researcher and Assistant Professor in Operations, Project, and Supply Chain Management, Alliance Manchester Business School.

Speakers:

- Matthew Jones, Practice Manager at Energy Systems Catapult.
- Sam Schiller, Co-founder and CEO Carbon Yield, Climate TRACE partner.
- Dr Laura Cardenas, Rothamsted Research.
- Dr Robin Pinning, Chief Technology Officer, STFC Hartree Centre - STFC UKRI.
- Dr Jens Jensen, UKRI-STFC Scientific Computing, Data Science Champion for SFN+, DAFNI.

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About SFN+

The Science and Technology Facilities Council (STFC) Food Network+ (SFN+) brings together STFC researchers and facilities with research and industry in the agri-food sector.

The objectives of the SFN+ are:

- To build an inclusive, dynamic, interdisciplinary network of researchers focused on innovative ways to use the skills and facilities funded by STFC.
- To kickstart interdisciplinary collaborations and research projects working towards safe, sustainable food systems both in the UK and developing countries.
- To enhance the impact of STFC/food interdisciplinary collaborations by encouraging co-design with the non-academic sector.

What do we do?

- The SFN+ is building an interdisciplinary community working to provide a sustainable, secure supply of safe, nutritious, and affordable high-quality food using less land, with reduced inputs, and in the context of global climate change and declining natural resources. We fund projects that put STFC capabilities to work in the agri-food industry.

Find more at: https://www.stfcfoodnetwork.org/

Find our April workshop programme and recording

Our April 28th workshop recording is available through this link. The webinar starts after approximately 15 minutes.

In the following pages, you can find the programme for the workshop.

UK Food Systems in 2050: Trends, Roadmaps and Future Research Needs

Panel Discussion and Participatory Workshop

Thursday 28th April 2022; 11am-5pm; Online

Full Programme

Session 1

Net Zero+ Food Systems: The Big Picture

11.00 - 11.05	Welcome	**Prof Sonal Choudhary**, Professor of Sustainable Management, University of York
11.05 - 11.25	UK Food Systems in 2050: Systems level Challenges	**Prof Toby Peters,** Professor in Cold Economy, University of Birmingham
11.25 - 11.35	UK Food System NZ Analysis: Current Trends and Future Research Directions	**Dr Stephen Mackenzie,** Sustainability Specialist (GHGs in Food Systems), WRAP
11.35 - 11.45	Climate Change Research Priorities for Sustainable Food Systems	**Prof Dominic Moran,** Professor of Agricultural and Resource Economics, University of Edinburgh
11.45 - 12.30	**Debate and brainstorming**: Q1: What is a resilient and NZ+ food system in 2050? Q2: What are the existing or proposed initiatives for achieving NZ+?	Co-Chairs: **Prof Sonal Choudhary**, Professor of Sustainable Management, University of York & **Prof Toby Peters,** Professor in Cold Economy, University of Birmingham

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12.30-13.00 Lunch Break

Session 2

Sector Specific Roadmaps – What are some of the Trends & Future Research Needs (from production to consumption)?

13.05-13.35	**Panel Presentations**: Current state of Sectoral NZ Roadmaps & Conflicts (5 mins each)	**Co-Chairs: Prof Judith Evans**, London South Bank University, UK; **Dr Stephen Mackenzie**, WRAP

	UK Primary Production: Prof Ilias Kyriazakis, School of Biological Sciences, Queen University Belfast **UK Food Manufacturing: Pete Robertson,** Chief Executive, Food & Drink Federation Wales **UK Consumption: Ms Alice Garvey,** Sustainability Research Institute, School of Earth and Environment, University of Leeds **Public Sector Procurement**: **Dr Luana Swensson,** Policy Analyst for Sustainable Public Procurement, Food and Agriculture Organisation of the United Nations (FAO) **UK Food Trade: Prof Tony Heron,** Prof of Int. Political Economy, University of York	
13.35-14.05	**Discussion:** Parallel Sessions for NZ Roadmaps: Co-developing Future Research Needs on MIRO Q3: What will this sector look like in 2050? Q4: How do we get there? What are some of the big questions we need to ask now?	**Breakout groups:** MIRO Support: University of Arts Research Needs on MIRO **UK Primary Production**: Co-Chairs – Prof Ilias Kyriazakis and Prof Richard Napier **UK Food Supply Chain (Manufacturing and Retail):** Co-Chairs Prof Toby Peters and Prof Judith Evans **UK Consumers:** Co-Chairs Dr Stephen Mackenzie and Dr Ximena Schmidt **UK Public Sector:** Chair Luana Swensson **UK Food Trade**: Chair Prof Tony Heron
14.05 -14.20	**Feedback**: Presentations from the Parallel Sessions (3 mins each)	**Co-Chairs: Prof Judith Evans**, London South Bank University, UK; **Dr Stephen Mackenzie**, WRAP
14.20-14.30	**Summary:** Session 2a	**Prof Judith Evans**, London South Bank University, UK; **Dr Stephen Mackenzie**, WRAP
14.30 -14.55	**Food systems Conflicts** **Debate and brainstorming:** Q5: What are the conflicts we need to manage in co-designing NZ+ Food Systems? Q6: Are there any unintended consequences we need to plan for?	**Co-Chairs: Prof Matt Lobley**, Professor of Rural Resource Management, University of Exeter; **Dr Christian Reynolds,** Senior Lecturer, The Centre for Food Policy, City University, London

	Q7: What kinds of business models and partnerships do we need that work for farmers, manufacturers, retailers and policy makers?	
14.55-15.00	**Summary:** Session 2b	**Dr Christian Reynolds,** Senior Lecturer, The Centre for Food Policy, City University, London
15.00-15.10	Coffee Break	

Session 3

NZ Food Systems Assessment and Measurements

15.10 – 15.40	**Panel Presentations:** NZ Food Systems Assessment and Measurements Manchester; (5 mins each) **Panellists:** **Energy Systems Catapult** - Regional and National Level NZ Models - data granularity needs **Climate Trace** - Global level Real-time CO2 emissions models - data, gaps and collaboration needs; **Dr Laura Cardenas**, Rothamsted Research - UK GHG inventory **STFC Hartree** - STFC: Data, AI, HPC and digital twinning for a NZ Food System **STFC Dafni -** STFC Food Network+ data science capability for modelling regional Net Zero+ impacts at scale	**Co-Chairs: Dr Ray Obayi,** University of Manchester; Dr Ximena Schmidt, University of Brunel.

15.35-16.00	**Debate:** NZ Food Systems Assessment Measurements Q6) Do we need to develop how we assess and measure NZ? Q7) What else do we need to assess to avoid any unintended consequences?	**Co-Chairs: Dr Ray Obayi,** University of Manchester; Dr Ximena Schmidt, University of Brunel.
16.00-16.05	**Summary:** Session 3	**Co-Chairs: Dr Ray Obayi,** University of Manchester; Dr Ximena Schmidt, University of Brunel.
16.05-16.15	**Next Steps:** Tangible Outputs from the Workshop; Follow-on Funding opportunities	**Prof Sonal Choudhary,** Professor of Sustainable Management, University of York.
16.15-16.30	Open Floor Discussion/ Brainstorming or any final thoughts	
16.30 – 17.00	Open Networking on Wonder Platform	

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