Foresight4Food

Food Systems of the Future

A SYNTHESIS OF FOOD SYSTEM DRIVERS AND RECENT SCENARIO STUDIES

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Executive Summary

Recent events including the COVID-19 pandemic and the Ukraine war have exposed the fragility of global food systems and the inadequacy of governance structures and policy actions to respond to food security threats. As the world faces increased volatility and uncertainty, the foresight community has emphasised the importance of considering a wide range of plausible scenarios when making food system decisions. However, as many of the important trends shaping the future seem to have become less certain the question arises how the food system community can incorporate these into robust and strategic foresight work to support the transformation of the global food system. This report reviews recently published foresight studies for food system outcomes, food system drivers and scenario narratives on global food systems in order to answer the following questions:

- What are the key drivers and trends used in foresight studies since the pandemic?
- Do we have enough information on these drivers to analyse them for future trends?
- What are the common themes and uncertainties around which global food system scenarios have been developed lately?
- How can future foresight work can be improved?

This report reviews 20 recent foresight studies on food systems that were published since the World Economic Forum report in 2017. These 20 studies were selected based on 3 criteria: 1) focus on agri-food systems 2) time frame from 2017 and onwards 3) published by influential organisations and/or high impact journals. The selection was also verified in consultation with the food system experts.

In the first part of the report, a review of food system outcomes is conducted with the purpose to understand which food system outcomes are dominating the narratives in the organisations working on global food systems and in the literature. There are two key takeaways from this review:

i. The discrepancies in the future trends reflect the broader challenge in foresight work: differing methodologies, time horizons, and assumptions lead to varying conclusions.
ii. While the reports may not entirely align in their projections, they all emphasise the critical need for systemic change to address malnutrition, hunger, obesity, environmental degradation, climate change and socio-economic inequalities.

In the second part of the report, a review of drivers of the global food system is presented. The purpose of this review was to identify the new emerging drivers and to identify the overlaps and discrepancies in the quantitative data from various sources. We identified 95 distinct factors or processes that drives the global food system, and their interactions and transitions will determine the future trajectories of the system's outcomes. The thematic assessment of these 95 drivers resulted in their classification into eight overarching groups or 'principal drivers': 1) Shifting demographics, 2) economic development, 3) changing diets & consumer behaviour, 4) technology, innovation & information, 5) climate, resources & environment, 6) policy & governance, 7) socio-cultural paradigms and inequalities, and 8) crisis & conflicts. During the review, some key observations were made that should be considered in foresight studies:

i. Established vs. emerging Drivers: Long-standing drivers like demographic trends and climate change remain important, while newer influences such as social media, e-commerce, and power imbalances are gaining relevance.
ii. Uncertainty and Impact: The uncertainty surrounding some drivers, particularly emerging ones, makes their future impact difficult to predict. Established drivers show more consistency but still vary across contexts and assumptions.
iii. Need for Continuous Refinement: The understanding of critical drivers should be open to constant updates and refinements as new data and trends emerge.
iv. Stakeholder Involvement: Consulting diverse stakeholders is essential for identifying context-specific critical drivers and developing targeted strategies for transformation.
v. Contextual data: there is lack of data around the contextual factors such as influences of social settings and the internet on diet preferences. How quantitative models use contextual data to simulate food system drivers' directions in the future is very complex and needs to be simplified and made more consistent.
vi. Focus on historic trends: There is an over-reliance on historical trends of drivers like population growth and climate change in quantitative models. Key drivers like labour migration, forced displacement, food affordability and level of digitisation remain understudied in terms of their plausible future trends, signalling a need for more forward-looking research.
vii. Careful consideration of study assumptions: Studies are designed for specific purposes, and the transferability of their underlying assumptions should be carefully considered.
viii. Socio-cultural paradigms: there are a lot of anecdotes and micro level case studies around how socio-cultural beliefs, values, norms are related of the way food is produced and consumed, however there are no evidence on how these factors drives the food system at a global scale. In the reviewed literature, the focus is more on various inequalities within and between communities.

In the third part, we selected eight studies that included scenarios (of the 20 preselection) focusing on global and EU food systems. We applied an inductive approach fort identifying common themes of the plausible food system futures and key uncertainties that were considered in the scenarios and then evaluated the potential outcomes of different governance actions across three key dimensions: health and nutrition, livelihoods and equity, and climate and environment. The analysis of the scenario narratives led to the following findings:

i. Plausibility of diverse futures: There are multiple plausible future pathways for food systems globally, ranging from scenarios where food systems fail to transition toward sustainability, health, and equity to more hopeful scenarios that align better with society's broader interests.
ii. Role of actors in driving change: Different actors, with their unique visions for food system change, play significant roles in shaping potential futures. The scenarios offer insights into ongoing debates about who should lead food system transformation and in what direction.
iii. Definition of sustainable and healthy diets: The reviewed scenarios reveal either inconsistencies or a lack of clear definitions for sustainable and healthy diets. This

gap highlights the need for establishing a consistent, universally accepted definition.

iv. Limited radical divergence in scenarios: Despite the diverse futures explored, only one of the scenarios envisions a more radical pathway compared to the existing food systems. This is the one where the central government decides what food is grown, who owns the land, how data and information is shared and what people should eat. This demonstrates the need for new ideas and real out-of-the-box thinking.

v. Need for new and radical thinking: There is a clear need for developing new global scenarios that account for recent disruptions and explore more radical possibilities for food system transformation, considering the long-term consequences for both people and the planet.

vi. Paradigm shift: Although all the studies reviewed have similar worldviews or paradigms, there is a notable paradigm shift in the way scenario narratives frame the role of stakeholders within food systems. The focus is transitioning from solely analysing system outcomes to exploring how diverse stakeholders influence and interact within the system. This reframing highlights the importance of participatory approaches and emphasizes the systemic interconnections between stakeholder actions and broader food system transformations, fostering a more inclusive and dynamic understanding of change processes.

vii. Governance paradigms: Although factors like consumption patterns, technology, and investment significantly influence food systems, governance structures play a crucial role in shaping the environment for these factors to interact. The review of scenarios reveals five embedded governance structures or actors that dominates food system viz. Government-centric control, Community-led and local governance, Big cooperates led, Fragmented governance, and Global institutions led. This finding underscores the importance of manging power dynamics for sustainable food systems future.

viii. Need for reviewing uncertainties: Megatrends such as shifting demography, technology and consumption patterns are often central in reviewed scenario exercises, but they are less relevant when disrupted by unexpected events, including trade conflicts, the rise of inward-looking, right-wing governments, or global pandemics.

ix. Scenarios for different socio-economic regions/countries: The trends in food system drivers vary significantly across economic regions and countries and is represented often at macro scale. Qualitative scenario narratives often depict these variations at the micro scale (socio-economic groups). This points to the need for better alignment of how both qualitative and quantitative studies present future of the food system at different scales.

x. Combining qualitative and quantitative scenarios- there is need for rigorous analysis to objectively understand the likely outcomes of different scenarios, including trade-offs between multiple outcomes.

A number of the key drivers shaping food systems, such as geopolitical conflicts, the cost-of-living crisis or climate change impacts, have significantly changed over the last decade, increasing uncertainty around food system change. At the same time food systems already dramatically underperform for food and nutrition security, environmental, economic and social outcomes. Thus, there is an urgent need for strategic discussions

and out of the box thinking about how food systems could and should change to be fit for the future and provide better outcomes. Foresight work needs to be a key ingredient for these discussions but while the reviewed recent foresight studies address many of the important drivers of change, they could also push the limits of our current thinking around the needed transformations further. Therefore, there is an urgent need for developing a new set of global food foresight studies that also consider various stakeholder perspectives on the impacts of new and old disruptions to the food system. We need to explore new, unconventional ideas about how we could provide healthy diets from sustainable food systems to consumers around the world while navigating the new uncertainties and trends the reviewed studies highlight. Foresight studies have a key role to play in shaping the urgent debates on food system change but for that we need to better address some of the key unknowns that have recently emerged as shaping our current food system more profoundly than ever.

1. Introduction

Thinking about the future to help drive desired transformations is the domain of foresight and scenario analysis. The objective is not to predict the future. Human systems, including food systems, are far too complex, dynamic and turbulent to be able to predict, with any degree of certainty, what the future will bring. However, it is possible to imagine the consequences of current trends and how different pathway of change, events, or shocks to the system might lead to very different futures. Embedding such futures thinking in social discourse, policy analysis, business strategy and scientific research can help in shaping a future that would be more rather than less desirable, while also being better prepared for future risks and opportunities. Even though the future cannot be predicted, it is, nevertheless, significantly shaped by the complex intertwining of the present ambitions, aspirations, and visions of different interest groups across society. The future we end up in is a function how we think about the future.

Transforming food systems to deliver better outcomes for health, livelihoods and the environment is one of the most critical challenges facing humanity in the 21st Century (OECD, 2021). The 'hidden costs' (externalities) of today's food systems, related to poor nutrition (Development Initiatives, 2020), the environment, and social injustice (FAO, 2022b) is a defining feature of the food systems of all countries.

This report reviews recent studies on the future of global food systems. It examines the status and directions of food system outcomes in terms of food security and nutrition, economic and social wellbeing, and environmental sustainability, and explores the main drivers likely to shape the future. It also reviews a set of global level scenario studies on food systems. The purpose of the report is to provide an overview of the status of future studies on food systems and to illustrate the key drivers and directions of food systems change that emerge from this body of work.

Foreisght4Food has undertaken this review as part of its overall agenda to help synthesise foresight work on food systems to provide accessible resources for foresight practitioners and researchers. This initial review will be followed up by work looking in more detail at the key uncertainties in drivers of change which could lead to different food system outcomes.

To create the societal understanding and political will necessary for change, there is a need for well-founded perspectives on the trends in food systems and the likely consequences of these trends. Bringing change also requires imagining radically different futures in which ambitions for good nutrition, greater equity, and environmental sustainability can be realised.

This review offers the following:

1. An **overview of the main global level foresight and scenario studies** on food system undertaken since 2017 (Section 4).
2. A **summary of trends in key food systems outcomes** related to health, livelihoods and environment (Section 5).
3. A **summary of key drivers of change** influencing the future of food systems (Section 6).

4. A **synthesis of food system scenarios** on global food system (Section 7).
5. Reflections on the current status of food systems foresight and scenario analysis and implications for future work in this area (Section 8).

Extremely comprehensive work on the drivers and triggers for food systems transformation has been done by FAO in recent years. The intention of this review is to place this work in a wider context of other studies and to provide readers with a summary of key trends in food system outcomes and drivers while also looking across the scenarios that were developed by some of these initiatives.

2. The Food Systems Framing

The historical focus on food production intensification, innovation in production technologies and management of urban-rural market linkages has proven inadequate to accomplish the structural eradication of hunger, micronutrient deficiencies, market risks and tackle climate change simultaneously (Koning et al., 2008). In the last decade, a more holistic version of food system framework has therefore been widely used to capture the complex interactions and feedback mechanisms between socio-economic and biophysical drivers (Brouwer, McDermott, & Ruben, 2020). Hence "food systems" is the frequently used concept around which issues of resilience, nutrition, environmental health and food security are being framed with the primary aim to enhance our understanding of the potential trade-offs and synergies among nutritional, environmental (sustainability and resilience), and economic (livelihood and equity) outcomes of the system.

Nevertheless, a wide variety of views exist about food system's boundaries, key components and their interactions. The most recent FAO framework uses the term 'agrifood systems' and defines it as "encompass(ing) the entire range of actors, and their interlinked value-adding activities, engaged in the primary production of food and non-food agricultural products, as well as in storage, aggregation, post-harvest handling, transportation, processing, distribution, marketing, disposal and consumption of all food products including those of non-agricultural origin" (FAO, 2022a). The conceptual model of a food system used in this report is based on the work of Foresight4Food (see Figure 1). This model of the food system integrates work by Ericksen (Ericksen, 2008), Ingram and Zurek (Zurek et al., 2022) with the market systems thinking of the Making Markets Work for the Poor (M4P) approach (Springfield Centre, 2015). Although not indicated in the definition, the illustrative framework shows feedback between agrifood system's outcomes and drivers as an important component of the system's dynamics which converges with the 'food system' definitions from Global Panel on Agriculture and Food Systems for Nutrition (Global Panel, 2020) and High Level Panel of Experts on Food Security (HLPE, 2020). The only difference is that the definitions in Global Panel and HLPE reports also recognises the natural and human systems and drivers that are essential for the sustainability of the food system.

Ultimately, the purpose of the 'food systems' framework is to provide insights for better understanding the trade-offs and synergies between activities intentionally or unintentionally taking place for achieving a healthy diet, environmental sustainability and economic growth in different regions, for specific disadvantaged social groups and by specific actors in the food value chain. This understanding is crucial for connecting the dots and finding the interventions for transforming the food system at scale.

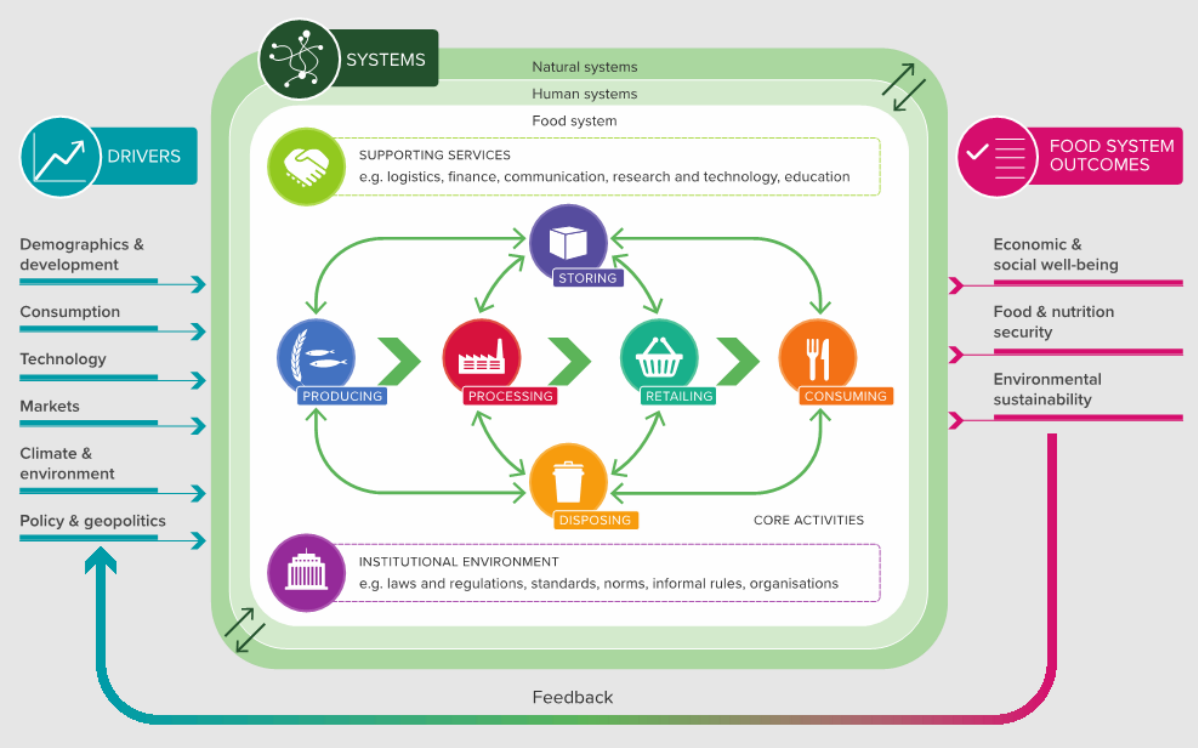


Figure 1: Food System Framework – Foresight4Food

The Food System framework is a simplified tool to help understand and visualise complex sets of relationships and can be adapted depending on how the conceptual model is constructed. It depends on the human perspectives and objective. Different people or groups may construct different models, and the models' design is dictated by the question(s) it aims to help address. Such a model is a human construct to aid understanding and is not a model of "reality". In literature, there are already numerous discourses surrounding the framing of interlinkages between fs activities and outcomes (Stefanovic, Freytag-Leyer, B., & Kahl, 2020). In the Foresight4Food project, the framework illustrated in Figure 1 is used.

Nonetheless, the Foresight4Food 'Food System' framework (Figure 1) underpins the crosscutting food system issues and the drivers, actors, outcomes, and enabling environments that operate within the food system boundary. Incorporating systems thinking, this framework consists of interacting components that transform inputs into outcomes. Feedback loops between internal components and the system's wider environment influence its behaviour and evolution, underlining the fact that food systems complex adaptive systems that are inherently unpredictable and difficult to control.

3. An Overview of Foresight and Scenario Analysis

There is nothing new about humans trying to anticipate the future. We have always done it. It is baked into our core thinking processes and sense making. Stories about the future, good and bad, drive the narratives around our politics, religion and identities.

Conscious efforts to bring futures analysis into policy making and development of organisational and business strategy emerged strongly in the second half of the 20th

Century in part driven by the need for considering alternative military scenarios and war gaming in the 2nd World War and during the Cold War.

Foresight and scenario analysis are different terms used for the general concept of exploring the future to improve decision making. With the application of foresight to government, organisational and business strategy the term "strategic foresight" has also gained much currency.

In this review we make the distinction between foresight and scenarios. Foresight is a more general concept related to any work that looks at future in terms of how it might be shaped by emerging trends, new innovations or shocks. Scenarios studies are a subset of foresight which construct contrasting futures for how a particular situation might be in the future based on a number of different uncertainties about the future. These can be quantitative, such as scenarios for how much global warming will occur. They can also be qualitative, such as how different level of global warming might influence geopolitical tensions. Many scenario processes try to combine qualitative and quantitative dimensions.

Key questions to be asking about food systems include: "*How will food systems nutritiously and sustainably feed 8.5 billion people in 2030?*" (WEF, 2017), "*What could our food system look like in 2050 and will it reach net zero?*" (Benton, T. et al., 2023), "*What will be the implications of food system changes on food safety across food chain?*" (Garnett et al., 2023), "*How much crop land will be required in the future?*"(Smith, Fletcher, Millard, Hill, & McNabb, 2022), and "*How will technology lead to food system transformation?*" (Moller, Voglhuber-Slavinsky, & Dönitz, 2020)

To cope with an increasingly turbulent world in the face of climate change and other emerging risks a wide range of global and national institutions, government entities and businesses have foresight and scenario related work. These include for example, the Intergovernmental Panel on Climate Change (IPCC), the Food and Agriculture Organization (FAO), the Organisation for Economic Co-operation and Development (OECD), the Cooperative Group on International Agricultural Research (CGIAR) the World Economic Forum (WEF), UN Global Pulse Strategic Foresight Project and the European Foresight Platform (EFP), along with many academic and think tank organizations. As illustrated by this review, there is a growing number of institutions with foresight work focused on the future of food systems.

Scenarios are a key tool used in foresight exercises to explore the inherent uncertainty about the future. Scenarios are narratives or stories about different plausible futures, developed to explore the implications of various trends and uncertainties. Scenarios do not predict the future but rather present a range of possible outcomes that can help stakeholders understand the potential impacts of their decisions. In the context of food systems, scenarios can illustrate how different combinations of drivers—such as climate change, technological innovation, or policy shifts—might affect food production, distribution, and consumption. This allows policymakers, businesses, and other stakeholders to explore the consequences of different strategies and make more informed decisions.

As with the wider field of foresight and futures studies there are many different approaches, methodologies and tools associated with scenario analysis. An important distinction is between explorative scenarios - how the future might be given different uncertainties or trends, and normative scenarios - how different groups of stakeholders might like the future to be given different interests and values.

Scenarios can play a crucial role in food system transformation by providing a framework for discussing and debating the future. They help stakeholders visualize how complex interactions between various elements of the food system might evolve and what new challenges or opportunities might arise. For example, scenarios can highlight potential risks such as food insecurity due to climate change or opportunities like the adoption of sustainable farming practices (Ericksen, Ingram, & Liverman, 2009). By exploring these possibilities, stakeholders can develop strategies that are robust under a range of future conditions, thereby increasing the resilience and sustainability of food systems.

4. Selection of Foresight Studies

This report reviews 20 recent foresight studies that examine food system drivers, outcomes, and scenarios using qualitative, quantitative, or mixed methods approaches (summarised in Table 1). Notably, eight of these studies were published after the onset of COVID-19, reflecting the heightened pressures and uncertainties facing global food systems due to pandemics, climate change, and geopolitical instability. The studies were selected based on three key criteria:

1. **Focus**: focus on the agri-food systems.
2. **Timeframe**: Published from 2017 onwards.
3. **Source**: Published by leading organizations or in high-impact journals.

The selection process was further validated through consultations with food system experts.

Since the COVID-19 pandemic, food system dynamics have evolved significantly, with new and influential drivers emerging. Recent reports, particularly those from the FAO, underscore a growing recognition of the uncertainties shaping the future of food systems. This analysis includes only studies that employ a robust conceptual framework with clear and consistent definitions of drivers and scenarios, and that offer a global or regional perspective. Studies focusing solely on specific aspects of the food system were excluded, for example (van Zanten et al., 2023) that explores the food production and consumption drivers that influences land use for agriculture in Europe.

The 20 selected studies were used to synthesise food system outcomes and map drivers of change and emerging trends. While a substantial body of quantitative modelling work underpins many of these studies and represents a critical subset of foresight research, such studies were excluded from direct review, as their insights are already captured within the selected reports.

Eleven of the 20 studies propose food system transformation pathways through scenario analysis, with three of these UK-focused and one European region focus. In this report,

exploratory scenario narratives from Global and Europe based studies (8 in total) were chosen for assessing the overlaps across scenario narratives and key assumptions around drivers that food system experts are making for creating scenarios. As experienced during the recent challenges like Ukraine war, covid-19 pandemic and instabilities in middle east, food system challenges are transboundary. The focus on global and regional studies ensures a comprehensive understanding of food system dynamics and challenges that transcend national boundaries, addressing issues relevant to the global context and interconnections.

The purpose and methodologies of the selected studies vary widely. Although each report includes a foresight component, the depth of analysis into the future of food systems differs. Some studies provide extensive insights around the quantitative data and model projections on food system drivers and outcomes drawing from modelling results while others utilise insights gained from stakeholder consultations to offer contextual analysis and recommendations for food system transformation. The purpose and the methods used in each study is summarised in table 1.

Table 1: Publications reviewed for the analysis of food systems drivers and scenarios

Publications	Organisation/ Author	Region and Year	Focus	Methodology
Future Food Systems: For people, our planet, and prosperity	Global Panel on Agriculture and Food Systems for Nutrition	Global 2020	Food system drivers and outcomes Scenario Analysis	Contextual based on quantitative data drawn from scientific literature. Scenario analysis based on 2x2 matrix (qualitative)
Three scenarios for Europe's food sector in 2035	Fraunhofer Institute for Systems and Innovation Research ISI	Europe 2020	Scenario Analysis	Qualitative analysis
Four Futures for the Global Food System	Boston Consulting Group	Global 2022	Scenario Analysis	Qualitative analysis
Scenarios for UK Food and Nutrition Security in the wake of the COVID-19 Pandemic	James Hutton Institute	UK 2021	Scenario Analysis	Qualitative analysis
Shaping the Future of Global Food Systems: A Scenarios Analysis	World Economic Forum 2017	Global 2017	Scenario Analysis	Qualitative analysis

Using scenario analyses to address the future of food	Tim Benton	Global 2019	Scenario Analysis	Qualitative analysis
Future foods: Morphological scenarios to explore changes in the UK food system with implications for food safety across the food chain	Garnett et al	UK 2023	Scenario Analysis	Qualitative analysis
Exploring global food system shocks, scenarios and outcomes	Hamilton et al	Global 2020	Scenario Analysis	Qualitative analysis
Scenarios for transforming the UK food system to meet global agreements	Maia Elliott & Riaz Bhunnoo	UK 2021	Scenario Analysis	Qualitative analysis
The future of food and agriculture- Alternative pathways to 2050	Food and Agriculture Organisation	Global 2018	Scenario Analysis	Integrated qualitative and quantitative approach
Thinking about the future of food safety- A foresight report 2022	Food and Agriculture Organisation	Global 2022	Food system drivers and outcomes	Contextual based on scientific literature
Food security and nutrition: building a global narrative towards 2030	HLPE	Global 2020	Food system drivers and outcomes	Contextual based on scientific literature
The future of food and agriculture- Drivers and triggers for transformation 2022	Food and Agriculture Organisation	Global 2022	Food system drivers and Scenario Analysis	Qualitative analysis
The future of food and agriculture- Trends and challenges 2017	Food and Agriculture Organisation	Global 2017	Food system drivers and outcomes	Contextual and quantitative analysis
IPCC 2022- Climate Change 2022: Impacts, Adaptation and Vulnerability	Intergovernmental Panel for Climate Change	Global 2022	Food system drivers and outcomes related to climate change	Quantitative modelling

EAT- Lancet	EAT	Global 2019	Food system drivers and outcomes	Quantitative modelling
Emerging trends in the agri-food sector: Digitalisation and shift to plant-based diets	Hassoun et al	Global 2022	Food system drivers and outcomes	Contextual based on scientific literature
Trends Shaping the Future of Agrifood	Stanton and Caiazza	Global 2023	Food system drivers and outcomes	Conceptual modelling
Understanding food systems drivers: A critical review of the literature	Christophe Bene	Global 2019	Food system drivers and outcomes	Contextual based on scientific literature
Responding to Evolving Megatrends	Independent Science for Development Council, CGIAR	Global 2024	Food system megatrends	Contextual based on scientific literature

5. Current Trends and Plausible Future Directions of Food System Outcomes

This section provides an overview of the current status and plausible future directions for key food system outcomes using the data drawn from open-source databases and reports. Not all the indicators of the food system outcomes have been analysed for their future directions in these resources and hence the future trends are presented for the indicators where data is present. The literature presents a range of plausible future scenarios for these outcomes, but it is crucial to recognize that these projections vary depending on the time scale, geographic focus, and underlying assumptions regarding technological advances, policy shifts, climate scenarios, and socio-economic factors. As such, food system foresight reports often reflect different pathways and priorities. In this section, we look at what the key reports say about food system outcomes and their pathways. The trends in the food system outcomes also reflects on the challenges and deficiencies in the current food system which needs to change in the future scenarios.

5.1 Food security, nutrition and health

Disruptions in the food system as a result of COVID-19 pandemic, conflicts (like Russia-Ukraine conflict and Gaza conflicts), weather shocks (like El Nino effects in South-East Asia and droughts), and domestic policies (like India's export restrictions on rice) have led to an increase in the number of people facing hunger since 2019. GRFC 2023 estimates that over a quarter of a billion people were acutely food-insecure and required urgent food assistance in 58 food-crisis countries/territories in 2022 (Figure 2). This is the highest number in the seven-year history of the GRFC. More than 40 percent of the population in IPC/CH Phase 3 (Crisis phase) or above or equivalent in the GRFC 2023 resided in just five countries/ territories – the Democratic Republic of the Congo, Ethiopia, Afghanistan,

Nigeria (21 states and the Federal Capital Territory (FCT)) and Yemen. The primary drivers of acute food insecurity in food-crisis countries are conflicts, economic shocks, weather extremes and forced displacement (Food Security Information Network (FSIN), 2023).

5.1.1 Hunger

According to the State of Food Security and Nutrition in the World report (FAO, IFAD, UNICEF, WFP, & WHO, 2023), between 691 and 783 million people faced hunger in 2022, representing an increase of 122 million people compared to 2019 (before pandemic) (Figure 3). Global hunger, measured by the prevalence of undernourishment (PoU) (SDG Indicator 2.1.1), remained relatively unchanged from 2021 to 2022 but is still far above pre-COVID-19-pandemic levels, affecting around 9.2 percent of the world population in 2022 compared with 7.9 percent in 2019.

Sub-optimal diets are now responsible for 20% of premature (disease-mediated) mortality worldwide, as well as for 20% of all disability-adjusted life years (DALYs). The outcome is rapidly escalating pressure on healthcare systems which are facing an epidemic of diet-related diseases – including stroke, cardiovascular disease, and diabetes. Affected individuals and families are at risk of becoming drawn into intergenerational cycles of poverty and inequality.

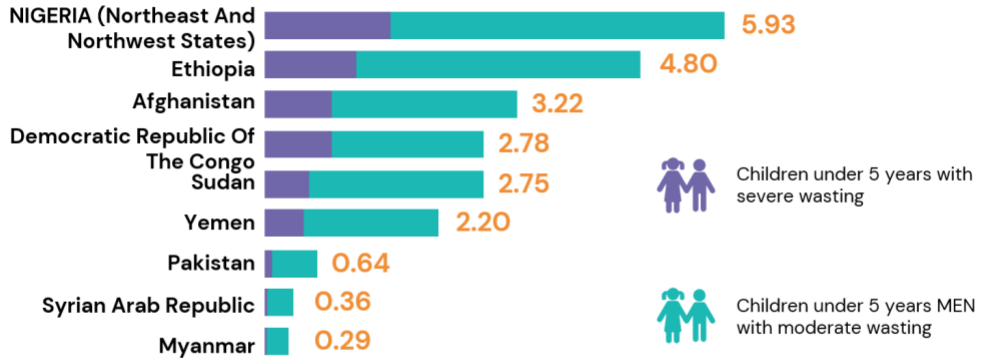
5.1.2 Nutrition

Most countries are not on track to meet the nutrition targets set for 2025 by the World Health Assembly (Global Panel, 2020). The regions with high level of acute food security, the number of child wasting tends to be high. In 30 of the 42 major food crises countries analysed in the GRFC 2023 where data on malnutrition were available, over 35 million children under 5 years of age suffered from wasting, with 9.2 million of them severely wasted (the most lethal form of undernutrition and a major contributor to child mortality). Out of the total estimated children with wasting in those countries, about 65 percent lived

in nine out of the ten countries with the highest number of people in IPC/CH Phase 3 or above or equivalent (Food Security Information Network (FSIN), 2023) (Figure 4). The global food crisis has worsened the undernutrition situation of adolescent girls and women whose livelihoods, income and access to nutritious food have been disproportionately affected by conflict, climate change, poverty and other economic shocks, including that of the COVID-19 pandemic from early 2020.

Future direction: FAO 2018 Alternative pathways (FAO, 2018) and 2023 State of food security (FAO, IFAD, UNICEF, WFP, & WHO, 2023) reports present different projected figures on undernourished people in 2030 (Table 2).

Figure 4: Numbers of children with wasting in countries/territories with largest numbers of people in IPC/CH Phase 3 or above or equivalent in 2022.



Estimates for Nigeria cover only the Northeast and the Northwest states while estimates for Democratic Republic of the Congo cover 150 health zones and 189 territories. Data were not available for Ukraine.

Source: *(Food Security Information Network (FSIN), 2023)*

Table 2: What different reports say about prevalence of undernourishment from the food system in the future

Variable	FAO Alternative pathways (FAO, 2018)	FAO State of food security (FAO, IFAD, UNICEF, WFP, & WHO, 2023)
Undernourishment/ Hunger	Under a BAU scenario, by 2030 more than 650 million people will be undernourished, of which almost 640 million will be living in LMIC. Percentage of population facing Undernourishment in 2050: BAU- 7.6 TSS- 3.5 SSS-12.4	Same data used in UN reports- It is projected that almost 600 million people will be chronically undernourished in 2030, pointing to the immense challenge of achieving the SDG target to eradicate hunger. This is about 119 million more than in a scenario in which neither the pandemic nor the war in Ukraine had occurred, and around 23 million more than if the war in Ukraine had not happened. Most progress is expected to occur in Asia, whereas no progress is foreseen in Latin America and the Caribbean, and hunger is projected to increase significantly in Africa by 2030

5.1.3 Overweight and Obesity

Globally, adult obesity nearly doubled in absolute value from 8.7 percent (343.1 million) in 2000 to 13.1 percent (675.7 million) in 2016. It is a leading form of malnutrition according to the latest Lancet report. In 2022, prevalence of obesity was higher than underweight in 177 countries (89%) for women and 145 (73%) for men. Adults affected by obesity are more likely to live in upper-middle- or high-income countries (73 percent of the global burden in 2016), and the prevalence is higher among women. Women with obesity are more likely to reside in urban areas and in wealthier households. Overweight in children has also worsened with 33.3 million in 2000 to 38.9 million in 2020. In contrast to adult obesity, 77 percent of the global overweight children were from lower-middle- or upper-middle-income countries, residing in wealthier households (FAO, 2022a).

Regional variability: The prevalence of moderate or severe food insecurity rose slightly in Africa and in Northern America and Europe and decreased non-significantly in Asia from 2021 to 2022. Statistics show that in 2022, Asia and Africa were home to more than 93 percent of the people affected by hunger (FAO, IFAD, UNICEF, WFP, & WHO, 2023). The only region showing encouraging progress is Latin America and the Caribbean, where moderate or severe food insecurity decreased from 40.3 percent in 2021 to 37.5 percent in 2022, the equivalent of 16.5 million fewer people in one year, mainly in South America. A comparison of food insecurity among rural, peri-urban and urban populations reveals that global food insecurity, at both levels of severity, is lower in urban areas. Moderate or severe food insecurity affected 33.3 percent of adults living in rural areas in 2022 compared with 28.8 percent in peri-urban areas and 26.0 percent in urban areas (FAO, 2023). The burden of nutrition related diseases varies across income groups. As per the global trends until 2022, low-and lower-middle-income countries bear the greatest burden of stunting, wasting, low birthweight, and anaemia cases while upper-middle- and high-income countries have the greatest burden of obesity cases (FAO, IFAD, UNICEF, WFP, & WHO, 2023).

Future direction: It is projected that almost 600 million people will be chronically undernourished in 2030, pointing to the immense challenge of achieving the SDG target to eradicate hunger. This is about 119 million more than in a scenario in which neither the pandemic nor the war in Ukraine had occurred, and around 23 million more than if the war in Ukraine had not happened. Most progress is expected to occur in Asia, whereas no progress is foreseen in Latin America and the Caribbean, and hunger is projected to increase significantly in Africa by 2030 (FAO, IFAD, UNICEF, WFP, & WHO, 2023). It has also been analysed that if the current trends continue, diet related diseases will have the highest economic impact in LMICs. For diabetes, for instance, the economic burden is expected to reach up to US$800 billion in East Asia and the Pacific and US$52 billion in sub-Saharan Africa.

5.2 Livelihoods, Economy and Wellbeing

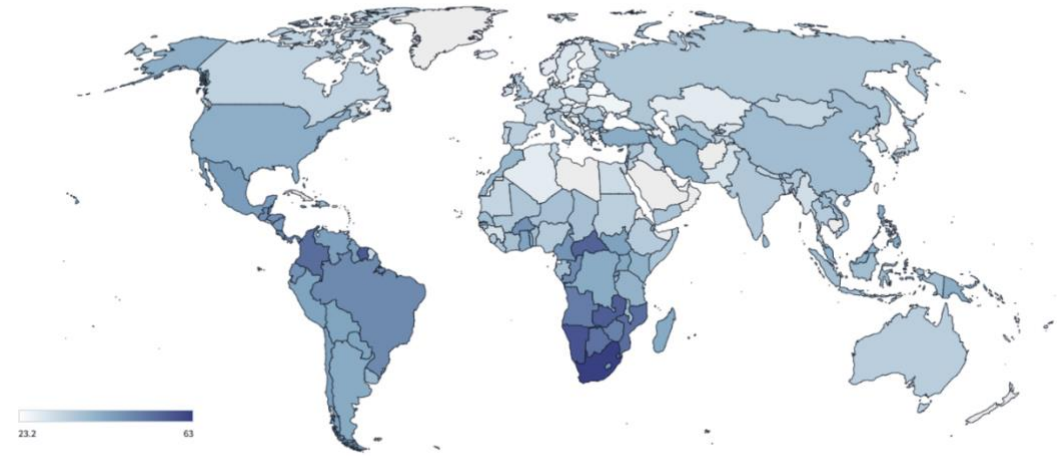
Globally, the food system is a major sector of employment, supporting the livelihoods of hundreds of millions of people across all stages of the value chain in both rural and urban areas. However, food system workers are among the world's poorest and most marginalized, often facing exploitation, labour rights violations, inequitable wages, and

other forms of harassment especially by indigenous people, women and children. Transforming food systems is essential to achieving just and equitable livelihoods, fostering social resilience for all who work within the system. There are no direct indicators of livelihood enhancement, equitable income and social wellness of the people involved in the global food system. Moreover, compared with other themes, the available data are more limited due to lack of disaggregation to distinguish food system livelihoods from others. But we can use four key indicator domains as a proxy of their well-being: income and poverty, employment, social protection, and rights.

5.2.1 Income and Inequality

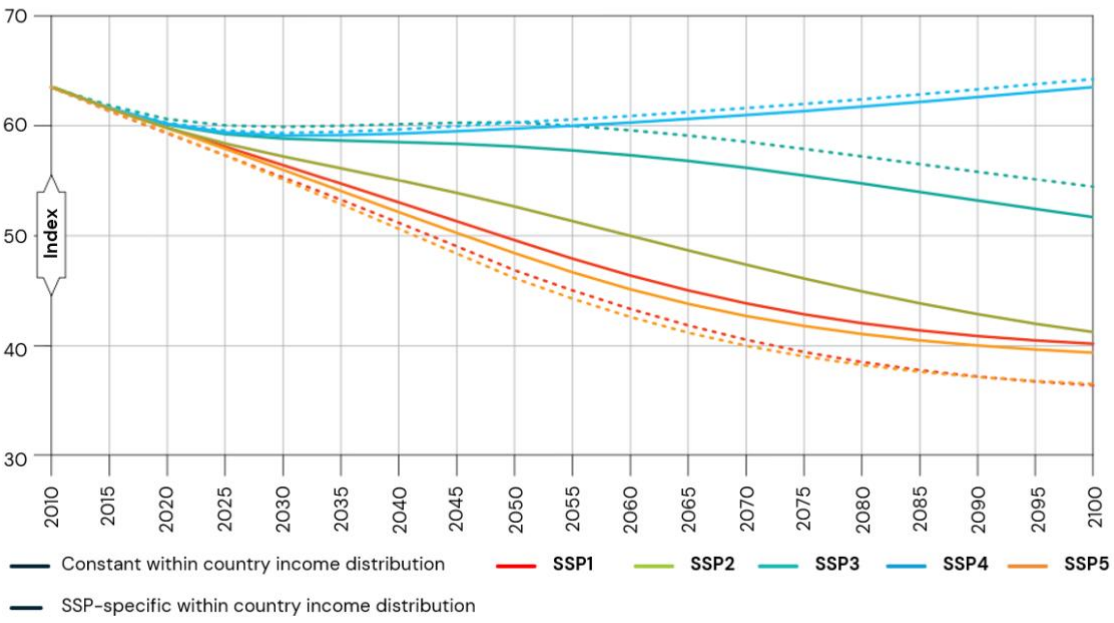
Inter region and intra region economic inequalities is an outcome as well as a key driver of the global food system. Globally, labourers in the food sector are amongst the poorest. Moreover, there is a big income gap between the poorest 10% and the richest 10%. A worker in the poorest 10% earns $374 per year, whereas a worker in the richest 10% gets $98,383 (International Labour Organisation, 2022). The long-term trajectory of poverty eradication and income gaps changed since the Covid-19 pandemic as many people lost jobs in the low-income countries. According to the Gini Index, high income inequalities are faced in Southern Africa and South American countries (Figure 5). However, in the sustainable, increased productivity and equitable growth scenarios (SSP1 and SSP5), poverty and inequalities are projected to reduce (FAO, 2022a) (Figure 6).

Figure 5: Gini Index showing the income inequalities across the world in 2021.



Source: *(The food systems dashboard.2024) based on (World Bank, 2024b)*

Figure 6: Global Gini index projections for alternative futures under shared socioeconomic pathways (2010–2100).

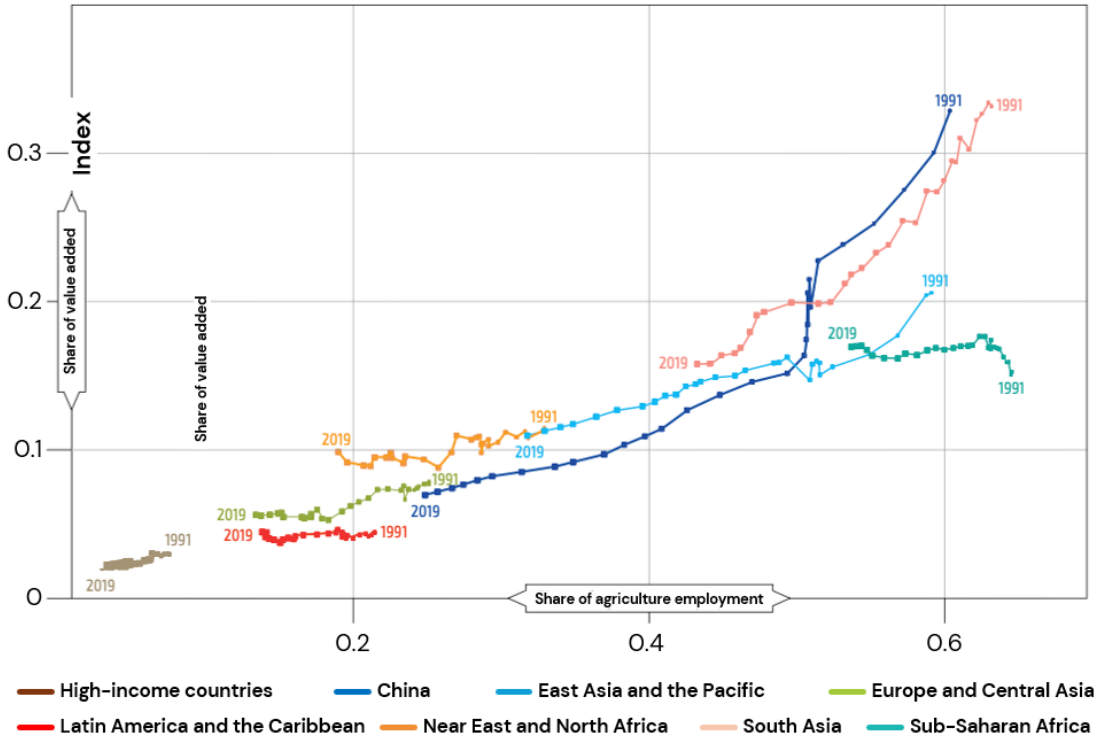


***Source**: (FAO, 2022a) based on data from (Van der Mensbrugghe, 2015)*

5.2.2 GDP

Declining GDP from agriculture (Figure 7) and fewer people working in agriculture are hallmarks of the structural transformation process that is integral to poverty reduction and rural transformation. Estimating the contribution of global food system to the national GDP and economic growth is challenging due to its complex nature. A model has been developed by Planet Tracker (Planet Tacker, 2023) that provides some estimations of the economic value of the Global Food System using a database of 4 million companies related to food system. It estimated that the global food system generate revenue which is equivalent to between 16 and 20% of Global GDP. It's noteworthy that up to 70% of revenues come from 0.06% of all companies in the database representing the dominance.

Figure 7: Share of agricultural value added in GDP and the share of agricultural employment (1991–2019).



Note: *Value added (agriculture, forestry and fishing) and GDP are both expressed in constant USD of 2015.*

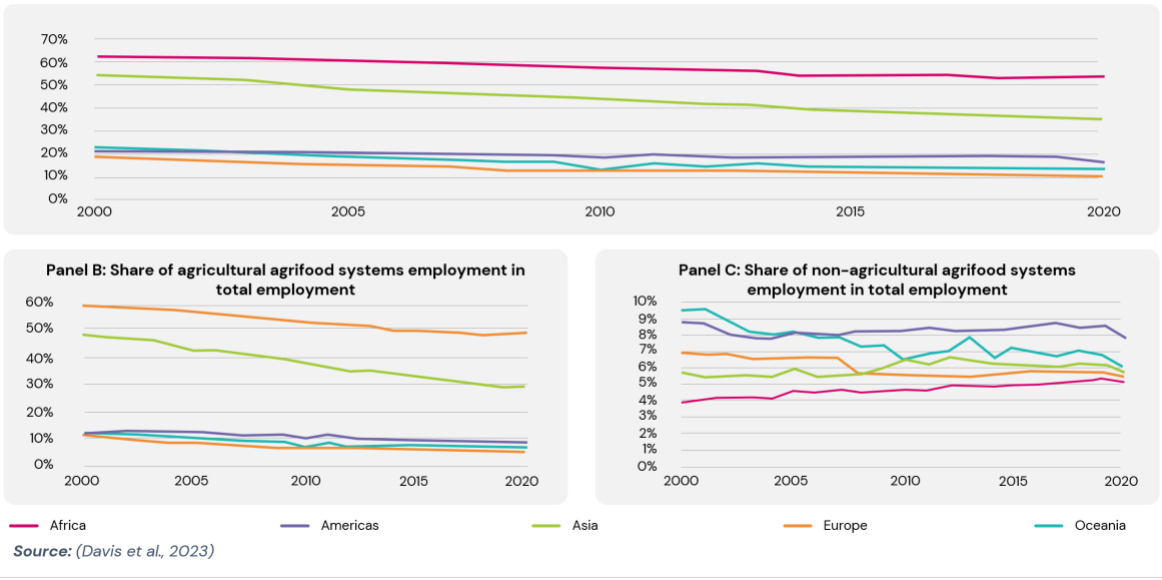
Source: *(FAO, 2022a)*

5.2.3 Employment in Agri-Food Sector (AFS)

In 2019, food systems provided employment for 1.23 billion people and (including household members) support over 3.83 billion livelihoods, in all stages of the value chain across rural and urban areas. With the growth in urbanisation, employment in agriculture is falling with labour moving to other sectors, often food related (food manufacturing, logistics, distribution and retail). The job migration is also an important driver in the food system influencing the livelihood and social-wellbeing outcomes.

As shown in figure 8 (panel A), across regions over time, the share of employment in AFS has been declining, attributed to the decline in the share of people employed in agriculture (panel B). The share of those employed in non-agricultural AFS remains relatively low as a share of total employment (panel C) but shows an increasing trend notably in Africa.

Figure 8: Share of employment in agrifood systems in total employment by region.

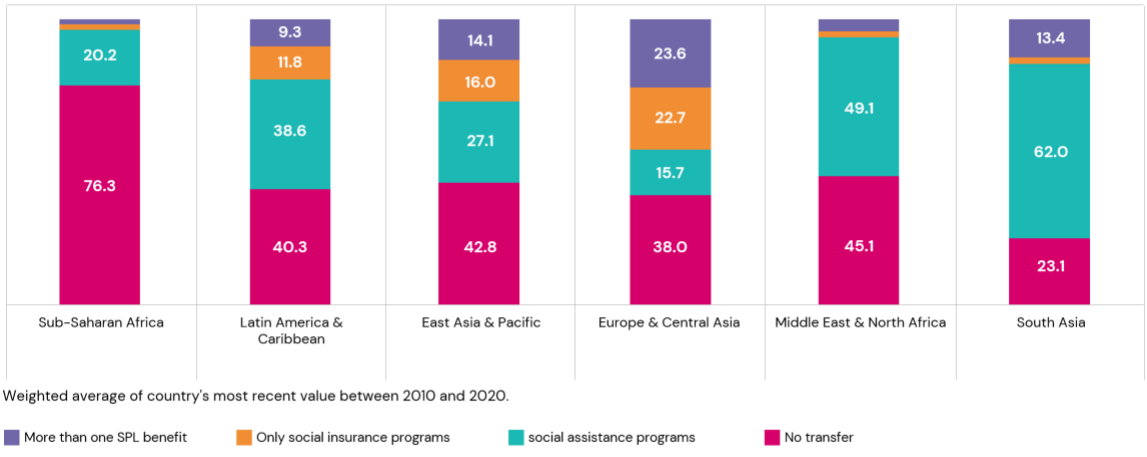


Source: *(Davis et al., 2023)*

5.2.4 Social Protection Coverage

Social protection as a result of holistic agri-food policies and equitable growth in the sector is an indicator as well as a driver of food security, equity and social-wellness. Programs dedicated to social protection have been impactful in combating poverty for small-scale food producers and informal workers who face chronic food insecurity and vulnerability to shocks. As shown in figure 9, in Sub-Saharan Africa, the coverage of social protection is the lowest compared to rest of the world, indicating the need for stronger policies for building resilience of the poorest and the marginalised food system labours in the region (World Bank, 2024a).

Figure 9: Coverage of Social Protection and Labour in total population (%).



Source: *(World Bank, 2024a)*

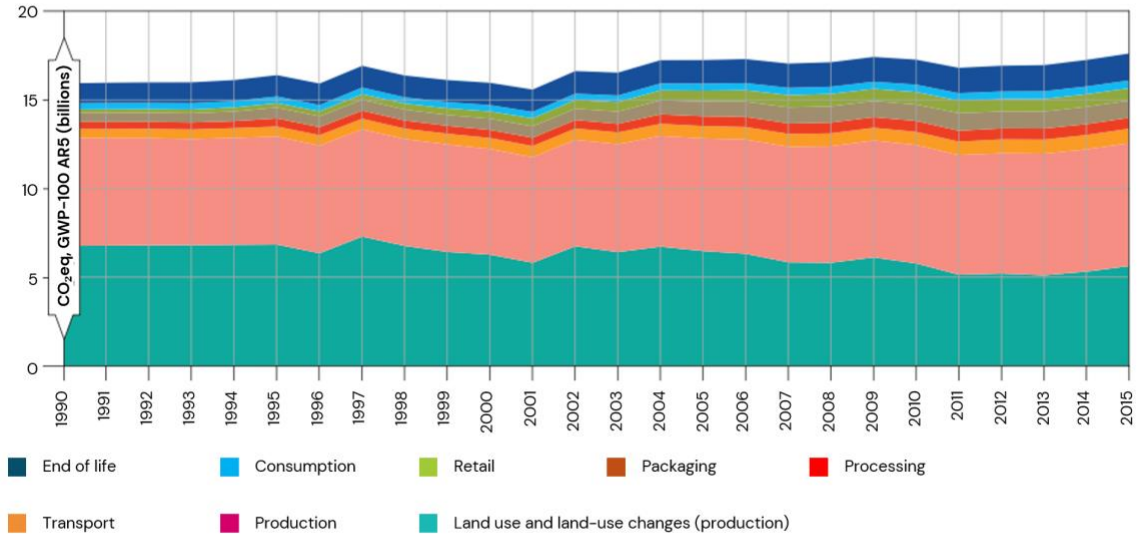
5.3 Climate and Environment

Global food system is locked in a spiral of decline with environmental systems: it is also a major cause of degradation of the environmental systems on which it itself depends (including biodiversity, freshwater, oceans, land, and soils). It is the largest cause of anthropomorphic greenhouse gas (GHG) emissions (28% of total GHG emissions in 2016), while agriculture alone accounts for 70-80% of freshwater use. Even without projected global population growth, global food system is operating well beyond planetary boundaries. The pressures placed on natural resources by food production have left 25% of the globe's cultivated land area degraded, while deforestation for agriculture is recognised as a major and irreversible cause of biodiversity loss (EAT-Lancet, 2019; IPCC, 2019). Important indicators of impacts of agrifood sector on climate, environment and natural resources are the GHG emissions, ecological footprint, freshwater withdrawals and crop land expansion.

5.3.1 GHG Emissions

Latest FAO report used EDGAR-FOOD dataset (Crippa et al., 2021) to elaborate on the contribution of the global agrifood system in the global GHG emissions. This dataset shows that while emissions resulting from land use and land-use changes activities (around 31 percent of the total from agri-food systems in 2015) dropped by 17 percent over the period 1990-2015, annual emissions resulting from agricultural production grew by 13 percent. This can largely be explained by the development of livestock production, a major source of methane, and, to a more limited extent, by more mechanization requiring fuel and electricity. Table 3 captures the various projections made in reports around GHG emissions from food system.

Figure 10: Global greenhouse gas emissions from agrifood systems by source (1990–2015).



Source: *(FAO, 2022a) based on (Crippa et al., 2021)*

Table 3: What different reports say about GHG emissions from the food system in the future

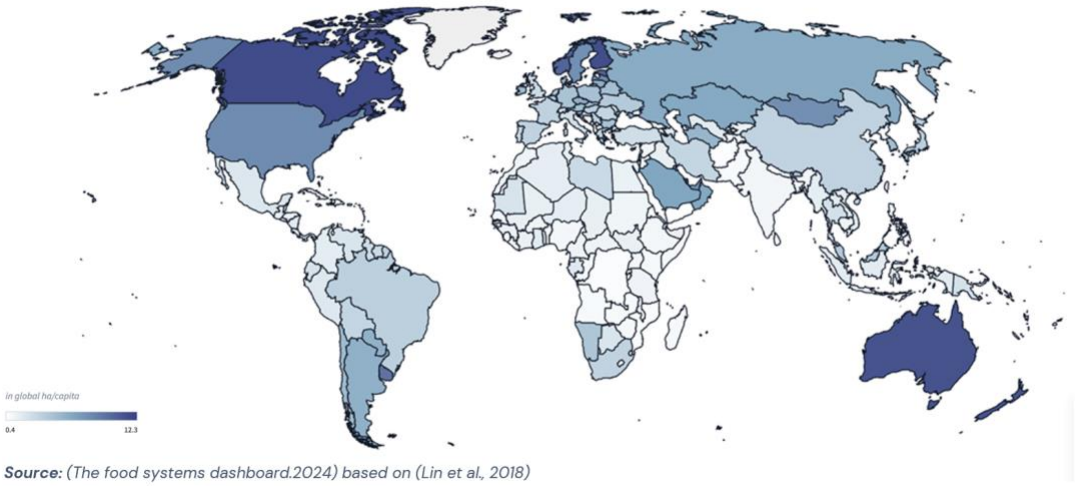
Variable related to climate change	(FAO, 2018) GHG emissions in three scenarios	(WEF, 2017)	(Global Panel, 2020)	(EAT-Lancet, 2019)
GHG emissions from food system	BAU- RCP 6.0 emissions would not exceed 8.0 gigatonnes CO2eq in 2050 TSS- (associated with RCP 4.5), GHG emissions from agriculture should broadly range between 3.2 and 6.4 gigatonnes of CO2eq in 2050. SSS- emissions exceeding 8.5 gigatonnes of CO2eq by the end of the period.	Despite efforts to decelerate climate change, the plans of 170 nations to curb emissions would still lead to an estimated temperature rise between 2.7°C and 3.7°C by 2100 – far above the critical 2°C global target,17 with resulting increases in food prices by as much as 84% by 2050	Animal products (meat, eggs, dairy, or fish) contribute the highest amount of GHGs, and this is projected to increase almost two-fold by 2050. A shift towards more sustainable, healthy diets could, for example, reduce GHG emissions by 41 – 74%	By shifting to sustainable and healthy diets, reducing food waste, and adopting improved production practices, global food system GHG emissions can be cut by 59% from 9.8 GtCO2e to 4.0 GtCO2e by 2050 under a business-as-usual scenario.

5.3.2 Ecological Footprint

There is well-established evidence indicating an irrevocable and continuing decline of genetic and species diversity, and degradation of ecosystems at local and global scales. The main causes of erosion of biodiversity are destruction and fragmentation of habitats, the overexploitation of resources by humans, pollution, climate change, and disease and invasive species, mostly caused by unsustainable agriculture practices, agricultural intensification, and resource intensive food supply chain. However, agricultural systems could enhance ecological health, if sustainable practices were adopted. The ecological footprint of food production is normalised by country population undermining the absolute degradation of ecological services in certain regions like South Asia (Figure 11). There is need for better tools for estimating ecological footprint of the various processes within the food system.

According to the projections in the IPBES report (Montanarella, Scholes, & Brainich, 2018), future reduction of biodiversity would reach 38 to 46 percent compared to the natural state by 2050, from around 34 percent in 2010. Drops are expected to continue in all world regions, but the greatest losses will most likely be in Central and South America, SSA and Asia.

Figure 11: Total ecological footprint of food production per person (global ha/capita) 2019.



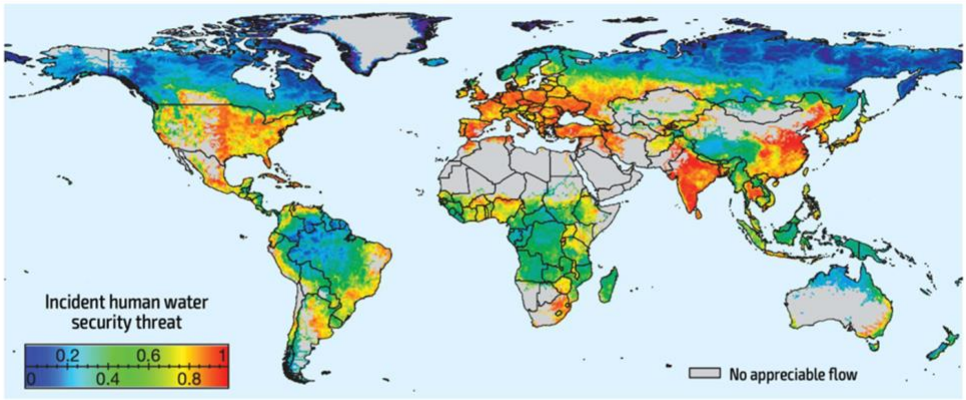
Source: *(The food systems dashboard.2024) based on (Lin et al., 2018)*

5.3.3 Freshwater Footprint

The pressure on renewable freshwater resources is growing. Currently, irrigated agriculture accounts for more than 70 percent of global water withdrawals, the rest being used for industries (20 percent) and municipalities (10 percent). Around 41 percent of these withdrawals are not compatible with sustaining ecosystem services. As illustrated in Figure 12, regions like India and parts of the USA are facing severe, human-induced water scarcity, primarily due to excessive water extraction for agricultural purposes.

The IPBES report (Montanarella, Scholes, & Brainich, 2018) flags the key role of agriculture, particularly irrigation and agricultural intensification, and it projects that "nearly half of the global population will live in water scarce areas in 2050, with the highest proportion in Asia.

Figure 12: Global geography of incident threat to human water security (2010).



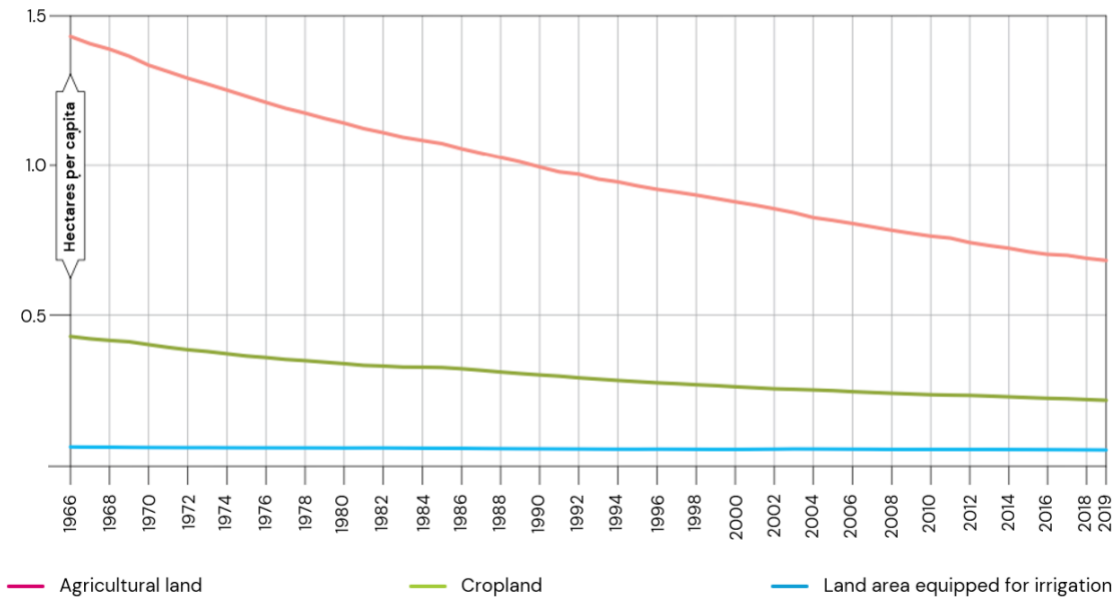
Notes: Dotted line represents approximately the Line of Control in Jammu and Kashmir agreed upon by India and Pakistan. The final status of Jammu and Kashmir has not yet been agreed upon by the parties. Final boundary between the Sudan and South Sudan has not yet been determined. Final status of the Abyei area is not yet determined.

Source: *(FAO, 2022a) based on (Vörösmarty, McIntyre, Gessner, & et al., 2010)*

5.3.4 Land Use

The amount of land per person available for agriculture is continuously decreasing (Figure 13). Worldwide agricultural land accounts for around 37 percent of land area. Between 1961 and 2019, agricultural land increased by around 6 percent (283 million hectares) to reach 4.75 billion hectares. Most of this land was gained at the expense of forests. Some area was also lost as it became unsuitable for agriculture because of unsustainable agricultural practices, natural degradation or urban expansion, and the development of infrastructure and extractive industries.

Figure 13: Global per capita agricultural land, cropland and land equipped for irrigation (1966–2019).



Source: *(FAO, 2022a)*

5.4 Key Take-Away from Review of Food System Outcomes

Despite the growing body of literature on food system outcomes, there remains a noticeable lack of comprehensive, globally focused studies. While climate outcomes, such as GHG emissions, have been extensively modelled and reported, other key areas, particularly related to health, nutrition, livelihoods, economies, and overall well-being, often lack the same level of detail and consistency. Organizations like the Global Panel, World Obesity Federation, WHO, and FAO are actively working to address the data gaps in health and nutrition outcomes, but future scenarios in these areas are still evolving. The significant lack of robustness is in the area of foresight on livelihoods, economies, and well-being.

The foresight work on food system outcomes highlights significant gaps and challenges, particularly in how various reports frame future scenarios. The projections across key reports, such as FAO's Alternative Pathways (FAO, 2018) and the State of Food Security (FAO, IFAD, UNICEF, WFP, & WHO, 2023), differ in terms of undernourishment estimates and future

hunger trends. For example, while FAO 2023 foresees nearly 600 million chronically undernourished people by 2030, FAO 2018's alternative pathways project up to 650 million under a business-as-usual (BAU) scenario. This discrepancy underscores the differing assumptions related to policy changes, technological advancements, and the impacts of shocks like COVID-19 and the Russia-Ukraine conflict. Similarly, reports addressing climate impacts and GHG emissions from food systems also diverge, with varying projections on the mitigation potential of sustainable practices. The EAT-Lancet report emphasizes the significant reductions possible through dietary shifts, while FAO and WEF reports provide different future GHG emissions estimates based on alternative socioeconomic pathways.

There are two important takeaways from this section:

i. The discrepancies in the future trends reflect the broader challenge in foresight work: differing methodologies, time horizons, and assumptions lead to varying conclusions.
ii. While the reports may not entirely align in their projections, they all emphasise the critical need for systemic change to address malnutrition, hunger, obesity, environmental degradation, climate change and socio-economic inequalities.

Here is an existential question for the foresight community- Should we work towards greater harmonization of methodologies, time horizons and assumptions in order to work towards convergence of conclusions (and risk becoming forecasters and predicters)? Or should we accept that different methodologies that are unavoidable given the complexity and uncertainty of food systems, and draw from those multiple perspectives to better explore that inherent complexity and uncertainty?

6. A Review of Key Drivers and Their Trends

A 'driver' is a process which influences how the food system actors behave, the value chain functions and therefore impacts the nature of the food system outcome. This section focuses on the drivers of the global food system, encompassing production, storage, distribution, consumption and disposal of food. We define "critical drivers" as factors with the potential to significantly impact these stages, identified either through known historical trends or emerging uncertainties. By analysing twenty publications (Table 2), we identified 95 distinct factors or trends that drives the global food system, their interactions and transitions will determine the future trajectories of the system's outcomes. The thematic assessment of these 95 drivers resulted in their classification into eight overarching groups or 'principal drivers' viz. 1) Shifting demographics, 2) economic development, 3) changing diets & consumer behaviour, 4) technology, innovation & information, 5) climate, resources & environment, 6) policy & governance, 7) socio-cultural paradigms and 8) crisis & conflicts. Thematic clustering facilitates systems thinking approach by revealing interconnections and trade-offs among drivers. While many drivers and their trends are mapped, in this report we focused on the most critical ones based on expert consultations (food system experts from Foresight4food steering group), selecting both established and new emerging drivers per principal group.

- **Well established drivers** are widely understood factors such as established farming practices, population growth, and trade agreements, which significantly impact food

production and access. These drivers were prevalent in the reviewed literature, providing detailed information and trends.

- **Newly recognised drivers** are emerging factors, such as agricultural or food system data ownership and the role of social media, whose full impact is yet to be determined. While recognized by stakeholders, these drivers are primarily discussed in recent post-pandemic research, leaving significant uncertainty about their future influence.

Subsequently, we compare quantitative data around the drivers drawn from selected reports to provide an overview of historical trends and uncertainty dimension to the future trends. Data availability around the historical and future trends of drivers in the selected reports was also supplemented with data from original sources. Where data exists, projections often diverge due to underlying assumptions and embedded uncertainties also reflecting differing conceptions of future trajectories. This complexity contributes to significant uncertainties in future outcomes.

This section synthesises the global level data from the selected studies. There is however a large area of modelling that looks at the various dimensions of food system and for specific geographical area which some of the FAO, CGAIR and Global Panel reports refer to and can be compared in future review studies. Section 7 will review which of these drivers are considered critical uncertainties and what assumptions have been made around them for development of future scenarios of food systems.

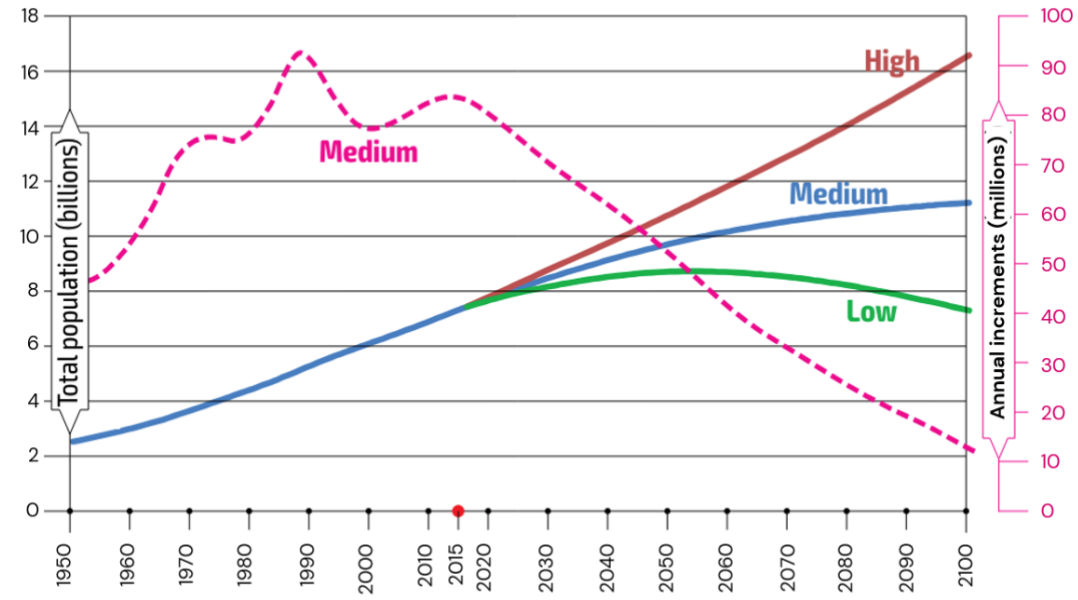
6.1 Shifting Demographics

Total population growth, age dynamics within countries and within urban-rural corridors, and migration of workforce effecting significantly impact food demand, production, and distribution, necessitating adaptive strategies within the food system.

6.1.1 Population Growth

The population growth rate has been declining since the 1960s and the absolute annual increments will also fall from 80 million people to 55 million by 2050 and 15 million by 2100. The total population will reach 9.73 billion by 2050 with this estimated rate, with most of this growth anticipated in Africa (+1.3 billion people) and Asia (+750 million people) (FAO, 2017). From a regional perspective, there will be increasing deceleration in East Asia, Latin America and South Asia. Some countries will however experience a drastic increase in population with Niger on top of the list amongst other Sub-Saharan countries. FAO 2017 Trends report (FAO, 2017) presented UN population data, stating that "considering the medium variant world's population will be 9.7 billion by 2050, 10.8 billion by 2080, and 11.2 billion by 2100". World Economic Forum report (WEF, 2017) used a different time scale reporting "The world population is expected to reach 8.5 billion by 2030, and the size of the global middle class is projected to increase from 1.8 billion in 2009 to 4.9 billion by 2030". In the graph below (Figure 14), the population under the high variant is expected to be 8.5 billion. The data thus shows high level of uncertainty in the population projections.

Figure 14: Global population growth to 2100, by variant



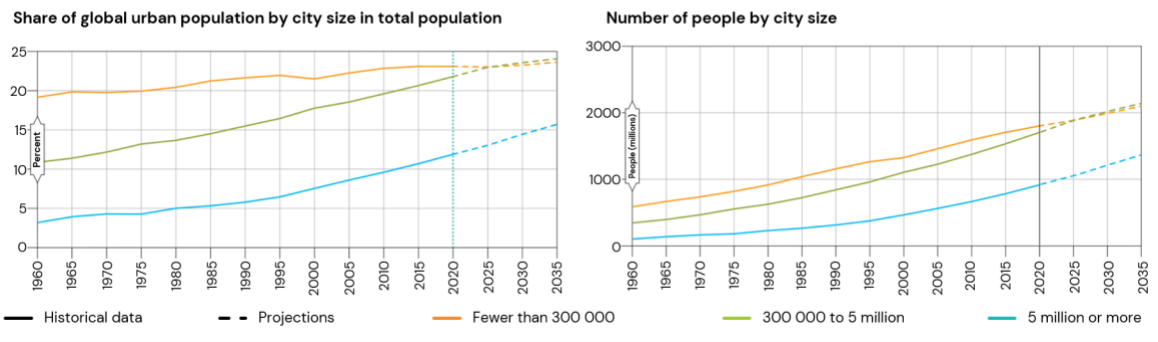
Note: Annual increments are 5-year averages.

Source: *(FAO, 2017) based on (UN, 2015)*

6.1.2 Urbanisation

Urbanisation is a key trend that's also linked with structural changes in the value chain (employment migration) and dietary changes. Recent reports from FAO focus on the urbanisation aspects of population growth. FAO report (FAO, 2022a) highlights "between 2020 and 2050, globally, the portion of people living in urban areas will shift from 53 percent to 70 percent, while by that date the world population could reach 9.8 billion people". The projection of urban population is shown in Figure 15.

Figure 15: Global urban population by city size: historical (1960–2020) and projected (2021–2035)- Graphs (FAO, 2022a)based on (United Nations, 2018)



6.1.3 Migration

Migration, including rural-urban migration, is a significant and growing trend that impacts food systems and rural development globally. Rural-urban migration is driven by factors such as economic opportunities, better living conditions, and access to services in urban areas. This migration can lead to both challenges and opportunities in rural regions. On one hand, it can result in labour shortages and demographic changes in rural areas, affecting agricultural productivity. On the other hand, remittances sent back by migrants can support rural economies by providing funds for investments in agriculture, education, and infrastructure (FAO, 2017, 2022a). This trend is also associated with the economic growth of large rural farmers, reducing the labour needs and forcing migration of agriculture labour in search of livelihood. Migration is reflected in the growth of urbanisation (e.g. uncontrolled growth in Cape Town), but it is hard to project the future rate of rural-urban migration within a small region. According to the data available in FAO's state of food and agriculture 2018 report, more than 1 billion people living in developing countries have moved internally as part of economic transformation; rural–urban and rural–rural migration flows are part of this process. Structural transformation is also reflected in the reduction of agriculture contribution to GDP and decrease in agriculture value added more significantly in China, South Asia and Easi Asia Pacific. The migration projections will rely on assumptions about multiple socio-economic factors.

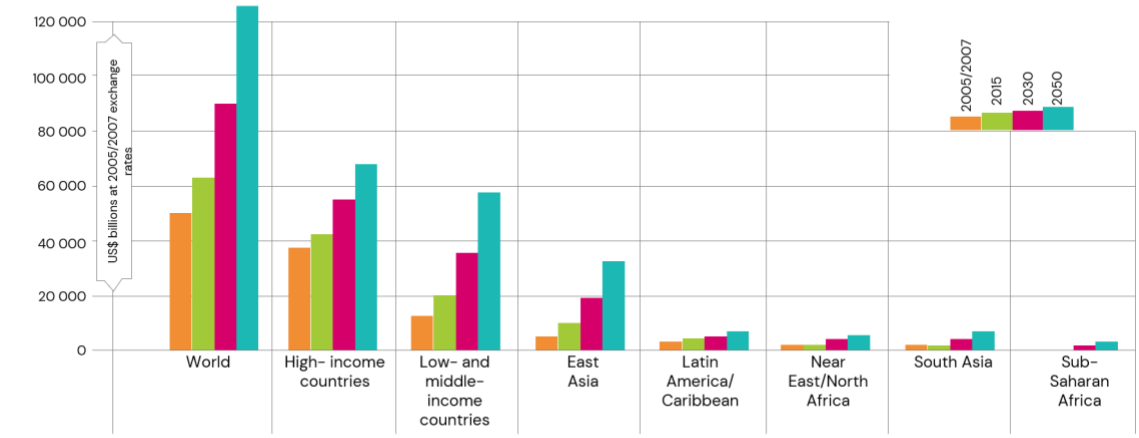
6.2 Economic Development

Economic growth and income levels determine purchasing power and food choices, often leading to shifts from staple local foods to diets influenced by lifestyle and food environments variedly in urban and rural areas. Economic development is also reflected in industrialisation of agriculture, structural shifts in value chain, public and private investments, access to market infrastructure, market connectivity of marginal farmers, and profit driven food monocultures.

6.2.1 Economic Growth

The world economy grew by 2.6 percent a year to almost double in size between 1990 and 2014. During that period, global economic growth was driven mainly by low- and middle-income countries, whose gross domestic product (GDP) grew by some 5.1 percent annually. China's GDP grew at double that rate, by more than 10 percent a year, and in 2014 the country accounted for 9 percent of global GDP, compared to just 2 percent in 1990 (UN, 2016). Per capita income in emerging East Asia and the Pacific increased by 7.4 percent annually between 1990 and 2014; in contrast, average income growth in sub-Saharan Africa stood at a meagre 1.1 percent a year, a reflection of starkly diverging growth patterns among low- and middle-income regions. Figure 16 shows the economic differences across regions in purchasing power parity terms. Economic growth projections in terms of GDP under different scenarios are provided in (FAO, 2017). based on moderate GDP growth assumptions, The FAO report assumes an annual growth rate for the world economy of 2.7 percent. Accordingly, global GDP would increase from about US$50 trillion in 2005–2007 to almost US$126 trillion (in constant 2005 prices) in 2050.

Figure 16: Growth in GDP to 2050 based on moderate global economic growth to 2050, by region



Note: Note: Regional groups do not include high-income countries.

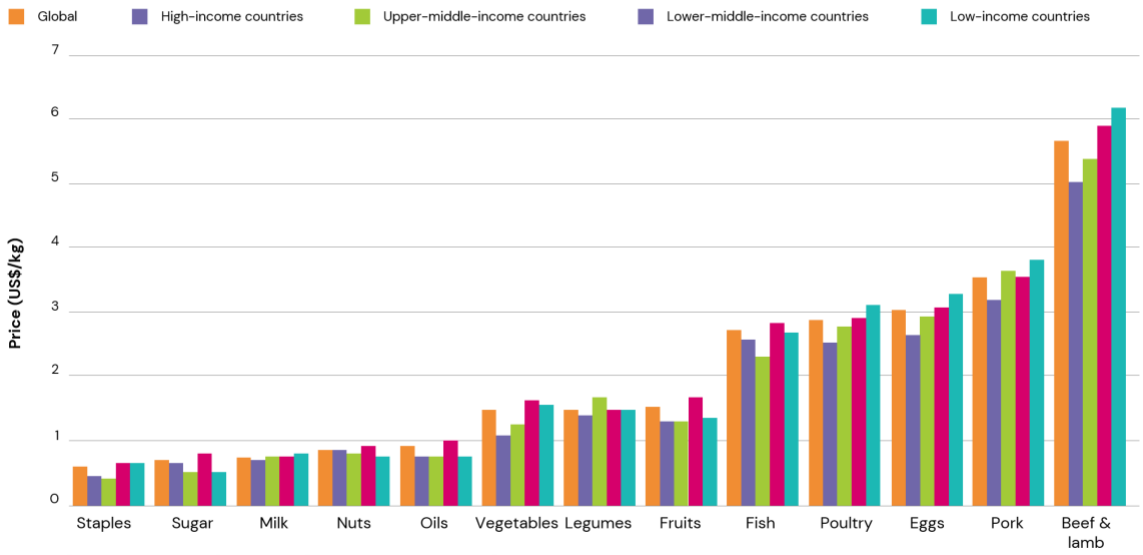
Source: *(FAO, 2017) based on (Alexandratos & Bruinsma, 2012)*

6.2.2 Food price and Markets

Unprecedented global events like pandemics and the 2007-8 economic crisis leading to food price fluctuations around the trend increased the volatility and uncertainty of future food prices (FAO, 2017). Typical measures of volatility suggest that food price volatility in the last 50 years reached its highest level during the 1970s. When taking into account the drop fluctuations in the food price index since the 2000, (mainly drop in 2015 and 2016 and spike in 2020-21), it seems that volatility is increasing to the level of 1970s (FAO, 2017). The real food price index (RFPI) shows steady decline between the 2010 and right before the Covid pandemic. There was drastic spike in the RFPI in 2020-21 which stabilised in 2022-23. In the recent years, there has been increase in the price indices for vegetable oils, dairy products and sugar which was counterbalanced by decreases in those of cereals and meat. In Nov 2023, the index stood 14.4 points (10.7 percent) below its corresponding level one year ago. Future food price projections are uncertain due to various assumptions regarding technological changes, policies, yields, market modifications, and conflicts like the Ukraine war (FAO, 2022a).

(Global Panel, 2020) links food prices with nutrition intake. According to the report, there is a significant price gap between foods recommended for healthy diets and cheaper, less nutritious options, with animal-source foods being the most expensive globally, followed by fruits, pulses, and vegetables, while staples and sugar are less costly in 2030 (Figure 17).

Figure 17: Projected food commodity prices in 2030 by income region



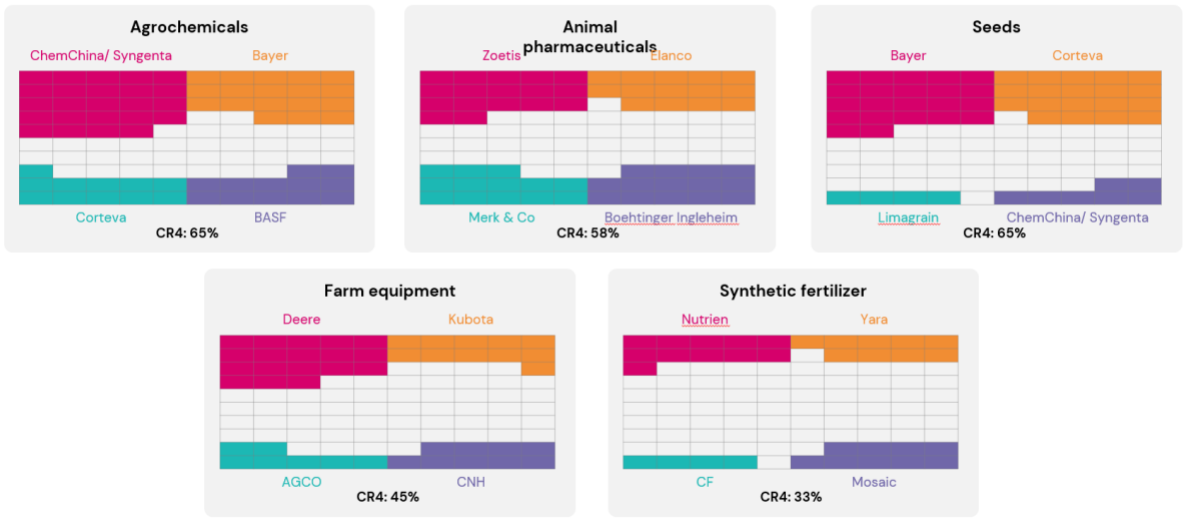
Source: (Global Panel, 2020) based on (Springmann et al., 2020)

6.2.3 Corporate Practices, Power and Influence

The structural changes in the food supply chain and the increasing influence of food corporates that is changing the distribution of power among actors in the food value chain is a key driver which has not been discussed widely in foresight literature. The concentration of agri-food activities within a limited number of corporate giants is an example of this structural change. This influences pricing, bargaining power, data ownerships, access to resources and diets. Monopolies in the food value chain can result in exploitation of farmers, inequitable distribution of profits, and challenges in achieving sustainability and resilience.

The market concentration is profound in the agri-input sector as shown in the data presented in (FAO, 2022a) (Figure 18). In the recent years, major mergers and acquisitions in the agro-chemicals and seed sectors. However, the food system experts speculate that with the development of widely accessible technologies like gene-editing technology, the cost of developing crop varieties could reduce enabling new and smaller companies (including start-ups) to grow (FAO, 2022a).

Figure 18: Four-firm market concentration (CR4) for seeds, agrochemicals, farm equipment, synthetic.



Source: (FAO, 2022a) based on (Hendrickson, Howard, Miller, & Constance, 2020)

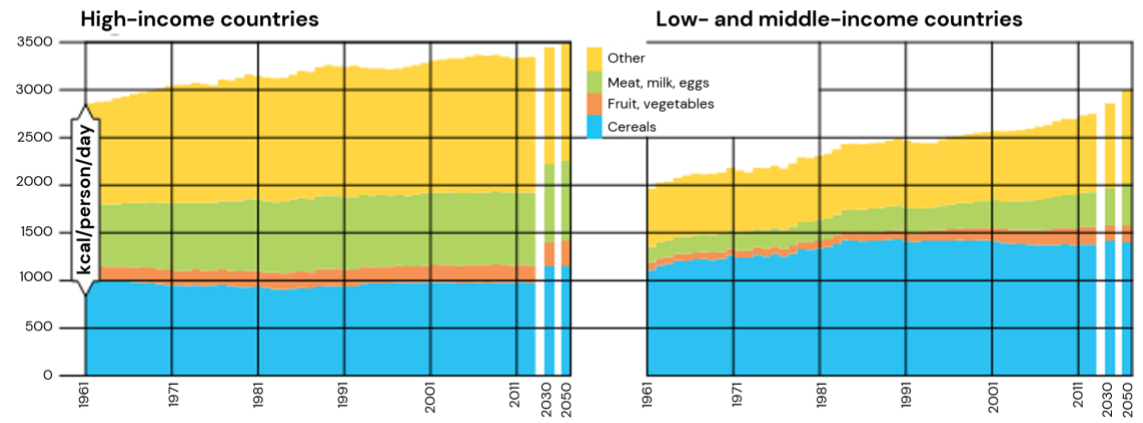
6.3 Changing Diets and Consumer Behaviours

Consumer awareness, preferences, and behaviours play a significant role in shaping the food system. Evolving consumer preferences, awareness of sustainability, and changing dietary habits drive shifts in food production methods, marketing strategies, and supply chain practices, shaping the trajectory of the food system.

6.3.1 Calorie Intake Related to Dietary Choices

Today's diet is the prime cause of 'triple burden' of malnutrition and environmental degradation (EAT-Lancet, 2019; Global Panel, 2020) and the future dietary choices is one of the key uncertainties in the global food system as described in (FAO, 2022a). Several factors directly influence the dietary choices viz. purchasing power, urban lifestyle, food environment, social influences, and interest in healthy and sustainable diet (FAO, IFAD, UNICEF, WFP, & WHO, 2023). Globally, according to the Global Panel report, food (calorie) demand will rise between 49% and 56%, depending on the assumptions used. Global Panel and FAO projections suggests that demand for animal products (dairy, meat, fish), as well as for vegetable oils, sugar, ultra-processed foods, and high fat and salty snacks is expected to grow from current levels and the gap in calorie intake between high-income countries (HICs) and low- and middle-income countries (LMICs) will reduce towards 2050 (Figure 19). What exactly people will be eating in cities and rural areas, depends on multitude of factors.

Figure 19: Per capita calorie intake by source, 1961–2050



Source: (FAO, 2017) based on (Alexandratos & Bruinsma, 2012)

6.3.2 Increased consumption of processed and ultra-processed food

As incomes rise, some common patterns of dietary shifts have emerged including consumption of processed and ultra-processed foods. This characteristic converges with the urban lifestyle and increase in disposable income. Urban diets tend to rely on an increasingly narrow base of staple grains, as well as on a greater consumption of animal sourced foods, oils, salt, sugar and processed foods. Obesity and overweight prevalence are found among both the richer and the poorer urban dwellers, as the latter consume inexpensive processed foods high in calories and low in nutritional value (FAO, 2022a). It's important to note that while there is a general trend of increasing consumption, there are variations between countries and regions. The transition in diets towards healthier and sustainable will require food system transformation. The projections of what people will be eating in future are not available, but there are a range of assumptions made under various scenarios that are presented in scenario studies reviewed in section 7.

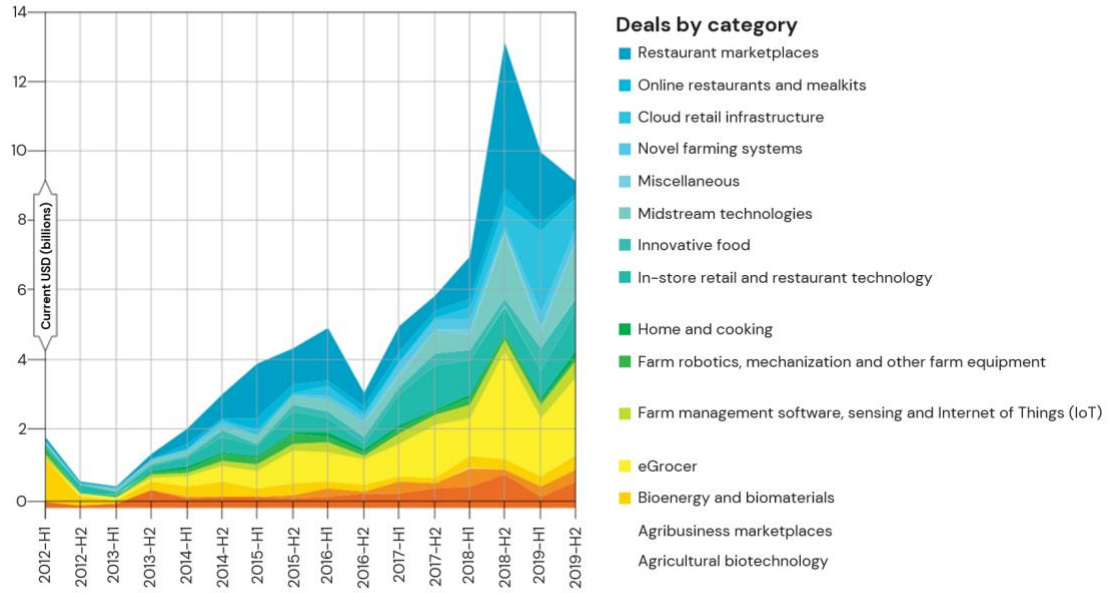
6.3.3 Acceptability of plant-based and vegan diets

A new trend in diet has been emerging i.e. veganism and plant-based diet. It is also linked with digitisation and innovation in plant-based foods (Hassoun et al., 2022). Many food industries have leveraged on people's awareness of impacts and ethical concerns around animal-based diet and are marketing plant-based alternatives. It reduces pressure on natural resources such as land and water, as plant-based foods typically require fewer resources to produce compared to animal products. This shift also promotes sustainability by lowering greenhouse gas emissions associated with animal agriculture, contributing to efforts to mitigate climate change and improve environmental stewardship. However, these products are typically ultra-processed, and their health impacts are not comprehensively researched.

6.4 Technology and Innovation

Technology, including automation, data analytics, and biotechnology, has a significant impact on food production and distribution. Advancements in technology, such as automation and biotechnology, revolutionize food production efficiency, supply chain management, and consumer engagement, reshaping the structure and operation of the food system. However, the future trajectory of technological adoption remains uncertain, influenced by factors such as investment, consumer behaviours, capacity building, and policy support. Venture capital investments in agriculture and food technology offer insights into historical trends but cannot fully predict future innovation (Figure 20). There are many assumptions made how the technology may play a major role in food systems transformation in the scenario studies. These assumptions are synthesised in section 7.

Figure 20: Global venture capital investment in agriculture and food technology by category



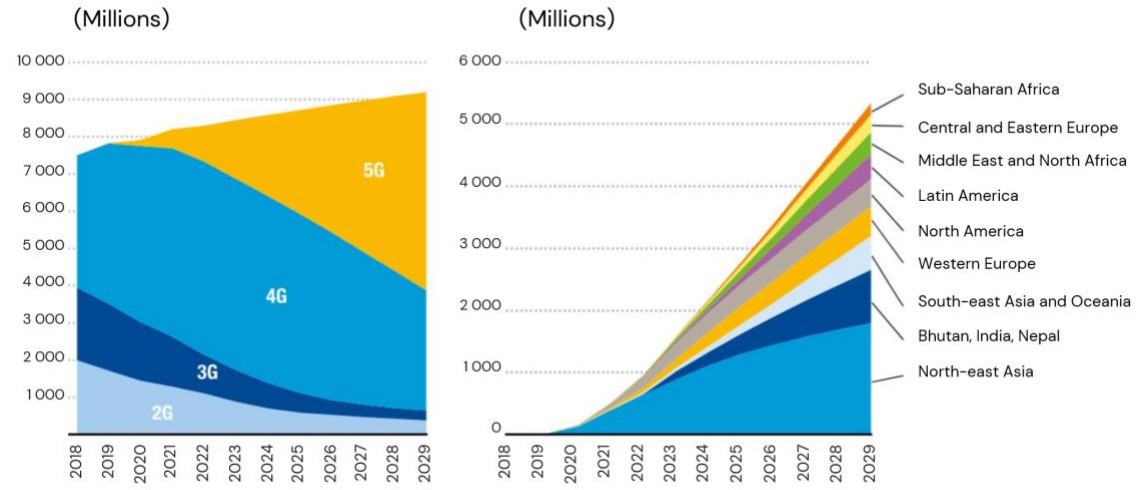
Source: *: : (FAO, 2022a) based on (AgFunder, 2019)*

6.4.1 Digitisation

The volume of global data traffic is forecast to grow by a factor of 2.5 by 2029. Much of this growth will be attributed to the improvements in mobile technologies. Access to 5G technology is expected to grow significantly in the near future, with global population coverage from 45% in 2023 to 85% in 2029 (Figure 21) (UN Trade and Development, 2024). In low-income countries, mobile phone subscriber penetration stands at almost 60 percent and is expected to grow rapidly. The farmer field schools approach has spread to more than 90 countries and has been used to train an estimated 20 million farmers (FAO, 2017).

Digital advances are supporting and accelerating achievement of each of the 17 Sustainable Development Goals which also constitutes food systems outcomes. Information and communications technologies are playing an increasingly important role in keeping farmers and rural entrepreneurs informed about agricultural innovations, weather conditions, input availability, financial services and market prices, and connecting them with buyers. It is also supporting automation of the food value chain. Many technologies such as Artificial Intelligence (AI), Internet of Things (IoT), Big Data (BD), blockchain, robotics, and smart sensors are being employed by the whole food supply chain from farm to fork (Hassoun et al., 2022). But technologies can also threaten privacy, erode security and fuel inequality. Increased digitisation also requires extraction of materials required for manufacturing digital devices and expand transmission network (UN Trade and Development, 2024). They have implications for big data management and environmental footprint (UN, 2024).

Figure 21: Global mobile subscription by technology (left) and mobile 5G subscriptions by country groupings (2018- 2029)



Source: (UN Trade and Development, 2024) based on (Ericsson, 2023)

6.4.2 Big Data

Currently, the big data industry, worth USD 198 billion in 2020 (around 0.2 percent of the value of global gross production), is set to proceed with rapid growth and should reach USD 684 billion by 2030, driven by the increased adoption of cloud computing, AI and the IoT, of which connected devices are expected to arrive at a stunning figure of 75 billion by 2025, with a value of EUR 5 trillion to 11 trillion. In addition, projections see the market for remote sensing and geospatial analytics rise from over USD 2 billion in 2018 to more than USD 8 billion by 2025 (FAO, 2022a).

Growing digitisation is enabling Big Data. In the food systems, Big Data (BD) is being applied particularly in the context of precision agriculture, smart farming and digital farming. BD technologies are expected to contribute to optimization of farm

production, minimization of disaster-related risks, reduction of costs of fertilizers application, more effective management of crop diseases and natural resources, mitigation of climate change and an enhanced food security. But growing collection and use of BD also raise some concerns of unequal power dynamics monopolies, and challenges in ensuring transparency and accountability because a few players have come to dominate large shares of the market. Future growth in BD technologies will also potentially have GHG implications (FAO, 2022a).

6.4.3 Artificial Intelligence (AI)

Most of the growth is big data analytics can be attributed to AI, specifically machine learning. The statistics on use of AI in food sector is not being published presently. But across various industries, AI adoption is expected to grow at an annual growth rate of 37.3% between 2023 and 2030 (Haan & Holznienkemper, 2024). At present, China is leading in AI adoption, with 58% of companies deploying AI and 30% considering integration. In comparison, the United States has a lower adoption rate, with 25% of companies using AI and 43% exploring its potential applications (Haan & Holznienkemper, 2024).

Currently, an AI revolution is happening in almost all industries including the agriculture and food industry on a global scale. There are two areas where AI is predicted to make a major contribution improving nutrition and cellular agriculture. From expert systems and fuzzy logic to Adaptive Neuro-Fuzzy Inference System (ANFIS), Near-Infrared Reflectance Spectroscopy (NIRS), Computer Vision System (CVS), and AI-driven sensors, these technologies are transforming food production, quality control, and safety like never before. Compared with big data, these technologies have unique characteristics and application scenarios, and each plays a unique role in solving problems and optimizing processes (Ding et al., 2023). However, there are concerns related with AI taking over jobs causing loss of employment and its material footprint (UN, 2024; UN Trade and Development, 2024)

6.4.4 Synthetic Biology

In December 2020, the first cell-based chicken nuggets were approved by in Singapore. As of November 2021, there are at least 76 companies developing similar products around the world (Byrne, 2021). Many types of products and commodities such as various types of meat, poultry, fish, aquatic products, dairy and eggs are in the pipeline for future commercialisation (FAO, 2022c). Worldwide, Impossible Foods (alternative protein producer) products are available in over 30,000 restaurants and 15,000 grocery stores (Voigt, 2020).

Developments in synthetic biology have enabled precision fermentation that allows microorganisms to be programmed to produce almost any complex organic molecule, including growth factors for the production of cell-based meat. Foods

produced through advanced cell engineering are believed to be approximately ten times more efficient than a cow at converting feed into end products, translating to ten times less water, five times less energy and 100 times less land. Compared to a beef patty, the Impossible Burger requires 96% less land and 89% fewer greenhouse gases. Synthetic biology has revolutionised what we eat today and is expected to have positive implications on food security, health and climate outcomes.

6.4.5 Agronomic Innovation

Key trends include increase in precision agriculture, which uses data-driven technologies such as drones, sensors, and GPS to optimise resource use, improve crop yields, and reduce environmental impacts. Another major trend is Clustered Regularly Interspaced Short Palindromic Repeats (CRISPR) and genetic engineering, enabling the development of crops with greater resistance to pests, diseases, and climate stresses. Genetically modified seed market analysts project a sales growth of more than 5 percent per annum to reach a value of more than USD 30 billion by 2026 (FAO, 2022a). Additionally, agroecology and sustainable farming practices like regenerative agriculture are gaining momentum by promoting biodiversity and soil health while minimising environmental harm. Innovations like vertical farming and controlled environment agriculture (CEA) are enabling year-round crop production in urban areas, reducing the need for large amounts of land and water. The increase in investment in agri-food technologies is driving these innovations.

Agronomic innovations are driving significant changes in global food production, helping address challenges like climate change and resource scarcity. A global and national focus in international research, subsidies and support for a few crop species (mainly high value crops) has contributed to an overall decline in agrobiodiversity. There is lack of research and innovation to support small holders growing local and indigenous varieties of fruits and vegetables and other crops. There is a possibility that a lack of adaptive capacity and policy support will drive farmers to move away from diverse crops, further reducing the resilience of food systems by increasing risk of crop loss from pests, disease and drought and potential loss of Indigenous or local knowledge (FAO, 2022a)

6.5 Climate, Environment and Resources

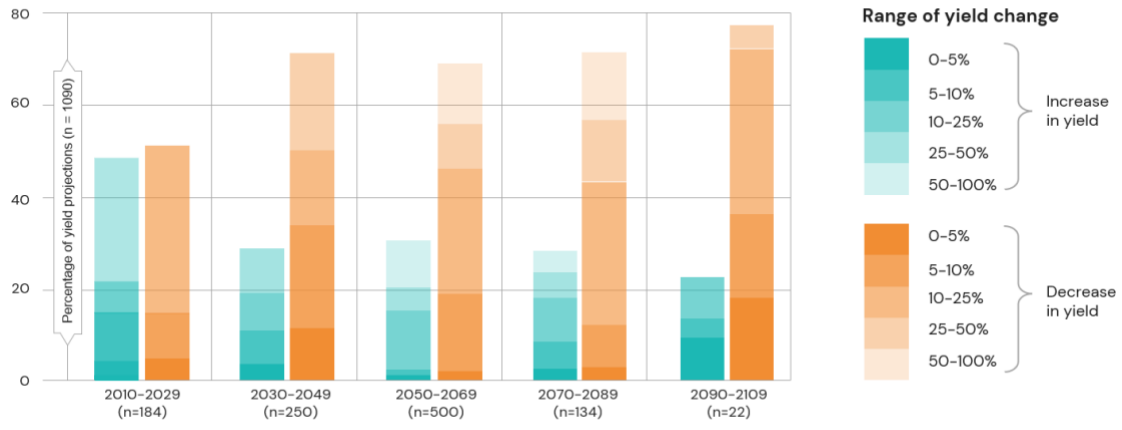
Climate change, resource availability, and environmental sustainability impact agricultural practices, food production, and supply chain resilience. The degrading status of land, competition for water and fuel, bio-fuel race, forest encroachments, food waste and food safety pose inevitable pressures on the food system.

6.5.1 Climate Change

The role of climate change and its effects on agriculture and food systems. Agri-food sector is one of the biggest contributors of global GHG emissions. The pervasive effects of climate change on agricultural productivity, resource availability, and extreme weather events pose significant challenges to food security and necessitate adaptive strategies within the food system. This is also one of the biggest uncertainties. Over the past 50 years, greenhouse gas (GHG) emissions resulting from 'Agriculture, Forestry and Other Land Use' (AFOLU) have nearly doubled, and projections suggest a further increase by 2050 (IPCC, 2022). According to IPCC, there are catastrophic effects of climate change on the food security due to impacts on crop, livestock, forestry, and fishery (inland and ocean) based food supply systems especially in Asia, Africa and South and Central America where communities heavily depend on natural ecosystems for food security (IPCC, 2019, 2022) with significant impacts on agricultural revenues in Argentina, Mexico, and Brazil (FAO, 2022a).

Although the uncertainty is high, the use of climate models in conjunction with crop models is contributing valuable insights into the possible impacts of climate change on yields. For the main cereals, projected yields, due to climate change under the different representative concentration pathways show significant regional increases and decreases but mostly downward shifts globally (IPCC, FAO). A study cited in FAO reports analysed results from various integrated climate and crop models (primarily wheat, maize, rice and soybeans) and indicates that climate change may significantly reduce yields in the long run (Figure 22). The most severe economic and food system impacts on crop yields and fisheries will be borne disproportionately by low-income countries (Global Panel, 2020).

Figure 22: Projected changes in crop yields owing to climate change



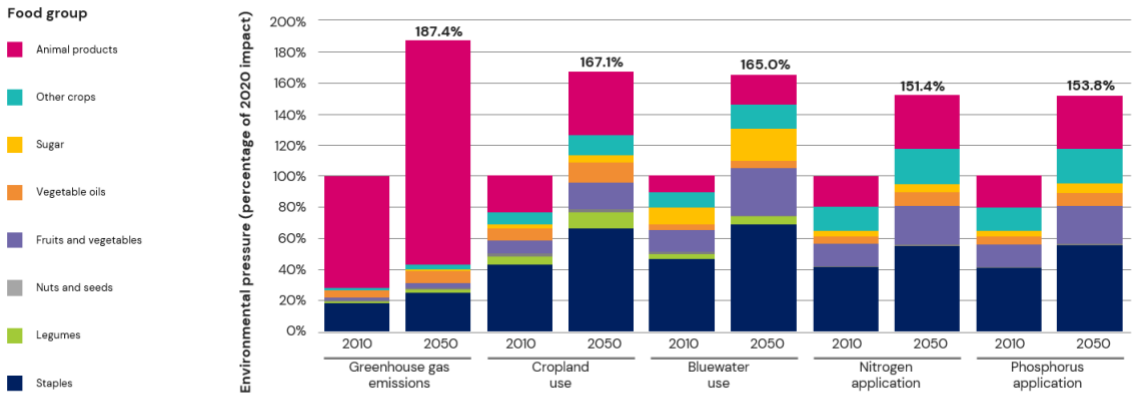
Source: (FAO, 2017) based on (Porter et al., 2014)

6.5.2 Land Degradation

Land degradation, deforestation and water scarcities are among the most visible manifestations of the unsustainable competition. Paradoxically, some efforts aimed at reducing greenhouse gas (GHG) emissions have led to further intensification of

competition for land and water resources for e.g. in countries intensively producing biofuel) (FAO, 2017). Expansion and concentration of agriculture (including raging, grazing and cropping) continues to be the main driver of land degradation. Agriculture is estimated to be the proximate driver for around 80 percent of deforestation worldwide. The highest levels of land degradation are manifest in the lowest-income countries (Global Panel, 2020; HLPE, 2020). Commercial agriculture is the most important driver of deforestation in Latin America, accounting for around two-thirds of total deforested area. In Africa and tropical and sub-tropical Asia, subsistence agriculture accounts for a larger share of deforestation than commercial agriculture. Between 2000-2010, low-income countries experienced both the largest annual net loss of forest area and annual net gain in agricultural area (FAO, 2017). With the continued trends in food production and consumption the cropland use is projected to increase from 12.6 M km^2 in 2010 to 21.1 M km^2 in 2050 i.e 67% (EAT-Lancet, 2019) with associated loss in biodiversity. Figure 23 shows the environmental footprints of different food groups (also showing land use increase by 67% by 2050) (Global Panel, 2020).

Figure 23: Impacts of different food groups on the environment, baseline and projections.



Note: Bluewater is fresh water in streams, rivers, lakes and aquifers.

Source: *(Global Panel, 2020) based on (Development Initiatives, 2020)*

6.5.3 Post Harvest Food Loss and Food Safety

Higher temperatures and humidity can increase post-harvest loss from pests and diseases, increase occurrence of food-borne diseases and contamination, and raise the cost of refrigeration and other forms of preservation (IPCC, 2022). Emerging food safety risks from climate change include those posed by toxigenic fungi, plant- and marine-based bacterial pathogens, HABs and increased use of chemicals (plant protection products, veterinary drugs) potentially leaving residues in food (IPCC, 2022). In African countries, the food loss occurred at the post-harvest stage is the highest and account for more than 20% of food originally intended for consumption. While it's difficult to extrapolate these trends as the food loss data is complex and scattered, the historical trends show that positive trend in decreasing post-harvest food loss in many regions including Latin America, South-East Asia and North-Africa has increased significantly (FAO, 2022a).

6.6 Policy and Governance

Varying degrees of involvements by the national governments and international governance structure in food production, distribution, and regulation of food safety standards, markets and food environments. The extent of governmental involvement in food-related policies, regulations, and support programs shapes market dynamics, food safety standards, and access to resources, influencing the overall stability and equity of the food system.

6.6.1 Subsidies and Incentives

Financial support, particularly input incentives for fertilizers, energy, and water, have been on a significant upward trajectory in recent decades. Subsidies coupled with government procurement of agricultural products, can inadvertently exacerbate pressure on natural resources for example by promoting use of synthetic fertiliser, ground water pumping, expansion of land etc. In fisheries, subsidies have fuelled overcapacity, leading to overfishing. While intended to boost production and food security, these subsidies often drive agricultural expansion, causing environmental damage and undermining the ecosystem services essential for sustainable food systems (FAO, 2017). A modelling exercise conducted by FAO reveals that simply removing agricultural support may have important adverse trade-offs. For example, in an extreme scenario whereby all agricultural support were removed by 2030 without being repurposed, GHG emissions are projected to fall by 78.4 million tonnes CO2e, but crop production, livestock farming production and farm employment are also projected to decrease by 1.3, 0.2 and 1.3 percent, respectively (FAO, IFAD, UNICEF, WFP, & WHO, 2023). Subsidies needs to be adjusted and balanced to drive sustainable food system transformation. In the past decade, OECD governments were on average allocating roughly 26% of their subsidy support to cereal grains, and 14% to fruits and vegetables. Interestingly, the share of sectoral support to fruits and vegetables was much higher in non-OECD countries at 37%. Reallocation of subsidies to nutrient rich fruits and vegetables will have a huge positive health outcome however, it needs to be balanced with profitable commodities for economic growth (Scenarios for rebalancing subsidies (Global Panel, 2020).

6.6.2 Inequalities in Support System- High Value Crop Growers Vs. Indigenous Growers

As part of the climate change adaptation strategies, there is a global and national focus in international research, subsidies, and support for a few crop species (mainly high value crops) has contributed to an overall decline in agrobiodiversity. There is lack of research and innovation to support small holders growing minor crops (IPCC, 2022). Example- In the Andean Altiplano of Bolivia, indigenous farmers have traditionally managed a diverse set of native crops which are drought and frost-tolerant, using cultural practices of seed selection and exchange, but have faced an increase in pests and diseases and a decline of traditional crops due to climate-change- related stresses, out-migration and intensification drivers (IPCC, 2022). There is a possibility that a lack of adaptive capacity and policy support will drive farmers to move away from diverse crops, further reducing the

resilience of food systems by increasing risk of crop loss from pests, disease and drought and potential loss of Indigenous or local knowledge (IPCC, 2022).

6.6.3 Land Deals

Since 2000, at least 160 million hectares have been under negotiation. Land deals surged after the 2007–2008 food price crisis and farmland investment boom. Land acquisition is often for industrialisation of agriculture in many areas (IPCC, 2022). This induces risks of injustice to local people as reduces access to water and food security. In some cases, land deals pose food security risks by re-orienting crop production to nutrient-poor crops predominantly destined for export, and/or excluding local populations from agricultural land. Growing land tenure insecurity may force farmers to engage in unsustainable farming and forestry practices. Strict regulations to address these risks are needed in the future.

6.7 Social-cultural Paradigms and Inequalities

Socio-cultural paradigms refer to the beliefs, values, norms, and behaviours that shape how people produce, consume, and relate to food. These societal paradigms along with inequalities in the society (mainly related to economic disparities) drive the food system by influencing dietary preferences, agricultural practices, food policies, and broader societal goals.

6.7.1 National Income and Growth Disparity

World Bank report suggests that economic growth is an important driver of poverty reduction. However, poverty reduction only materializes if the gains of economic growth are shared across social strata (FAO, 2022a). FAO trends and challenges report (FAO, 2017) presented AT2050 projections to describe the plausible economic growth disparities in the future. According to the report, despite the higher average annual GDP growth rate in low- and middle- income countries to 2050, the average incomes of the population of low- and middle- income countries would remain only a fraction of those of people living in high-income countries, rising from 8.5 percent in 2005–7 to 16 percent in 2050. Furthermore, given the large difference in initial levels of per capita GDP, the income gap would continue to widen in absolute terms, from US$25 500 to almost US$40 000. FAO future of food and agriculture report (FAO, 2018) presented three different future scenarios of the income inequalities between countries (Table 4).

Table 4: What different reports say about inequalities in future

Variable	(FAO, 2018)- Gini index in three FAO scenarios	(Global Panel, 2020)
Income inequality	BAU- slow reduction of inequality up to 2050 compared with 2012, with the Gini index only dropping from 0.63 to 0.58. If China is not factored into the calculation of this global inequality index, BAU portrays an even larger inequality up to 2050, with the Gini index only falling to 0.63 from an initial 0.67. TSS- more equitable income distribution across countries than BAU, with the Gini index significantly dropping between 2012 and 2050 to 0.46 (or 0.48 if China is excluded). downward trend observed globally in the last decade continues until 2050 SSS- income inequality follows a pattern similar to the BAU scenario up to 2050.	By 2030, the number of people living in fragile settings is projected to reach 2.3 billion, which includes 80% of the global poor. That represents another 500 million people over today's total

6.7.2 Loss of Indigenous Cropping Culture

Indigenous cropping practices contribute to agricultural biodiversity, resilience, and cultural heritage preservation. The conservation of these cultures and recognition of indigenous knowledge is important for sustainable food production, resilience to environmental stressors, and food system governance that leads to equity and fairness. FAO (FAO, 2022a) and HLPE (HLPE, 2020) reports highlighted that despite the indigenous food systems being the most resilient systems, indigenous people's knowledge is at the risk disappearing in the near future due to lack of dedicated policies and the multitude of issues associated with food industrialisation and urban growth. There is no variable that can illustrate this trend.

6.8 Crisis and Conflicts

Radicalism, terrorism, and natural disasters increasing vulnerability and forced displacement. Reforms in internal and multilateral trade policies disrupts the system. Vulnerabilities stemming from radicalism, terrorism, natural disasters, and trade disruptions underscore the need for robust risk management, emergency response mechanisms, and resilience-building efforts within the food system. (Global Panel, 2020) report states that "millions of people live in extremely fragile situations caused by conflicts, disasters, physical displacement, political discrimination and more. According to the OECD, by 2030, the number of people living in fragile settings is projected to reach 2.3 billion, which includes 80% of the global poor."

6.8.1 Forced Migration

Global Panel foresight report (Global Panel, 2020) outlines how forced migrations or displacement, often caused by political instability, violence, and climate change, lead to significant disruptions in agricultural production and food supply chains. These disruptions exacerbate food insecurity and malnutrition, particularly in low- and middle-income countries. Warming ocean temperatures are expected to drive smaller fish sizes, smaller fisheries, and significant migration of fisheries away from the tropics and toward the poles. Territorial conflicts for protecting indigenous lands have also grown generating displacements. According to the UN (FAO, 2022a) "40 to 60 percent of armed conflicts over the past 60 years have been caused, funded, or sustained by the lack of natural resources." Displacement due to violent conflicts has reached all-time high. The number of forcibly displaced people has doubled over the last ten years, outpacing countries' ability to generate durable solutions. Most conflict-related internal displacements took place in sub-Saharan Africa (SSA) and Near East and North Africa (NNA). The world is facing the largest forced displacement crisis ever recorded, with at least 100 million people forcibly displaced in the decade since 2010 (FAO, 2022a).

6.8.2 Decreasing Multilateralism

Multilateralism is under severe strain as the global order undergoes a profound transformation. Great power competition and the rise of populist nationalism have eroded the foundations of international cooperation. The paralysis of key institutions like the WTO and UNSC is a stark symptom of this decline. A shifting geopolitical landscape, characterized by the West's relative decline and the East's ascent, coupled with the growing influence of non-state actors, has created a volatile environment marked by instability and unpredictability. FAO (FAO, 2022a) reports this trend leading to major uncertainties for conflicts and crisis. In 2016, more countries experienced violent conflict than at any time in nearly 30 years.3 In 2019, there were 54 active armed conflicts in the world, up from 52 in 2018 and matching the post–Cold War peak of 2016.

6.8.3 Global Pandemics

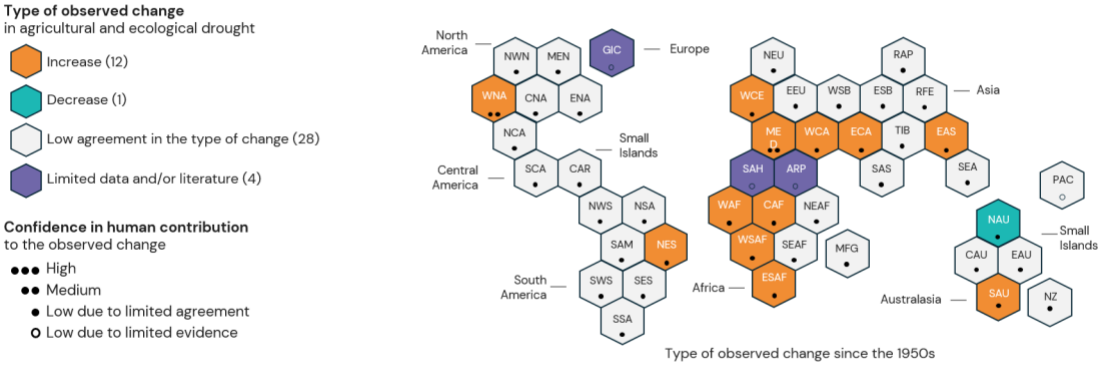
The global pandemics such as Covid-19 pandemic has emerged as a significant driver and uncertainty of food systems, impacting multiple facets from production to consumption. Synthesising the finding of research articles, more recent reports i.e. Global Panel foresight report (Global Panel, 2020), FAO drivers report (FAO, 2022a), Hassoun et. al (Hassoun et al., 2022), and HLPE report (HLPE, 2020), highlighted the impacts of global pandemics on food systems by disrupting supply chains, altering demand patterns, and exacerbating food insecurity. Lockdowns and travel restrictions led to labour shortages and logistical challenges, resulting in delays and wastage. Economic downturns reduced household incomes, limiting food accessibility and affordability, particularly among vulnerable populations. In 2020, young workers (aged 15 to 24 years) incurred an employment loss of 8.7 percent in 2020, almost 2.5 times greater than for adult workers. Official information released by Colombia, Costa Rica, Ecuador and Paraguay on the impact of the COVID-19 pandemic shows that monetary poverty increased sharply between 2019 and 2020 (FAO, 2022a). Consumer behaviour shifted towards non-perishable foods, causing supply-demand imbalances. The pandemic also accelerated the adoption of digital technologies in food

distribution and agriculture, underscoring the need for more resilient and equitable food systems. In Kenya, digitisation boosted during covid lockdowns. In 2020, 70 percent of Kenyan farmers increased their use of mobile phones to send and receive mobile money and between March and May 2020, users of the youth-run agricultural marketplace, Mkulima Young, increased fourfold.

6.8.4 Extreme Weather Events

Extreme climate events such as droughts, floods and storms, weather seasonal variations, and slow-onset processes such as sea level rise linked to climate change, are also unfolding interconnected emergencies. Extreme climate events impact food security and cause additional disruptions throughout value chains. According to the modelling results (Figure 24), several regions will be affected by more severe agricultural and ecological droughts even if global warming is stabilised at 2°C, including MED, WSAF, SAM and SSA (*high confidence*), and ESAF, MDG, EAU, SAU, SCA, CAR, NSA, NES, SWS, WCE, NCA, WNA and CNA (*medium confidence*). Some regions are also projected to be affected by more severe agricultural and ecological droughts at 1.5°C (MED, WSAF, ESAF, SAU, NSA, SAM, SSA, CNA, *medium confidence*) (Seneviratne et al., 2021).

Figure 24: Observed change in agriculture and ecological drought and confidence in human contribution to the changes since 1950s



Source: (Seneviratne et al., 2021)

6.9 Key Takeaways from Review of Drivers

The mapping and review of the food system drivers confirms that there is need for a deeper understanding of both established and emerging drivers, which are shaped by complex interconnections and uncertainties. Identifying the critical drivers that have quantifiable trends and the drivers that cannot be or haven't been quantified are equally important but the information around the well-established drivers is more comprehensive in the reviewed studies. Hence, continuously refining our understanding around both contextual and quantitative trends is essential to developing effective strategies for

sustainability. By maintaining an open dialogue and collaborating with stakeholders, we can adapt to new drivers and trends, guiding the food system toward better health outcomes, improved livelihoods, and environmental protection.

There are few important take-aways from this section:

i. **Established vs. Emerging Drivers:** Long-standing drivers like demographic trends and climate change remain important, while newer influences such as social media, e-commerce, and power imbalances are gaining relevance.
ii. **Uncertainty and Impact:** The uncertainty surrounding some drivers, particularly emerging ones, makes their future impact difficult to predict. Established drivers show more consistency but still vary across contexts and assumptions.
iii. **Need for Continuous Refinement:** The understanding of critical drivers should be open to constant updates and refinements as new data and trends emerge.
iv. **Stakeholder Involvement:** Consulting diverse stakeholders is essential for identifying context-specific critical drivers and developing targeted strategies for transformation.
v. **Contextual data**: there is lack of data around the contextual factors such as influences of social settings and internet on diet preferences. How quantitative models use contextual data to simulate food system drivers' directions in the future is very complex and needs to simplify and consistent.
vi. **Focus on historic trends:** there is a lot of focus on the historic trends of the drivers and data around projections of limited drivers is from the quantitative models used in FAO, UN and World Bank studies. There is an over-reliance on historical trends and established drivers, such as population and climate change, in quantitative models. Key drivers like labour migration, forced displacement, food affordability and digitisation remain understudied, signalling a need for more forward-looking research.
vii. Careful consideration of study assumptions: Studies are designed for specific purposes, and the transferability of their underlying assumptions should be carefully considered.
viii. Socio-cultural paradigms: there are a lot of anecdotes and micro level case studies around how socio-cultural beliefs, values, norms are related of the way food is produced and consumed, however there are no evidence on how these factors drives the food system at a global scale. In the reviewed literature, the focus is more on various inequalities within and between communities.

7. A Review of Recent Global Food System Scenarios

As outlined in section 4, ten of the twenty studies reviewed in this study contained scenario narratives around the food system. Among these, seven presented global-scale scenarios, two focused on the UK food system, and one examined the European food system. For the synthesis of the food system scenarios, only the global and EU studies (8 in total) were reviewed (making a list of 30 scenario narratives). The EAT Lancet report (EAT-Lancet, 2019) was also excluded from scenario synthesis as that report does not provide narratives of the global food system scenarios but only provide projections of food system

outcomes under various assumptions. Despite the attention for global food systems and the growing interest in foresight and scenario analysis, the number of global, regional or national food system scenarios on the topic is limited.

The eight scenario studies (see Table 5) are diverse in terms of the focus, scenario methodology employed and degree of stakeholder engagement. However, all the scenario analyses are explorative (rather than normative) and all have been developed using some combination of critical uncertainties (key drivers for which longer-term directions are unclear). Methods/tools adopted in these reports include Consistency matrix, quantitative economic tools, 2 x 2 matrix, morphological matrix, expert consultations and combination of quantitative models. The critical uncertainties and key drivers used in these scenario exercises are summarised in section 7.3 and in Table 5. Further, as this review shows, the main global level scenario studies that have been completed all have various limitations in relation to scope, rigor or stakeholder engagement.

The scenario reports exhibit varied focal points such as food security, sustainability, nutrition or global shocks reflecting the diverse approaches to envisioning the future of global and regional food systems. **'Three scenarios for Europe's food sector in 2035'** (Moller, Voglhuber-Slavinsky, & Dönitz, 2020) emphasizes regulatory, technological, and societal changes within Europe, addressing the unique challenges and opportunities the region faces, such as the implications of EU policies, the shift towards sustainable diets, and innovations in food production. **'Exploring global food system shocks, scenarios, and outcomes'** (Hamilton et al., 2020) and '**Shaping the Future of Global Food Systems: A Scenarios Analysis**' (WEF, 2017) delve into the potential shocks that could disrupt the global food system and the outcomes that might result. These reports place significant emphasis on resilience, exploring how unexpected events—such as pandemics, scarcity of resources, climate extremes, or geopolitical conflicts could rapidly alter the food system. The focus here is on the systemic vulnerabilities and the need for robust strategies to mitigate risks and adapt to sudden changes. Similarly, '**Using scenario analyses to address the future of food'** (Benton, Tim G., 2019) also emphasizes on the current trends and emerging issues, such as shifts in consumer preferences, technological innovations, and global markets. While '**Four Futures for the Global Food System'** (Unnikrishnan et al., 2022) stresses on the implications of food system scenarios on key actors and the inequalities in the food system outcomes for high income and low-middle income countries. **"Future Food Systems: For people, our planet, and prosperity"** (Global Panel, 2020) takes a holistic view, integrating social, environmental, and economic dimensions into its foresight exercise. This report emphasizes the interconnectedness of food systems with broader global challenges, such as poverty alleviation, environmental stewardship, and economic inclusivity. It advocates for a food system transformation that supports sustainable development goals, emphasizing equity, health, and planetary well-being. Finally, **'The future of food and agriculture: Alternative pathways to 2050'** (FAO, 2018) and **'The future of food and agriculture: Drivers and triggers for transformation 2022'** (FAO, 2022a) focuses on multiple global trends and uncertainties and explore how different pathways could influence global food security, environmental sustainability, and economic development, providing a more comprehensive analysis of possible future scenarios on a worldwide scale.

The most comprehensive scenario study in terms of broad stakeholder consultation was that conducted by the World Economic Forum. However, this was mostly with global level experts and institutions, with limited national or local level input. Actors from across international institutions, civil society, governments and research were involved. However, because the study was conducted under the auspices of the World Economic Forum, it is not necessarily seen by all actors as an unbiased global consensus document. Further, this scenario analysis is now seven years old and pre COVID and the increase in geopolitical tensions, including the war in Ukraine.

The two sets of scenarios that were part of the FAO foresight /global perspectives studies were largely developed by experts as part of the wider foresight analysis. Given the small number or global level scenario studies and constraints of each, it needs to be recognised that the field of global food systems scenario analysis is itself quite limited.

7.1 Critical Uncertainties Used in Scenario Studies

All eight scenario studies used a combination of uncertainties to derive their set of future scenarios (table 5). These are the key drivers or factors for which the future state is uncertain – critical uncertainties in scenario terminology. As detailed in Table 5, some of the scenarios were constructed using two critical uncertainties in a 2X2 matrix while others used a larger number of uncertainties.

These uncertainties have been clustered into common groups giving rise to 8 main areas of uncertainty (see Annex C). In alphabetical order the uncertainty clusters are:

1. **Biological shocks** – degree to which human or animal disease, or pest, outbreaks could disrupt the food systems
2. **Business structure** – degree of control of food systems by large global corporate entities and how much opportunity there would be for smaller scale producers and food system enterprises
3. **Climate** – extent to which climate impacts on food systems and how food system may respond to the needs for mitigation and adaptation
4. **Diets** – degree to which diets shift to consumption patterns which support better health and better environmental outcomes
5. **Environment** – extent of impact of food production on environment and level of more resource conserving practices
6. **Equity** – extent to which poorer group can afford healthy diets, how exploitive the food system is of its producers/workers and extent to which poorer groups are more vulnerable to food systems shocks
7. **Globalisation** – degree to which food widely traded globally or locally produced and consumed, degree of food sovereignty for nations, and degree of global cooperation or competition/conflict around food system related issues.
8. **Technology** – impact of new technologies (known and unkown) on overall structure and function of the food system (e.g. AI, reducing labour, radically different food production technologies, innovations in health monitoring)

The is a considerable degree of commonality and consistency across the scenarios in terms assumptions about the key factors that are likely to impact on the future of food

systems. The most common factor or uncertainty is, unsurprisingly climate change, followed by diet (consumption patterns).

Table 5: Summary of foresight studies with scenario narratives around food system

Study	Author	Year	Focus	Methodology	Stakeholder Participation	Critical Uncertainties	Scenarios
Three scenarios for Europe's food sector in 2035	Europe- Fraunhofer Institute for Systems and Innovation Research ISI	2023	Future governance of European Union food systems	Multi-factor with consistency matrix	Experts and FOX partners	Appreciation of products promoting ecosystem services; Measures to reduce climate change in the food sector; Degree of centralisation of food production; Purchasing behaviour related to food; Public and private investment in food and agriculture; AI in the value chain	Scenario 1- Strong regulation puts the brakes on entrepreneurship and public trusts government. Scenario 2 Society drives sustainability- food is sourced locally, shorter supply chain saves resources and customer cares more about environment and climate change. Scenario 3 A CO2-currency and retailers dominate trade and consumption.
The future of food and agriculture Alternative pathways to 2050	Global- FAO	2018	Global food systems - generally	Based on Shared Socio-Economic Pathways (SSPs)	Combination of various activities involving different levels of stakeholder involvements	Economic growth, international governance, human development, energy use and GHG, welfare and lifestyle, land and water use, agricultural policies, yields and innovation.	Scenario 1- BAU Scenario 2- Towards sustainability (TSS) Scenario 3- Stratified societies (SSS)
Exploring global food system shocks, scenarios and outcomes	Global- Hamilton et al	2020	Possible shocks to the future of food systems	Prioritisation of likely socks	Stakeholders from research, policy, retail, NGO's, production, energy and insurance sectors. All residing in UK	technology, connectivity, trade, food price, environmental health, food waste, food diversity	Scenario 1- Automation Scenario 2- extreme weather Scenario 3- financial speculation Scenario 4- monoculture vulnerability
Using scenario analyses to address the future of food	Global- Tim Benton	2019	Global food systems - generally	Two critical uncertainties matrix	No stakeholders involved. Authors' perspectives	Dietary shifts; level of connectivity (globalised vs. localised)	Scenario 1- Unchecked consumption in a globalised world

							Scenario 2- Sovereign (in)sufficiency Scenario 3- Global, green and healthy Scenario 4- Localised and sustainable
Shaping the Future of Global Food Systems: A Scenarios Analysis	Global- World Economic Forum	2017	Global food systems - generally	Two critical uncertainties matrix	Extensive with global level stakeholders	Demand Shift (resource-intensive versus resource-efficient); Market Connectivity (high connectivity versus low connectivity)	Scenario 1 – Survival of the Richest Scenario 2 – Unchecked Consumption Scenario 3 – Open-source Sustainability Scenario 4 – Local Is the New Global
Four Futures for the Global Food System	Global- BCG	2022	Global food systems - generally	Muli-factor	Unclear	the state of the world's agriculture, climate change, and global economic and geopolitical dynamics	Scenario 1: Uneven progress Scenario 2: The rise of Africa Scenario 3: Every country for itself Scenario 4: Coordinated step forward
The future of food and agriculture - Drivers and triggers for transformation 2022	Global- FAO	2022	Global food systems - generally	Two critical uncertainties matrix	Based on expert consultations and previous scenario development work by FAO communities	Geopolitics and power; Economic growth and employment; Demography; Resources and climate; Agriculture; Technology and investment in agrifood systems; Poverty, inequality, food security and nutrition outcomes	Scenario 1-More of the same (MOS) Scenario 2- Adjusted future (AFU) Scenario 3- Race to the bottom (RAB) Scenario 4- Trading off for sustainability (TOS)
Future Food Systems: For people, our planet, and prosperity	Global- Global Panel	2020	Nutrition oriented focus on global food systems	Two critical uncertainties matrix	Wide range of experts	environmental risks (environmental breakdown vs. green and stable) and the nature of economic growth (profit at any cost vs. inclusive growth).	Scenario 1- Perfect storm, business as usual Scenario 2- Volatile, but inclusive Scenario 3- Green, but unequal Scenario 4- Perfect calm

7.2 Scenario Clusters - Methodology

Cork at al. 2022 describe scenarios as "narratives constructed to explore alternative futures and to test or develop the logic behind the futures-thinking involved". As also noticed in the selected articles on scenario analysis, methods for developing scenarios (e.g., models, creative works), processes (e.g., expert-driven, participatory) and objectives (e.g., optimising and enhancing current power structures, challenging the status quo, fostering novel futures) vary. Another primary distinction in the selected scenario analysis studies lies in the 'critical uncertainties' or 'key drivers' around which they are constructed developed.

The principles governing future food systems can be delineated and categorized based on the priorities embedded in various scenarios, offering distinct clusters or clusters that describes future food landscapes (Sitas, Harmáčková et al. 2019). Clustering the scenarios into different categories of world views is one of the methods for synthesising scenarios in the literature. For example- the 'global scenario cluster' framework, which has been used to deduce the implications of various scenarios, particularly in terms of their impact on the key drivers influencing system outcomes or goals. The 'global scenario cluster' although not focusing on the food system per se, uses mental models that assumes economic growth, environmental protection, population changes and policies are the key attributes for the global food system's dynamics in the future which are also relevant in the food system transformation. An analysis of eight publications detailing various food systems scenarios collectively presented 30 distinct scenarios, which were classified into overarching themes, called 'clusters'. The sorting was done by identifying common themes, characteristics, and underlying principles across these scenarios. Inspired by IPBES clusters (Sitas et al., 2019), we clustered 30 scenarios into five worldviews: Continuing trends, Global sustainability, Local solutions, Rising inequality, and Uncontrolled Chaos (Table 6). An inductive reasoning approach was taken to categorise the scenarios into these worldviews based on their underlying assumptions about key food system drivers.

7.3 Emerging Scenario Clusters

A clustering of similar scenarios (Annex D) give rise to 5 main scenario themes or clusters for the future of food systems. Each of the individual scenario does not necessarily fit perfectly with these scenario clusters, however the clusters do give an overview of broad commonalities.

1. **Continuing trends** – a business-as-usual scenario with some minor corrections to manage immediate issues but a continuation long-term negative impacts, driven by the existing dominant structures of the food system
2. **Global sustainability** – recognition of emerging food system risks drives a new global compact across governments and businesses to transform food system to avoid crises
3. **Local solutions** – in a world of increasing geopolitical tensions and an inability to construct global agreements for change, national governments and local

communities bring change based on ideas of food sovereignty and localised food systems.

4. **Rising inequality** – nations and individuals with wealth act to protect their own interests in the short term, leading to escalating inequality, increasing exploitation in the food system and big disparities in those who can afford to eat healthy diets and those who cannot.
5. **Uncontrolled chaos** – escalating crises caused by climate change or other shocks, with no effective governance national governments or global scales leads to a breakdown of food systems with social and political instability and large-scale humanitarian crises.

The story lines for each of the scenarios are constructed around the uncertainties they selected (see section 8.2 above) along with a set of other trends and factors. These are summarised below, showing for which scenario the particular trend or factor was present. Scenario numbers indicate the scenarios (Annex B) where the corresponding trend is used.

1. Development including global cooperation range from isolationism and protectionism to enhanced international collaboration. **Key trends:**

    - **Fragmentation:** Increased geopolitical tensions and trade barriers. Scenarios 12, 15, 21
    - **Multilateralism:** Cooperation on global challenges such as climate change and food security. Scenarios 5, 13, 17, 22
    - **Dependency:** Enhanced interconnectedness of global supply chains and economies. Scenarios 3, 11, 13, 16, 17
    - **Power dynamics:** Shifts in global power balance and increasing influence of some actors. Scenarios 3, 11, 15, 19, 20, 25

2. Consumption Patterns ranges from resource-intensive, high-consumption lifestyles to minimalist, plant-based diets focused on local and seasonal foods. **Key trends:**

    - **Resource-intensive consumption:** Scenarios 3, 11, 15, 16
    - **Shift towards healthier and more sustainable diets:** Increased preference for locally sourced and produced food. Scenarios 2, 5, 13, 14, 17, 18
    - **Conscious consumption:** Growing awareness of environmental and social impacts driving consumer choices. Scenarios 2, 17, 18
    - **Polarization:** Disparity between high-consuming and low-consuming populations. Scenarios 15, 16

3. Technology and innovation ranges from highly developed and integrated systems to more traditional methods. There is a tension between technology as a tool for sustainability and efficiency versus its potential to exacerbate inequalities and create new risks. **Key trends:**

    - **Increased automation and data:** high levels of automation in agriculture and food processing (Scenarios 7, 11, 16); optimising supply chain **(**Scenarios

1, 3, 17); and rise in e-commerce for food distribution and consumption (Scenario 3)
    - **Improvements using biotechnology and genetic engineering:** Focus on developing high-yielding and resilient crop varieties (Scenarios 11, 16); focus on enhancing product quality and shelf life (Scenario 3)
    - **Renewable energy growth:** Integration of renewable energy sources into food production and processing. Scenarios 2, 5, 13, 14, 7, 18, 22
    - **Data sovereignty:** Governments or corporations controlling vast amounts of data (Scenarios 1, 3)

4. Resource use ranges from intensive resource exploitation to circular economy approaches. **Key trends:**

    - **Efficiency:** Focus on maximizing resource productivity and minimizing waste. Scenarios 2, 5, 7, 13, 14, 17
    - **Depletion:** Overexploitation of resources in some scenarios leading to scarcity and conflict. Scenarios 3, 4, 6, 11, 15, 16
    - **Regeneration:** Efforts to restore and conserve resources through sustainable practices. Scenarios 2, 5, 14

5. Climate

6. Governance mechanisms **range f**rom centralized, authoritarian control to decentralized, participatory governance. **Key trends:**

    - **Strong state control:** Varying degrees of state involvement in the food system. Scenario 1.
    - **Market-based approaches:** Reliance on market forces to drive change. Scenario 3
    - **Multi-stakeholder partnerships:** Collaboration between governments, businesses, and civil society. Scenarios 2, 5, 17, 18, 22

7. Equity issues **range from** increasing inequality to greater social justice. **Key trends:**

    1. **Disparity:** Widening gap between rich and poor, both within and between countries. Scenarios 3, 4, 6, 11, 15, 16, 19, 23, 25
    2. **Inclusive growth:** Efforts to reduce poverty and inequality through equitable distribution of benefits. Scenarios 1, 5, 17, 18, 22
    3. **Social unrest:** Potential for conflict and instability due to inequality and injustice.

The 'Continuing Trends' cluster represents a pathway where the status quo prevails, characterised by reliance on the existing development paradigm focused on fossil fuels, power concentration, and short-term thinking. Economic growth and efficiency are prioritized over long-term sustainability and social equity. Consumer desires and purchasing power shape consumption patterns, while market giants drive technological change, focusing on short-term gains in resource efficiency and economic profits. Climate

change and environmental degradation are addressed through isolated efforts and minor policy adjustments, lacking a systemic approach to long-term sustainability. This pursuit of economic growth exacerbates disparities and ethical conflicts. However, in some regions, there is a growing emphasis on sustainability and efforts toward global cooperation, which offer potential for positive food system outcomes. While other clusters explore alternative approaches, this cluster highlights the risks and consequences of maintaining the status quo.

The most optimistic pathway for the food system outcomes is the characterised in the 'Global sustainability' cluster stands out in contrast to the other clusters due to its emphasis on international collaboration and coordinated action to address global food system challenges including inequalities and climate crisis. As the key players in the food system interacts and collaborates, the dependencies and trade-offs in the global food system is recognised which is important for developing holistic and balanced policy frameworks considering environmental, social, and economic factors. These factors together create a foundation for addressing food security, sustainability, and equity issues on a global scale. In the scenarios focusing on global sustainability, while challenges undoubtedly persist, the cooperative approach offers the greatest potential for positive change. This cluster highlights the embeddedness of synergic governance mechanisms which are responsible and influential at all scales in the successful systemic transformation.

As the name suggests, within the 'local solutions' cluster, the focus is on local food production, reduced reliance on global supply chains, and increased self-sufficiency. In this pathway, the food system can benefit from the technological advance but the focus in on reducing the environmental footprint and resilience at the local scale as opposed to the 'continuing trends' and 'global sustainability' clusters. Consumer empowerment and strong local governance inherently play a major role in achieving the local goals and hence participatory approaches in bringing systemic changes becomes crucial. If compared with assumptions in the 'global sustainability' cluster, assumption within local solutions aligns with the difference in geographical scale and type of transformative elements for example: food safety regulations and monitoring systems, consumer preference tracking and response systems, etc are important tools in managing the local systems.

The 'Rising Inequalities' cluster highlights the potential for worsening social and economic disparities, with serious implications for food security, environmental sustainability, and social stability. A central theme across these scenarios is the widening gap between rich and poor, both within and between countries, leading to unequal access to resources and opportunities. While the 'Continuing Trends' cluster shares some similarities, particularly around unmanaged inequalities, 'Rising Inequalities' explicitly focuses on social stratification and the breakdown of social support systems. These scenarios also point to environmental degradation in low- and middle-income countries as a consequence of economic development in wealthier nations. Although there is recognition of integrated environmental and climate strategies, the cluster warns of potential social unrest if these strategies are not implemented inclusively.

The last cluster 'uncontrolled chaos' incorporates worst case scenarios where everything goes wrong and absolute downfall of the food system is realised. The cluster is

characterized by a focus on the negative consequences of unsustainable development and the failure to address global challenges. These scenarios highlight the risks of unchecked consumption, resource depletion, climate change, and inequality. The scenario in this cluster serves as a stark warning of the potential consequences of inaction and the urgent need for coordinated global efforts to address the challenges facing the food system. While the direction of drivers in 'Continuing trends' and 'Rising inequalities' clusters may also lead to challenges in the future, the 'Uncontrolled Chaos' cluster emphasises the chaotic and unpredictable nature of these challenges. This cluster can also be interpreted as the extreme version of the "Continuing trends" cluster, where the negative consequences of inaction escalate to a critical level.

In essence, scenarios with most positive outcomes are 'Global sustainability' and 'Local solutions' where synergic sustainability is prioritised. While the underlying goal in both clusters is sustainability for healthier people and planet, it differs in scale and approach. Sustainable localisation focuses on local solutions, while global cooperation seeks to address challenges through international collaboration.

While these two clusters might appear contrasting, they are not mutually exclusive and have overlaps. Both models recognize the role of technology in driving food system transformation. For instance, the "Scenario no. 2: CO2-currency" scenario highlights technological innovation in a market-driven context, while "Scenario no. 22: Coordinated Step Forward" emphasizes technology's role in climate-smart agriculture within a cooperative framework. Another overlap is that both models acknowledge the importance of global trade, albeit with different priorities. 'Continuing trends' emphasises trade for profit maximisation, while 'Global sustainability' views trade as a tool for shared benefits and sustainable development.

As it can be noticed that not all world views lead to a positive trend in the key drivers, a balance between market forces, global cooperation and sustainable localisation maybe required when considering food system transformation. For instance, trends in 'global sustainability' can create a framework for fair trade and sustainable development goals, trends in 'continuing trends' cluster can drive innovation and economic growth whereas sustainable localisation is required to promote self-sufficiency and community well-being while considering social equity issues. However, without effective governance and regulation, market forces can exacerbate global inequalities and environmental problems.

There are many overlaps of cluster trends in scenarios. There are scenarios which incorporates balance between the trends in clusters 'global sustainability' and 'rising inequalities' for example in scenario 29- 'Green but unequal'. While there are scenarios where despite substantial local efforts and capacity building, challenges persist for environmental and socio-economic systems at the larger scale (e.g. scenario 24-'adjusted future'). Some scenarios exhibit both positive and negative outcomes. For example, Scenario 17 promotes resource efficiency but also acknowledges potential inequality.

This analysis reveals that the clusters described here represent various potential trajectories for food system outcomes, influenced by a multitude of factors beyond those explicitly listed in Table 6. These factors, such as consumer power, civil society movements, technological advancements, investment systems, and bilateral relations, can

significantly shape the future of food systems. In the following section, by assessing the potential outcomes of each cluster in terms of health and nutrition, livelihoods and equity, and climate and environment, we provide a framework for understanding the implications of different governance structures and actions. While these clusters offer simplified representations of complex systems, they can serve as proxies for evaluating the potential consequences of various policy choices and interventions.

Table 6: Scenario clusters (rows) based on global growth direction, key drivers (columns) and the general assumptions in scenarios (cells).

Cluster	Global Cooperation	Diets and consumer behaviour	Technology, innovation and information	Environment and Resource Use	Climate	Policy and governance	Inequalities
Continuing trends	Status quo – struggling to be effective	Food insecurity and unhealthy diets increase	Driven by short-term market opportunities	Largely exploitive with some minor improvements	Gradual improvement but not fast enough	Fragmented efforts for change constrained by economic interests	Focus on basic needs, trade-off
Global sustainability	Strong, collaborative approach	Achieving good nutrition becomes driving force	Focused on achieving health and environmental outcomes	Efficient, focus on renewable resources	Major efforts and investments for mitigation and adaptation	International agreements and institutions	Increasing equity is a driving force
Local solutions	Nations turn inwards due to ineffective global mechanisms	Improving diets drives many local initiatives	Big focus on appropriate technology and indigenous knowledge	Efficient, focus on sustainability, and biodiversity	Local communities take action, but global mitigation is weak	Highly decentralized and participatory	Local quality of life by less resource intensive
Rising inequality	Dominated by powerful economic interests	Duality of good and poor nutrition between rich and poor	Works largely to the interests of elites	Poorer nations and people forced to exploit resources to survive	Focus on adaptation which can only be afforded by rich	Heavily influenced to protect short-term interests of wealthy	Extreme, with punitive measures against unrest
Uncontrolled Chaos	Significant breakdown of global order	All nations struggle to meet food security and nutrition needs	Technology fails to be help tackle emerging crises	Natural disasters and collapse of ecosystems become overwhelming	Severe negative impact, extreme weather affecting all	Weak and ineffective at all levels	extreme with conflict civil unrest

Note: These columns are presented in the same order at the drivers are listed in Section 6, but there is no specific trend around demographics in the scenarios, hence there is no column

7.4 Scenario clusters vs. food system outcomes

The primary value of the scenario clusters lies in their ability to stimulate strategic thinking about the implications of each worldview. This includes considering the plans and potential actions required as the future unfolds, regardless of its eventual shape. Each set of assumptions or perspectives carries strategic consequences for the three key food system outcomes: food security, nutrition, and health; climate and environment; and livelihoods, economy, and wellbeing. These outcomes, in turn, become drivers that influence events and stakeholders within the food system. By weighing the implications

of various scenario clusters, one can identify strategic needs and interdependencies within the food system.

As shown in table 7, each scenario cluster was assessed for its potential for both positive and negative outcomes. Although the table deduces potential implications for the food system outcomes, it must be elaborated with considerations of the specific assumptions made in each scenario. Future events will not match any of the outcomes exactly as it will depend on various factors, including specific policies, technological advancements, societal changes and other transformation strategies implemented. This is a key area for further investigation and discussion, and precisely the area where qualitative and quantitative approaches need to be linked. Qualitative scenarios without clear quantitative support risks unrealistic expectations about outcomes likewise quantitative analysis without meaningful scenarios risks being of limited relevance for decision makers. However, weighting the potential positive and negative outcomes of the food system pathways like shown in table 7, can help understand the trade-offs. For example, 'local solutions' could lead to improved regional food security and sustainability, but it could also lead to limited food choices and nutrient deficiencies. Similarly, 'continuing trends' could lead to a wide variety of food choices and economic growth, but it could also lead to unequal access to food and environmental damage.

Table 7: scenario clusters (rows) and potential food system outcomes (columns)

Scenario Cluster	Type of outcome	Food security, nutrition and health	Climate and environment	Livelihoods, economy and wellbeing
Continuing trends	Positive outcome	Wide variety & availability of food choices	Innovation in agriculture & potential for sustainability (market forces)	Economic growth & job creation (agribusiness)
	Negative outcome	Unequal access & diet-related health problems	Resource depletion & environmental damage (profit motives)	Increased income inequality & livelihood insecurity (small farmers)
Global sustainability	Positive outcome	Improved global food security & access to healthy diets	Coordinated efforts for sustainability & environmental protection	Fair trade & opportunities for all countries to participate
	Negative outcome	Potential for dependence on global systems & vulnerability to disruptions	Challenges in implementation & enforcement of global agreements	Potential for dominance by powerful countries & unequal benefits
Local solutions	Positive outcome	Fresh, local food & focus on healthy diets	Reduced transportation emissions & environmental footprint	Strong local economies & support for small farmers
	Negative outcome	Limited variety & potential for food insecurity (local disruptions)	Lower overall production & potential for local environmental issues	Limited economic growth & potential for isolation

Rising inequalities	Positive outcome	Improved access to food for some groups. Better health outcomes for the wealthy	Potential for increased environmental protection in areas with strong governance.	Economic growth for the already established economies and economically strong households.
	Negative outcome	Increased food insecurity and malnutrition for marginalized populations. Worsening health outcomes for the poor, including malnutrition and disease	Increased exploitation of natural resources and environmental degradation by the poor. Negative consequences being outsourced to the food exporting regions.	Increased poverty, unemployment, and social unrest among the poor.
Uncontrolled Chaos	Positive outcome	None	None	None
	Negative outcome	Widespread malnutrition, food insecurity, and hunger	Severe environmental degradation & resource depletion	Economic collapse, social unrest, and mass migration

7.5 Governance and paradigms of development

All 30 scenarios reflect, either explicitly or implicitly, assumptions about the **nature of food system governance. In particular, they show varying roles and power of national governments, global institutions, local communities and corporate entities in how food systems and wider economic and social systems are governed.**

Associated with these ideas about governance are a deeper set of differing assumptions and worldviews about what constitutes positive development and how this can be achieved. These include assumptions about economic growth, the role of globalisation, the influence of different cultures and economic power blocks, the degree to **which consumption patterns should be influenced by government interventions and the role of different forms of agriculture.**

Each scenario involves a unique set of key stakeholders who trigger events and trends and carries strategic implications for these stakeholders. The scenarios analysis presented in the reviewed studies **is not build around governance per se but notions about food system governance are implicit in the selected driving forces and storylines.** The analysis revealed five different notions of food system governance across the 30 analysed scenarios:

1. **Government-centric control:** Strong governmental control over food production and distribution with a focus on sustainability and national security. **Key trends-**
   - Government ownership and management of agricultural land.
   - Emphasis on sustainable practices and environmental stewardship.
   - Extensive data access, utilization of data sovereignty for efficient resource allocation.
   - Trust in government for providing nutritious food and ensuring accessibility for all citizens.

- Limited consumer understanding of food production complexities.

2. **Community-led and local governance:** Decentralized governance with emphasis on local sustainability and community involvement. **Key trends-**
   - Consumer-driven demand for sustainable and local food production.
   - Limited role of national government with strong local governance.
   - Consumer preferences driving sustainable and local food production.
   - Revival of traditional and seasonal eating practices.
   - reliance on local markets and community-based agriculture.

3. **Big cooperates led:** Market-driven approach with heavy reliance on technology and efficiency. **Key trends-**
   - Specialized global markets and dominance of large retailers.
   - Emphasis on technological progress and efficiency in production.
   - Consumer profiling and data sovereignty for personalized services.
   - Economic success prioritized over environmental concerns.
   - Limited emphasis on sustainability and environmental impacts.

4. **Fragmented governance:** Inadequate response to global challenges, resulting in persistent issues and unmet sustainability goals. **Key trends-**
   - Social and environmental inequities.
   - Failure to address food access, utilization, and sustainability challenges.
   - Efforts to achieve Sustainable Development Goals (SDGs) fall short.
   - Lack of coordination in addressing food access and utilization
   - Persistent food insecurity, poverty, and environmental degradation.
   - Emphasis on short-term gains over long-term sustainability.

5. **Global institutions led:** Global cooperation towards sustainable development and equitable access to food. **Key trends-**
   - Emphasis on global cooperation, sustainability, and resilience.
   - Social, environmental, and economic dynamics promoting equity and sustainability and equitable access to resources and food.
   - Universal progress towards achieving SDGs and continued efforts post-2030.
   - Focus on resource-efficient and inclusive food production systems.
   - Adoption of climate-friendly technologies and practices
   - Transparent and resilient supply chains
   - Collaboration among nations and stakeholders for climate mitigation and resilience.
   - Focus on health and nutrition.

7.6 Key Take Aways from Review Of Scenarios

The reviewed set of scenarios, and their associated uncertainties and trends, illustrate that very different futures for food systems across the planet are quite plausible. Some of these scenarios show the potential risks of not transitioning food systems to a healthier, more environmentally sustainable and equitable footing. At the same time, other scenarios show

opportunities for change and offer hope for a future for the food system that is in better alignment with society's overall interests.

The scenarios also show some of the long-term implications of different actors, with their specific preferences and ideas around food system change, taking the lead in reshaping the system. This can help the reader understand some of the current debates on who should drive system change and into what direction.

That said, none of the scenarios portray radically different food system futures and the majority of the scenarios can be mapped onto earlier ideas and archetypes of change options (such as green futures, divided worlds etc). In addition, many of the studies focus more on regional food systems, such as the EU. This is surprising as both the Covid-19 pandemic and current geopolitical conflicts have drastically reshaped some of the key food system drivers. This all points to the need for not just developing a new set of global scenarios that can take better account of these new developments and their implications for food system across the globe, but also for some deeper, more radical thinking about potential food system futures and their consequences for people and the planet.

The key take aways from the review of scenarios are:

i. Plausibility of diverse futures: There are multiple plausible future pathways for food systems globally, ranging from negative scenarios where food systems fail to transition toward sustainability, health, and equity to more positive, hopeful scenarios that align better with society's broader interests.
ii. Role of actors in driving change: Different actors, with their unique visions for food system change, play significant roles in shaping potential futures. The scenarios offer insights into ongoing debates about who should lead food system transformation and in what direction.
iii. Definition of sustainable and healthy diets: The reviewed scenarios reveal either inconsistencies or a lack of clear definitions for sustainable and healthy diets. This gap highlights the need for global experts to collaborate and establish a consistent, universally accepted definition. Developing such a definition is crucial for creating robust and comparable scenarios.
iv. Limited radical divergence in scenarios: Despite the diverse futures explored, only one of the scenarios envisions a more radical pathway compared to the existing food systems. This is the one from the Fraunhofer report where the central government decides what food is grown, who owns the land, how data and information is shared and what people should eat.
v. Need for new and radical thinking: There is a clear need for developing new global scenarios that account for recent disruptions and explore more radical possibilities for food system transformation, considering the long-term consequences for both people and the planet.
vi. Paradigm shift: Although all the studies reviewed have similar worldviews or paradigms, there is a notable paradigm shift in the way scenario narratives frame the role of stakeholders within food systems. The focus is transitioning from solely analysing system outcomes to exploring how diverse stakeholders influence and interact within the system. This reframing highlights the importance of participatory approaches and emphasizes the systemic interconnections

between stakeholder actions and broader food system transformations, fostering a more inclusive and dynamic understanding of change processes.

vii. Governance structures: Although factors like consumption patterns, technology, and investment significantly influence food systems, governance structures play a crucial role in shaping the environment for these factors to interact. The review of scenarios reveals five embedded governance structures or actors that dominates food system viz. Government-centric control, Community-led and local governance, Big cooperates led, Fragmented governance, and Global institutions led. This finding underscores the importance of manging power dynamics for sustainable food systems future.

viii. Need for reviewing uncertainties: Megatrends such as shifting demography, technology and consumption patterns are often central in reviewed scenario exercises, but they are less relevant when disrupted by unexpected events, including trade conflicts, the rise of inward-looking, right-wing governments, or global pandemics.

ix. Scenarios for different socio-economic regions/countries: The trends in food system drivers vary significantly across economic regions and countries, while scenario narratives often depict implications for socio-economic groups in a more general sense. It would be effective if scenario narratives also captured the variations between different economic regions and the interactions among them. This approach would enable stronger connections between qualitative narratives and quantitative data, facilitating a more nuanced understanding of regional dynamics and supporting the extrapolation of plausible future trends.

x. Combining qualitative and quantitative scenarios- there is need for rigorous analysis to objectively understand the likely outcomes of different scenarios, including trade-offs between multiple outcomes.

8. Conclusions and Implications

This review highlights the growing body of foresight work related to food systems. However, despite the critical role food systems play in the climate debate, achieving the Sustainable Development Goals (SDGs), and ensuring long-term planetary and human well-being, there is currently no work of comparable scale and depth to what the IPCC has achieved for climate futures. As a result, the existing foresight efforts often raise as many questions as they answer. For many drivers of food system change, analysis of their future evolution and the factors influencing this is still limited.

This is perhaps not surprising given the immense complexity of food systems and the multiple interactions with all other human and natural systems. Further, food systems foresight analysis needs to contend with numerous political-economic and social factors, and very different contexts across localities, countries and regions. Consequently, larger questions emerge about how the utility of foresight and scenario analysis can be optimised in supporting food systems transformation. Broadly there are two dimensions, the scientific and the societal engagement.

On the scientific side, there is a need for more robust, systematic analyses that integrate both qualitative and quantitative data, particularly on emerging drivers like e-commerce and power imbalances in food value chains. Additionally, better integration of global and

regional foresight insights is essential for understanding how local factors interact with broader global trends. For instance, understanding global market dynamics alongside local factors can help address issues like food prices and food security at a regional scale.

On the societal engagement side, participatory approaches are underutilized. Although there has been growing interest in foresight for food systems transformation, there has been little investment in large-scale, multi-stakeholder scenario development, especially at the global or regional level. While technical reports have compiled existing scientific data, these lack the depth of participatory foresight that engages stakeholders across scales which is critical for achieving inclusive and actionable insights. For example, despite efforts like the 2021 UN Food Systems Summit, and national food systems dialogues that accompanied this process, there is still no comprehensive scenario development process that incorporates diverse perspectives from global to local levels.

This review has illustrated that despite increasing interest in foresight for food systems transformation, there is quite limited investment in participatory global, regional or national scale scenario work. The most comprehensive foresight work to date has been focused on the compilation of existing scientific data into technical oriented reports. Seemingly the most widely used and quote work on global food systems scenarios is the 2017 WEF report.

This review of food system drivers and scenario studies revealed a mix of known drivers that continue to shape food systems, such as demographic developments or climate change issues. But it also identified new emerging drivers such as protein alternatives, the role of e-commerce, especially since the Covid-19 pandemic, or concerns about the power balance and data ownership along food value chains. Which of these drivers are particularly important within a given food system context depends of course on stakeholder perceptions, but the range of driving forces considered in the reviewed studies shows the breadth of issues decision makers need to consider for understanding and adapting to the various influences as well as for managing drivers coming down the track.

The review also highlighted the differing uncertainty ranges attached both to known and emerging drivers. For many drivers, particularly the longer-known ones such as demographic trends, the wider body of research on their potential trends and direction of trends allows for narrowing the uncertainty space (i.e. projections for these drivers converge around similar trends). That said, as time frames, methods and assumptions underlying the forward looks in the various studies differ it is often difficult to compare (quantitative) trend assessments. There are also various drivers, such as government interventions in food systems or the role of social media in shaping consumer behaviour, that can show a wide range of different trend directions, making these drivers particularly interesting for scenario development. Although technology is transforming at a rapid rate and the impacts are being measured, it is however uncertain who will drive these technologies (industries, consumers, farmers or government) and what will be the purpose (climate change mitigation or adaptation, increased resource efficiency, automation, economic benefits, etc.).

With respect to new scenario work described in eight of the analysed studies, five clusters emerged in the analysis that portray varying underlying principles and world views about how the world and its food system could change in the future. The clusters vary on basic ideas around the role of globalization and cooperation across nations, the role of the governments, local communities or markets as key shapers of food systems, the role of equality and social cohesions in society as well as on the role of a focus on environmental sustainability in the future. Depending on how these differing key issues vary in importance and how these are shaping different combinations of driving forces they have major implications for food system outcomes. The scenarios clusters also show a differing use of interventions options, from policy to technology to education and beyond, to achieve food system transformation towards better outcomes. Thus, they provide a good overview of the breadth of options for change (and their potential implications) that can be considered by the many stakeholders working on solving our current food system dilemma and striving for better outcomes.

In conclusion, this report reinforces the importance of combining scientific rigor with societal engagement to enhance the utility of foresight for food system transformation. By refining foresight practices and ensuring they are adaptable and inclusive, we can better navigate the complexities of modern food systems and develop more targeted strategies for a sustainable future.

These contributions emphasise on core principles of foresight—adaptability, dealing with uncertainty, scenario rigor, and strategic utility while advancing discussions on adapting foresight practices to the complexities of modern technological, environmental, and economic landscapes.

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Annex A: Global food systems' drivers and trends and source

Demographics	
Population growth	FAO trends (2017); WEF (2017); FAO Alternative Pathways (2018); Benton, T. (2019); Bene, C. (2019); Global Panel Report (2020); FAO Foresight (2022); FAO drivers (2022); Garnett et al (2023);
Family composition	Garnett et al (2023);
Migration	FAO trends (2017); WEF (2017); FAO Alternative Pathways (2018); Benton, T. (2019); HLPE (2020) Hamilton et al (2020); FAO Foresight (2022) FAO drivers (2022);
Urbanisation	FAO trends (2017); FAO Alternative Pathways (2018); Benton, T. (2019); Bene, C. (2019) HLPE (2020) FAO Foresight (2022); FAO drivers (2022);
Age structure	FAO trends (2017); FAO Alternative Pathways (2018); HLPE (2020) FAO Foresight (2022); FAO drivers (2022);
Economic development	
Income and GDP growth	FAO trends (2017); WEF (2017); FAO Alternative Pathways (2018); Benton, T. (2019); Bene, C. (2019) HLPE (2020) Hamilton et al (2020); Fraunhaufer EU scenarios (2023); BCG report (2022); FAO Foresight (2022); FAO drivers (2022); Garnett et al (2023);
Cost of living (disposable income)	Garnett et al (2023);
Access to markets (for small farmers and processors)	WEF (2017); FAO Alternative Pathways (2018);
Food price and markets	FAO trends (2017); WEF (2017); FAO Alternative Pathways (2018); Global Panel Report (2020); HLPE (2020) Hamilton et al (2020); James Hutton UK scenarios report (2021); Elliott, M. et al (2021); Fraunhaufer EU scenarios (2023); FAO Foresight (2022); FAO drivers (2022);
Financial speculations (profit driven private sector)	WEF (2017); Global Panel Report (2020); Hamilton et al (2020);
Financial actors influence	WEF (2017); FAO Alternative Pathways (2018); Global Panel Report (2020); HLPE (2020) Hamilton et al (2020); FAO drivers (2022); IPCC (2022);
Poverty (urban and rural)	FAO trends (2017); WEF (2017); FAO Alternative Pathways (2018); Benton, T. (2019); Global Panel Report (2020); Hamilton et al (2020); FAO Foresight (2022); FAO drivers (2022);
Women employment and empowerment	HLPE (2020)
Market concertation of food and agriculture input and output	Hamilton et al (2020); FAO Foresight (2022);
Structural changes- labour mobility	FAO trends (2017); James Hutton UK scenarios report (2021); FAO drivers (2022);
Structural changes- agribusiness and enterprises (more jobs in downstream and migration for job opportunities)	FAO trends (2017); FAO Alternative Pathways (2018); HLPE (2020); Hamilton et al (2020); James Hutton UK scenarios report (2021); FAO drivers (2022);
Internationalization of private investments	WEF (2017); Bene, C. (2019); Hamilton et al (2020); BCG report (2022);
Access to infrastructure (e.g.	Bene, C. (2019); HLPE (2020); FAO Foresight (2022);

post-harvest infrastructure)	
Centralisation of agri-hubs	Fraunhaufer EU scenarios (2023);
Food processing industries growth	WEF (2017); FAO Alternative Pathways (2018); HLPE (2020) Hamilton et al (2020); Fraunhaufer EU scenarios (2023);
Monoculture of economically attractive food	Hamilton et al (2020); Elliott, M. et al (2021); Fraunhaufer EU scenarios (2023);
Public and private investments	FAO trends (2017); FAO Alternative Pathways (2018); Benton, T. (2019); HLPE (2020) Hamilton et al (2020); Fraunhaufer EU scenarios (2023); BCG report (2022); FAO Foresight (2022); FAO drivers (2022);
Power balance in value chain (growing concentration in supply chain)	FAO Alternative Pathways (2018); Benton, T. (2019); Global Panel Report (2020); HLPE (2020); Hamilton et al (2020); Fraunhaufer EU scenarios (2023); BCG report (2022); FAO drivers (2022);
Blue' economy -growth in economic activities around aquaculture and fisheries	FAO drivers (2022);
International trade of agri-goods	FAO trends (2017); WEF (2017); Benton, T. (2019); Hamilton et al (2020); James Hutton UK scenarios report (2021); BCG report (2022); FAO drivers (2022); Stanton et al (2023); Garnett et al (2023);
Domestic markets connectivity	WEF (2017); HLPE (2020); IPCC (2022);
Structural changes-retail and wholesale	FAO trends (2017); WEF (2017); James Hutton UK scenarios report (2021);
Level of cross-country interdependencies (globalised system/local system)	WEF (2017); Benton, T. (2019); Global Panel Report (2020); Hamilton et al (2020); James Hutton UK scenarios report (2021); Fraunhaufer EU scenarios (2023); BCG report (2022); FAO Foresight (2022); FAO drivers (2022); Stanton et al (2023) Garnett et al (2023);
Changing diets and consumer behaviour	
Increase in calorie intake	WEF (2017); Benton, T. (2019); EAT-Lancet (2021); FAO drivers (2022); FAO Foresight (2022);
Increased consumption of animal-based protein	FAO trends (2017); WEF (2017); Benton, T. (2019); Hamilton et al (2020); James Hutton UK scenarios report (2021); Elliott, M. et al (2021); EAT-Lancet (2021) BCG report (2022); FAO drivers (2022); IPCC (2022); Hassoun et al (2022); FAO Foresight (2022);
Interest in healthy diet (awareness)	WEF (2017); Benton, T. (2019); Bene, C. (2019); HLPE (2020); Hamilton et al (2020); James Hutton UK scenarios report (2021); FAO drivers (2022); Hassoun et al (2022); Stanton et al (2023); Garnett et al (2023);
Increase consumption of processed food UPFs	FAO trends (2017); WEF (2017); Benton, T. (2019); Hassoun et al (2022
Influence of product labelling and information	Fraunhaufer EU scenarios (2023);
Appreciation for sustainable farming products (awareness)	Benton, T. (2019); Global Panel Report (2020); HLPE (2020); James Hutton UK scenarios report (2021); Fraunhaufer EU scenarios (2023); FAO drivers (2022); Hassoun et al (2022); Stanton et al (2023); Garnett et al (2023);
Shift to vegan and vegetarian diets	Stanton et al (2023);
Social media role	Benton, T. (2019); Hamilton et al (2020);
Food fraud	FAO Foresight (2022);
Technology, innovation, information	
Agronomic innovation e.g. new cultivars	HLPE (2020); IPCC (2022);

Systemic approaches (inter alia agroecology, conservation, circular economy and organic agriculture)	HLPE (2020); FAO Foresight (2022); FAO drivers (2022);
Biotechnology	WEF (2017); FAO Alternative Pathways (2018); FAO Foresight (2022); IPCC (2022);
Climate smart agriculture	FAO trends (2017); WEF (2017); Elliott, M. et al (2021); Fraunhaufer EU scenarios (2023); BCG report (2022); FAO drivers (2022);
Digitisation (access to information)	FAO trends (2017); WEF (2017); Benton, T. (2019); Bene, C. (2019); HLPE (2020); Fraunhaufer EU scenarios (2023); FAO Foresight (2022); FAO drivers (2022); Hassoun et al (2022 Stanton et al (2023) Garnett et al (2023);
AI in food retail	Fraunhaufer EU scenarios (2023); FAO drivers (2022); Hassoun et al (2022
Alternative proteins (burgers from insects, meatless meat)	Hamilton et al (2020); Fraunhaufer EU scenarios (2023); FAO Foresight (2022); Hassoun et al (2022
e-trading (online shopping) growth	FAO drivers (2022); Fraunhaufer EU scenarios (2023);
Big data and ownership and data-driven decision making	WEF (2017); HLPE (2020); Fraunhaufer EU scenarios (2023); FAO Foresight (2022); FAO drivers (2022); Hassoun et al (2022
Automation/technologies adoption (3d printing, blockchain, robotics, smart sensors, etc)	WEF (2017); Hamilton et al (2020); FAO drivers (2022); Hassoun et al (2022 Stanton et al (2023); Garnett et al (2023);
Food packaging	FAO foresight (2022); Fraunhaufer EU scenarios (2023);
Poor yields	FAO Alternative Pathways (2018); Hamilton et al (2020); Elliott, M. et al (2021);
Post-harvest contamination	IPCC (2022);
Livestock diseases	HLPE (2020); FAO drivers (2022); IPCC (2022);
Toxic substances in food- GMOs, allergens, processing contaminants	Hassoun et al (2022); Stanton et al (2023)
Anti-microbial resistance	FAO Foresight (2022); FAO drivers (2022);
Climate, resources and environment	
Resource availability (water, land, energy, soil) and demand	WEF (2017); FAO Alternative Pathways (2018); Benton, T. (2019); Global Panel Report (2020); HLPE (2020); Hamilton et al (2020); Elliott, M. et al (2021); Fraunhaufer EU scenarios (2023); BCG report (2022); FAO Foresight (2022); FAO drivers (2022); Stanton et al (2023); Garnett et al (2023);
Land degradation	FAO trends (2017); WEF (2017); FAO Alternative Pathways (2018); Benton, T. (2019); Bene, C. (2019) Global Panel Report (2020); HLPE (2020) Hamilton et al (2020); Elliott, M. et al (2021); FAO Foresight (2022);
Competition for land and deforestation	FAO trends (2017); FAO Alternative Pathways (2018); IPCC (2022);
Competition for water	FAO trends (2017); WEF (2017); FAO Alternative Pathways (2018); IPCC (2022);
Increased inputs (water, N, P)	FAO Alternative Pathways (2018); EAT-Lancet (2021)
Biodiversity loss	FAO Alternative Pathways (2018); Benton, T. (2019); Hamilton et al (2020); Elliott, M. et al (2021); EAT-Lancet (2021) FAO Foresight (2022); FAO drivers (2022); Stanton et al (2023)
Climate change	FAO trends (2017); WEF (2017); FAO Alternative Pathways (2018); Benton, T. (2019); Global Panel Report (2020); HLPE (2020); Hamilton et al (2020); Elliott, M. et al (2021); EAT-Lancet (2021); Fraunhaufer EU scenarios (2023); BCG report (2022); FAO Foresight (2022); FAO drivers (2022); IPCC (2022); Stanton et al (2023)

Agriculture encroachment in forests	FAO Alternative Pathways (2018); Hamilton et al (2020); FAO drivers (2022);
Food waste (along the value chain)	FAO trends (2017); WEF (2017); Elliott, M. et al (2021); EAT-Lancet (2021); Fraunhaufer EU scenarios (2023); Stanton et al (2023); Garnett et al (2023);
Intensification of biofuels (changing demand balance between food/feed/fuel)	HLPE (2020); Elliott, M. et al (2021); EAT-Lancet (2021)
Air quality (emission from agriculture)	Benton, T. (2019);
Food safety	Bene, C. (2019); Stanton et al (2023)
Food borne diseases	FAO trends (2017); HLPE (2020)
Transboundary pests and diseases	HLPE (2020); Hamilton et al (2020); Fraunhaufer EU scenarios (2023); FAO Foresight (2022); FAO drivers (2022); IPCC (2022);
Policy and governance	
Climate mitigation strategies- (e.g. Subsidies and incentives for shifting cropping pattern- biofuels)	FAO trends (2017); Benton, T. (2019); HLPE (2020); James Hutton UK scenarios report (2021); Elliott, M. et al (2021); EAT-Lancet (2021)
Climate adaptation- shift to reliable crops	FAO trends (2017); Hamilton et al (2020); IPCC (2022);
Governance and regulations of land (land tenures and deals)	HLPE (2020); Fraunhaufer EU scenarios (2023); IPCC (2022);
Food trade regulations and deals	WEF (2017); Fraunhaufer EU scenarios (2023); Garnett et al (2023);
Food safety and security policies	WEF (2017); Benton, T. (2019); Garnett et al (2023);
International trade regulations and transparency	WEF (2017); Benton, T. (2019); Hamilton et al (2020); Elliott, M. et al (2021); Fraunhaufer EU scenarios (2023); Garnett et al (2023);
Food quality standards	James Hutton UK scenarios report (2021);
Role of multi-laterals (food security governance)	HLPE (2020); BCG report (2022); FAO drivers (2022);
Labour migration policies	James Hutton UK scenarios report (2021);
Social cultural attitudes and inequalities	
Loss in indigenous cropping culture	IPCC (2022);
Socio-economic resilience – small holders shifting to livestock farming	IPCC (2022);
Livelihood needs	WEF (2017); Hamilton et al (2020); EAT-Lancet (2021)
Farmers resilience through bilateral alliances	WEF (2017);
Social norms and traditions	HLPE (2020)
Social stratification	HLPE (2020)

Social inequalities	FAO trends (2017); WEF (2017); FAO Alternative Pathways (2018); Benton, T. (2019); Global Panel Report (2020); HLPE (2020); Hamilton et al (2020); James Hutton UK scenarios report (2021); Elliott, M. et al (2021); FAO Foresight (2022); FAO drivers (2022);
Gender inequalities	FAO trends (2017); WEF (2017); FAO Alternative Pathways (2018); FAO Foresight (2022);
Income disparity	FAO trends (2017); WEF (2017); FAO Alternative Pathways (2018); Benton, T. (2019); Hamilton et al (2020); Elliott, M. et al (2021); FAO Foresight (2022); FAO drivers (2022);
Access to job opportunities	James Hutton UK scenarios report (2021); FAO Foresight (2022);
Access to assets and basic human services	FAO Alternative Pathways (2018); Hamilton et al (2020); James Hutton UK scenarios report (2021); Elliott, M. et al (2021); FAO Foresight (2022); FAO drivers (2022);
Injustices related to climate vulnerabilities, investment diversions etc.	FAO trends (2017); WEF (2017); FAO Alternative Pathways (2018); Benton, T. (2019); Hamilton et al (2020); Elliott, M. et al (2021); Fraunhaufer EU scenarios (2023); BCG report (2022); FAO Foresight (2022); FAO drivers (2022);
Role of social sector and grassroot organisations	BCG report (2022);
Unequal resource distribution (access for small holders)	HLPE (2020)
Animal welfare concerns	Hamilton et al (2020); Hassoun et al (2022
Crisis and conflicts	
Water-related Conflicts	Benton, T. (2019); FAO Foresight (2022);
Geopolitical conflicts and wars	FAO trends (2017); Benton, T. (2019); HLPE (2020); Hamilton et al (2020); FAO Foresight (2022); FAO drivers (2022); Hassoun et al (2022
Radicalism and terror	Benton, T. (2019);
Natural disasters (weather extremes)	FAO trends (2017); Benton, T. (2019); Bene, C. (2019); Hamilton et al (2020); FAO Foresight (2022);
Covid/ pandemics	Global Panel Report (2020); HLPE (2020); Hamilton et al (2020); James Hutton UK scenarios report (2021); FAO drivers (2022); Hassoun et al (2022
Global economic crisis	HLPE (2020)
Displacement and forced migration	FAO trends (2017); Global Panel Report (2020); FAO drivers (2022);

Annex B: List of scenario studies and scenario narratives reviewed in this study

Article	Uncertainties/ drivers used	Scenario number	Scenario	Storyline/narrative
Three scenarios for Europe's food sector in 2035 Europe-Fraunhofer Institute for Systems and Innovation Research ISI	Appreciation of products promoting ecosystem services; Degree of centralisation of food production; Purchasing behaviour related to food; Measures to reduce climate change in the food sector; Public and private investment in food and agriculture; Sustainability in the food sector; Growth paradigm in transition; Food safety and security; AI in the value chain; Food losses and waste; Quality and quantity of labels; Packaging of food; Resource availability: land, water, energy; Ownership of Data; Balance of power within the value chain; Society's attitude towards new technologies; Platforms and "Product as a service" in the food sector	1	Scenario 1 **Strong regulation puts the brakes on entrepreneurship and public trusts government**	states own agricultural land, produce food according to local conditions and care for the well-being of all their citizens. Consumers do not understand the complexity of food production nor do they care about how it influences the environment around them. They trust their government in providing nutritious food and ensuring accessibility for all citizens. The awareness for the necessity of environ- mentally friendly and sustainable food production is present and promoted by science. In this future, politicians have recognised that sustainable agriculture is vital to national food security. However, the state not only owns and manages agricultural land, it also has data sovereignty and access to data along the whole food value chain, e.g. to the purchase data of all e-commerce grocery stores. How this data is used and what are the implications for citizens will be explained.
		2	Scenario 2 **Society drives sustainability - food is sourced locally, shorter supply chain saves resources and customer cares more about environment and climate change**	In this future, people are driving developments forward through their search for a healthy lifestyle in harmony with nature. They are aware of many interconnections and see the big picture. Sustainable behaviour is in the heart of society. Economic growth is no longer the main paradigm to follow. Agricultural land is in the hand of many, especially local biodiversity is of high value and many fresh foods are produced within a 1-mile radius. In this future, the role of the national government is limited, but there are well-organised governments at the local level. Consumers' opinions are significantly determining a sustainable and local production of food. This has an effect on the availability of certain products, but for other reasons than in scenario 1. Further important aspects, like which values the society thrives for is further explained. The role of local communities in reaching high levels of self-sufficiency in food production and the contribution of individuals in living a sustainable life is elaborated in the scenario description. Why high food prices are accepted, whether consumers become producers, how the relationship between citizens and farmers evolved, which role retailers play in logistics, and what other properties food must fulfil is at the core of this future world. Additionally, "Food as a Service" evolves as a distinctive concept

				combining technological innovation with decentralisation and resource savings.
		3	**Scenario 3 A CO2-currency and retailers dominate trade and consumption**	In a globalised world, markets and technologies ensure prosperity for top performers High-specialised global markets rule the world. Dynamic technological progress, a competitive surrounding and unlimited growth characterise this future scenario best. Retail and sales have huge market power, e-commerce is mainly in the hands of the big box retailers and the shift towards online consumption of food is completed. In this world, flexibility is highly valued by consumers. Willingly provided transparency about consumer data gives retailers data sovereignty. Foodservice platforms evolve and are in the large part successful because of consumer profiling. Agricultural production has to be efficient and economically successful in the first place. The effects on land and biodiversity are of minor importance. How agricultural and processing technologies evolve in this environment is further explained in the scenario description. The role of global trade on the variety and prices of food as well as on its security is as central in this future as CO2-prices, the largescale industrial processing of food and the use of side streams. Other questions are how powerful national and local governments remain, how AI and new digital solutions are used to help consumers, why circular economy is the new paradigm to follow, and why natural resource and biodiversity protection, as well as climate change mitigation, are still of importance.
The future of food and agriculture Alternative pathways to 2050 Global-FAO 2018	economic growth, international governance, human development, energy use and GHG, welfare and lifestyle, land and water use, agricultural policies, yields and innovation.	4	Scenario 1-BAU	This global future develops according to socio-economic, technological and environmental patterns that fail to address many challenges for food access and utilization, as well as for sustainable food stability and availability, despite efforts to achieve and maintain SDG targets
		5	Scenario 2-Towards sustainability (TSS)	Virtuous social, environmental and economic dynamics in this scenario ensure fairly generalized equity in terms of access to basic services, as well as universal and sustainable access to sufficient, safe and nutritious food mostly produced with environmentally sustainable methods. Thanks to comparatively more resource- efficient food production systems and inclusive societies, challenges for both access and utilization, as

				well as sustainable food stability and availability, are lower than under the BAU scenario.There is universal progress to achieve SDG targets and efforts continue after 2030.
		6	Scenario 3- Stratified societies (SSS)	In this scenario, societies are structured in separate layers. Self-protected elite classes, such as groups of people who have decisional power and use it primarily to protect their position and interests, do not feel the urgency to conserve natural resources or mitigate climate change. At the same time, increased poverty, food insecurity and poor nutrition leads to the over-exploitation of natural resources and unmanaged agglomerations. In this scenario both equity and sustainable production are more seriously challenged than under the BAU scenario.
Exploring global food system shocks, scenarios and outcomes Global- Hamilton et al 2020	technology, connectivity, trade, food price, environmental health, food waste, food diversity	7	Scenari 1- Automation	In a not too distant future, a reduced number of suppliers and producers enable greater efficiency and automation technology becomes so advanced that the trucks transporting food from the producer to the supermarket no longer need drivers. Automated processes control many aspects of the food system (from production to point of sale) such as stock control, storage temperatures, transport and finance. This creates a highly efficient system and less redundancy. Computer driven systems allow maximum efficiency and increased profits, but these highly connected systems and narrow margins leave the system vulnerable to accidental failure (e.g. computer bug, or geomagnetic storm) or malicious action (e.g. cyber-attack).
		8	Scenari 2- extreme weather	A developing economy is heavily reliant on the export of a high-value raw commodity. It is the biggest producer of the crop globally and has thus invested heavily in the infrastructure needed to successfully produced and transport the good. The commodity is a key ingredient in many processed goods consumed across the globe, with hundreds of factories in disparate countries involved in processing it into thousands of end products. A drought in the region leads to the widespread loss of the crop. Income losses lead to localised civil unrest, with negative consequences for infrastructure and transport routes in and out of the country. Humanitarian aid and military intervention are required as poverty increases and civil unrest escalates. The situation increases migration causing increased social and political instability beyond the initial drought region.

		9	Scenari 3- financial speculation	In a not too distant future a surge of social media interest in health foods leads to increasing financial speculation in agricultural commodities, triggered by a desire to profit from future food price spikes. Higher potential profits lead to increases in land value and consolidation in farming activities as large agricultural production companies become more dominant. Fewer, larger farms lead to sizable areas of monoculture.
		10	Scenari 4- monoculture vulnerability	A single plant variety dominates soybean production in South America. The success of this variety has made other cultivars largely superfluous. Plantations are owned by multinational companies and one region in particular is a globally important producer of soybean for livestock feed. A new pathogen emerges in South America that destroys a sizeable proportion of global soybean. This causes thousands of job losses as farmers lose their crops and the multinational owners lose their investors. There is a shortage of feed for livestock leading to greater pressure on Amazon deforestation to produce more soybean. Cattle are fed on grass and barley causing barley prices to increase. Pigs and poultry have no easy alternative feed and animals are culled early.
Using scenario analyses to address the future of food Global- Tim Benton	Dietary shifts; level of connectivity (globalised vs. localised)	11	Scenario 1- Unchecked consumption in a globalised world	This is the 'business as usual future'. More people on the planet, demanding more processed food based on a small handful of globally traded commodity crops, and more livestock consumption made possible from intensive feed production. The downward pressure on prices, within this scenario's conventional business model, causes a concentration in few crops grown at scale in breadbasket regions, global homogenisation of diets and makes it economically rational to waste food and over-consume calorie-dense products. This drives obesity and ill-health. In a world where meeting demand is the primary driver, 'sustainable intensification' is the mantra, and long supply chains the norm. Given intensive and efficient farming at large scales, and few crops and demand growth, overall emissions increase, driving climate change. This impacts on yields in many places, and, at the same time, increases land competition – as more land is required for negative emissions technologies (such as afforestation) to mitigate climate change. So ever greater yields are sought from the same area of crop-land, with high-tech, super intensive cropping systems, intensive livestock production (with lots of concentrated feed). To intensify and to build climate resilience, requires the broad

				adoption of biotechnology as well. Smallholder agriculture is increasingly amalgamated into larger land areas to provide yields and allow interconnection to global markets.
		12	Scenario 2- Sovereign (in)sufficiency	This is a world in which nations look more locally or even inwards. Sovereign states have 'taken back control' from global markets and regained the 'sovereignty' they sacrificed to the 'the single worst trade deal' ever negotiated,11 brokered within the international architecture of cooperation (the UN, WTO and other bodies), as well as multinational corporations. The ingrained notion that food should be cheaper from the dividend for protectionist policies, and the lack of political or social desire for a 'nanny state' telling people what to eat, shapes the way the system works. With a greater need for self-sufficiency, and a loss of agricultural efficiency that comes from comparative advantage and global trade networks, there is no scope for meeting demand from dietary breadth – so countries base diets on the handful of commodity crops in which they can specialise. These restricted crops are processed into food that can be consumed with pleasure, without regard to nutrition. Agriculture is super-intensive, but with little international cooperation there is no drive for land-based mitigation so the agricultural footprint expands, and farming becomes more intensive, more extensive and drives more climate change. Nation states that differ in their endowments (land, water, soils, climate) and needs (population) become increasingly unequal. Endowment-poor, but highly populated, countries increasingly project power and grab land; endowment-poor nations with low population size struggle, and human migration increases. Both these undermine the national security of endowment-rich countries.
		13	Scenario 3- Global, green and healthy	This is a world in which globalised cooperation works, and supply chains are long (and climate agreements are cooperatively ratcheted-up). Commodity-crop agriculture remains the predominant mode of agriculture at scale, with nutrition added through biofortification during the processing that adds other pleasurable attributes technologically but with fewer calories than the added sugar and fats in the scenarios above. Governments promote

				preventative healthcare, so people eat less and this reduces land-use pressure, and because climate mitigation happens more aggressively there are fewer climate impacts and less need for the extensive deployment of land-based negative emissions technologies, further easing the pressure on land. Intensification is significant as land remains limited, but not to the extent of the scenarios above, because government incentivises lower waste (partly through shifting subsidies making food pricier, partly through waste taxes and food-carbon taxes). The shifting subsidies, and changing social norms, result in small-scale but intensive horticulture (including lots of urban and vertical farming) for high-value, nutritious crops, grown in the urban environment and periurban fringe. Large-scale horticulture is increasingly adopted by technologically advanced, arid, states – where pest pressure is low and there are technological solutions to provide water (desalination, 'smart' irrigation).
		14	Scenario 4- Localised and sustainable	This final scenario presents more of a world of circular food systems, diversified to provide healthy diets in more isolated regional food systems. Agriculture is more locally diverse, with more complex rotations, with mixed farming for nutrient cycling (including waste streams for local livestock and aquaculture). Because this system is more localised, the advantages of global competition maximising comparative advantage mean that the food system has to have efficiency built in, rather than a focus on increasing only agricultural efficiency. Agriculture policy is driven by nutritional needs not economic growth considerations. Health costs are avoided, through emphasis on 'preventative healthcare', and, along with circularity, agriculture is more diversified and landscapes more disparate. Food prices reflect the resources required to grow them, so environmental externalities are internalised. Because agriculture is more diverse, but food is less abundant, the value added by processing is relatively expensive, so people increasingly shift towards home preparation of food. The increased efficiency of the food system (people fed healthily per hectare) reduces food system emissions, globally mitigating climate risks. As with Scenario 2, more localised systems will exacerbate between-country inequality, which may lead to aggressive land-grabbing, or mergers of countries into larger local blocks (creating regionalised food systems). Additionally, food systems reflect more local climates/soil/water conditions, creating both

				greater seasonality of diets, and local specificity built on locally adapted produce.
Shaping the Future of Global Food Systems: A Scenarios Analysis Global-World Economic Forum 2017	Demand Shift (resource-intensive versus resource-efficient); Market Connectivity (high connectivity versus low connectivity)	15	Scenario 1 – Survival of the Richest	In this scenario, a combination of resource-intensive consumption and disconnected markets creates stark differentiation between the haves and have-nots. A relatively few isolated, wealthy populations are able to produce and innovate to meet their needs; isolated, poor or import dependent markets are facing intensifying hunger and poverty. Increasing distrust in globalization has led to nationalist sentiment and isolationist policies. There are fewer and weaker multilateral trade agreements, and trade barriers are slowing global economic growth. Population growth, rising inequality and food prices have led to increased conflict and migration, and intensifying resource needs have prompted a new wave of investments by foreign entities in land and water resources. Climate change continues unabated. Technology innovation is defined by a broad disparity of access and adoption. Reactionary decision-making and a crisis mindset are perpetuating a fragile system. Most people are worse off in this world, but some fare better than others. Developed countries and upper classes are relatively better off than those in poorer contexts as, for the time being, they can still afford high food prices and comfortable lifestyles. Within these limited rich markets, technology and select other sectors are performing well financially (although growth is slow globally). Entrepreneurs still have access to funds from limited investors, and innovate with a focus on niche business opportunities rather than broader social services and underlying global challenges.
		16	Scenario 2 – Unchecked Consumption	In this scenario, there is a combination of resource-intensive consumption and highly connected markets which has enabled rapid growth with serious consequences. Driven by ever-increasing demand, trade is accelerating as markets boom. Technology has spurred efficiencies in food production and distribution, with yield improvements as the top priority. Obesity and health costs rise dramatically as billions of consumers transition to a high-volume, high calorie, low nutrient-density diet. The "foodprint" expands as natural resources – including water, biodiversity and land – are severely

				depleted and components of key ecosystems such as fisheries and drylands begin to collapse, increasing costs of water purification and intensifying impacts in other regions as consumers seek alternate sources of food. Growing food demand is contributing to driving climate change well past 2°C of global warming. There are several short-term winners in this future. Many global food producers and retailers benefit from an increase in sales due to higher demands for foods – especially multinational companies which benefit from increased trade, globalization and strong global-brand recognition. Regionally, high-exporting countries benefit as trade levels increase to meet demand. Many consumers also benefit from low food prices: because the external costs of food are not incorporated into the price, resource-intensive foods remain relatively cheap. Importantly, however, these short-term benefits will be outweighed by longer-term costs and risks. This future comes at a heavy cost for others. Regions with limited access to natural resources are facing even scarcer access, while those with abundant natural capital are under pressure from actors searching for more resources: for instance, tropical forest countries are facing alarming rates of deforestation. At the same time, small and medium enterprises are losing market share against efficient and powerful global players, and smallholder farmers disconnected from global markets are likely to be left behind.
		17	Scenario 3 – Open-source Sustainability	In this scenario, a combination of resource-efficient consumption and highly connected markets enables a rise of greater transparency in business and in markets. Commodity markets have been stress-tested, and checks and balances instated, to reduce volatility and the risk of a crash. There is a proliferation of food sources, which reduces over-reliance on a few breadbaskets, improving the resilience of food systems. An increasingly interconnected trade system, however, still leaves the world susceptible to the effects of extreme weather events and other economic and political shocks. A stronger global economy enables more consumers to purchase food priced at its "real" cost, as influenced by new business models and policies that support sustainable choices and healthy diets. There is a movement towards personalized nutrition and healthcare, and more people use mobile apps to drive their shopping and eating habits. There is improved trust, interdependency and trade among

				governments. Governments uphold commitments to climate change agreements; however, inevitable volatile weather events continue. A rural transformation attracts youth to data-driven agriculture, but older farmers struggle to keep pace. This future has a relatively high proportion of winners. For farmers, there is greater availability, affordability and adoption of technologies that increase productivity, decrease costs expand access to key information and services. For companies, although such scrutiny generated costs and difficult changes in the short term, many are benefiting from improved productivity and more reliable sourcing. Governments benefit from collaborative trade agreements and access to data that informs effective policy design. Importantly, while this future may be bright for some, there are also stakeholders that are relative losers. For instance, some farmers may be shut out of the new, more connected economy, without viable alternative livelihoods. The surge in open-source information creates a disincentive for long-term research and development (R&D) among some companies; this is coupled with a shift in investment further towards the development rather than the research. More generally, consumers may be either winners or losers, based on their means, as food would become more expensive to capture its full cost.
		18	Scenario 4 – Local Is the New Global	In this scenario, resource-efficient consumption and low connectivity of markets have led to fragmented food systems whereby nations rely heavily on self-sufficiency. There is a rise in local food movements as consumers increase their focus on sustainable local products. Consumers in developed countries rediscover and appreciate local diets and develop a new respect for food, taking additional measures to reduce food waste. Progressive policies have successfully reduced the price point for healthier diets relative to unhealthy diets. Together, these factors enable a shift towards more balanced diets and a reduction in obesity and related diseases. Markets become increasingly local, with large variances in standards and protocols. Shorter supply chains and increased plant based diets reduce the strain on environmental resources. However, at the macro level, comparative advantages among food-producing regions are lost. Nations without good agricultural land struggle to meet demand and hunger hotspots proliferate. Country-specific innovation

				flourishes but diverse standards hamper scale. In this future, the clear winners are the countries that can achieve self-reliance through available natural and human capital. Successful nations are able to rebalance crop production towards greater diversity, positioning smaller producers to successfully meet local demand. Additionally, a focus on local assets and building connections within communities unlocks strong entrepreneurship for food production – including through urban and vertical farming – and along the value chain. In this world, import-dependent countries and emerging mega cities, such as Lagos, are struggling to feed a growing population and facing increasing malnutrition. This prompts scarcity, unrest and migration. Other losers in this scenario are industrial farmers who are unable or resistant to rebalancing their crop production as demand shifts toward a greater variety of crops. Local food movements could also negatively impact sales for global food producers and retailers, as clients defer to local producers and brands.
Four Futures for the Global Food System Global-BCG 2022	The state of the world's agriculture, climate change, and global economic and geopolitical dynamics	19	SCENARIO 1: UNEVEN PROGRESS	Global coordination stalls, but a few breakout nations among high-income countries (HICs) in the Global North lead a policy-driven development agenda and promote the uptake of existing climate-smart technologies. Meanwhile, inequity worsens as extreme weather decimates the Global South, food availability declines, and prices increase unevenly across the world. In this scenario, global supply chains become concentrated and dominated by countries such as Canada and the Nordics that build on their low-carbon exports. Agricultural technology remains focused on industrial and contract farming, displacing smallholder farmers around the world. The Global South suffers in the face of ongoing high debt, as the world—and especially Europe—prepares for increased numbers of climate refugees.
		20	SCENARIO 2: THE RISE OF AFRICA	In this scenario, Africa accelerates its agriculture potential through unprecedented South-South cooperation, technology transfers, and private sector investments, especially from countries such as India and China. Overall, food availability and productivity increase, prices drop, and hunger declines, but the benefits are not distributed evenly across the continent. Moreover, intensified agriculture leads to backsliding on climate goals.

				This scenario imagines a world in which reduced global trade results in more powerful regional trading blocs. Shorter food staple supply chains lead to intensified agriculture, notably in Africa, thanks in part to rapid adoption of technological advances in climate-smart agricultural inputs. At the same time, however, increased protein consumption on the continent and a lack of international consensus on climate policy cause greenhouse gas (GHG) emissions to increase there and elsewhere.
		21	SCENARIO 3: EVERY COUNTRY FOR ITSELF	A self-sufficiency narrative takes root globally, leading to significant reductions in global agricultural trade. By necessity, alternative foods such as millet replace global commodities. However, limited climate action leads to a point of no return. Resource-rich countries benefit; others suffer. In this scenario, a significant increase in protectionism has wide-reaching negative effects. Food costs rise and availability declines as global trade collapses by 20%. Supply chains are disrupted and profits in private sector agricultural decline. The failure to stem global warming leads to extreme weather events and further reductions in agricultural yields. Countries rush to protect their populations, but inequality and social unrest increases.
		22	SCENARIO 4: COORDINATED STEP FORWARD	Spurred by a food system disaster exacerbated by Russia's invasion of Ukraine, greater global coordination in climate policy and agriculture gains momentum. This promotes adoption of existing climate-friendly innovations. The private sector is pressured to follow along, especially benefitting companies that made early strategic bets on green ventures. In this future, collective action yields to numerous benefits. Global trade rises, and supply chains grow more resilient and transparent, significantly reducing food waste and loss. Demand shifts toward more nutritious, environmentally conscious foods such as plant-based proteins. A global consensus emerges on slowing global warming, leading to investment in climate-friendly and humane agricultural practices, including better protection of arable land and decreased GHG emissions.

The future of food and agriculture - Drivers and triggers for transformation 2022 Global-FAO 2022	Geopolitics and power; Economic growth and employment; Demography; Resources and climate; Agriculture; Technology and investment in agrifood systems; Poverty, inequality, food security and nutrition outcomes	23	Scenario 1- More of the same (MOS)	Ineffective development strategies and policies, economic imbalances across and within countries and skewed international trade, including persisting commodity dependency of many low-income countries (LICs), resulted in national and geopolitical grievances, deteriorating social and humanitarian outcomes, and a continuous environmental neglect throughout the 2020s and beyond. Agrifood systems kept struggling to satisfy an increased food demand as a result of the persistence of conventional agricultural practices that eroded the natural resources base. Dramatic crop yield improvements that materialized during the second half of the twentieth century turned out to be unsustainable in the long run. On the demand side, diets had been only marginally rebalanced to limit reliance on resource-intensive food, rich in animal products. Short-termism and the belief that it was possible to solve issues without questioning the prevailing development paradigm based on fossil energy and power concentration, drove most decisions in the majority of countries and at the global level. Key social and environmental trade-offs were left unaddressed, with no progress made on poverty and hunger eradication. Global corporations continued to prioritize shareholder profit as their primary bottom-line indicator and their fiscal elusion kept jeopardizing public budgets and actions. Public-private partnerships (PPPs), quite fashionable in the 2020s, could have had some potential for transformation, but were mostly ill-conceived and not monitored, so they mostly ended up becoming “green-washing or social-washing" devices. As a consequence, the 2030 Agenda and the “four betters” were substantially not achieved by 2030, and the few temporary successes were disproportionately distributed. During the subsequent decades, issues related to climate change, including weather extremes, economic downturns, conflicts and mass migrations, did not allow for any further progress, but rather led to further degradation and high risks of systemic failures.

		24	Scenario 2-Adjusted future (AFU)	Efforts towards adjusting some drawbacks of the development paradigm prevailing in the 2020s ensured some successes in terms of access to basic services, food security and nutrition. Some civil society movements temporarily succeeded in pushing governments to engage in multilateral agreements aimed at addressing issues that required global governance, such as mass migrations and blatant inequalities across and within countries. Some governments, in a quite timid last-minute attempt to meet selected SDG targets, tried to tackle the most urgent economic, social and environmental trade-offs and adopted fiscal policies to fund social protection measures, as well as modest GHG emissions measures and trade regulations. Agrifood and socioeconomic and environmental systems at large could have benefited from such interventions. However, piecemeal approaches, conflicts of interest among public decision-makers subject to the pressure of private lobbies, did not allow for the achievement of more resource-efficient food production or for a substantial internalization of environmental externalities, or the implementation of disincentives for consumption of resource-intensive food. PPPs contributed in some instances to progress towards SDGs, but in several others, they revealed themselves to be only “green-washing or social-washing" devices, as was spotted by a few civil society movements, while systemic governance weaknesses persisted at all levels. Therefore, although some well-being-related SDG targets and “betters” had been achieved in the aftermath of 2030, agrifood and socioeconomic and 2o transform and ensure maintenance of these achievements in the subsequent decades.
		25	Scenario 3-Race to the bottom (RAB)	Societies had been progressively structured in separate layers where self-protected elite classes, i.e. groups of wealthy individuals with transnational interests, held a strong decisional power and largely influenced sovereign governments. To preserve their interests, various means, differently blended depending on the institutional set-up of the different geostrategic blocks, had to be increasingly used in order to manipulate and control people, including ideological propaganda, the myth of good versus evil, the creation of external enemies, more traditional “command-control-punishment” instruments associated with pervasive social media restrictions and remote surveillance. Both agrifood technologies and consumer preferences had been increasingly shaped to satisfy the needs of business oligarchs. They

				not only disregarded natural resource conservation and climate change, but also maximized their surplus extraction from domestic and international agrifood value chains by ignoring diversification and resilience. In this context, PPPs became an element of deceptive narratives about development and played a mere "green-washing or social-washing" temporary function. In addition, the lack of social cohesion, citizens' limited awareness, the increasing dependency of most sovereign countries on oligarchies had left ungoverned global issues, such as climate change, pandemics, energy transition, big data generation and control, international capital flows and migrations. A series of consecutive economic crises, exacerbated inequalities and widespread poverty worldwide, and fuelled instability, civil wars and international conflicts. Ineffective or lacking multilateral cooperation at all levels along with diverging interests of leaders of geostrategic blocks engendered conflicts at a global scale, leading to the collapse of substantial parts of socioeconomic, environmental and agrifood systems. Famine, forced mass displacements, degradation of natural resources, loss of biodiversity and ecosystems' functions, and emergence of new pandemics, as well as nuclear and bacteriological contamination, were just signs of a world in complete disarray. By 2030, most SDG targets and the "four betters" were far from being achieved and by 2050, they had become a remote dream.
		26	Scenario 4- Trading off for sustainability (TOS)	New power relations, systems and actors emerged during the second half of the 2020s, thanks to civil society movements that progressively increased individual awareness and social commitment towards sustainable development at large. Distributed and participatory power and governance models gradually took over and complemented, or partially replaced, other power relationships based either on "command-control-punishment" mechanisms – typical of autocratic governments – or on the enormous influence of big transnational companies able to steer formally democratic sovereign governments. At world level, this brought about the reshaping of the institutional structures created in the aftermath of the Second World War and of the global development paradigm that ensued and prevailed in the last part of the twentieth century and during the first decades of the current century, based on narrowly defined GDP growth. As a result,

				multistakeholder national and global governance systems became much more effective in conducting global transformative processes. Thanks to these forces, before 2030, governments implemented strictly targeted social protection policies that significantly improved the quality of life of most vulnerable layers of societies. The immediate well-being of all the other citizens was traded off for longer term investments in sustainable production processes, energy transition, GHG reduction, and natural resource conservation and restoration. All this paid back before 2050, also thanks to some well-designed and closely monitored PPPs. Agrifood systems largely contributed to the overall socioeconomic and environmental transformation. Small and commercial farms and multinational corporations progressively adopted more sustainable technologies for food production, integrated multi-output energy and agrifood processing and generated remunerated environmental services. Concurrently, consumers, starting from those in high-income countries (HICs), shifted away from excessive consumption of energy- and natural resource-intensive animal products also because of increased food prices that fully reflected the "true costs of food", including social and environmental ones. Paradoxes, disparities, uncertainties and challenges had not disappeared, but they played out differently because well-educated citizens had developed critical thinking, had become much less prone to manipulation, more aware of trade-offs that emerged in development processes, and readier to engage in addressing and solving them. Although, by 2030, the "four betters" had not yet materialized fully, solid bases had been built that led to their full achievement and maintenance in the subsequent decades.
Future Food Systems: For people, our planet, and prosperity Global-Global Panel 2020	environmental risks (environmental breakdown vs. green and stable) and the nature of economic growth (profit at any cost vs. inclusive growth).	27	Scenario 1- Perfect storm, business as usual	It is 2040, and predictions made decades ago about the impacts of climate change have turned out to be correct. Average global temperatures have risen by more than two degrees. Sea levels are higher and extreme weather events – such as heatwaves, 'super-typhoons' and droughts – are regular occurrences, impacting more people with greater intensity. Everyone is affected, but especially those living in low-lying continental lands and in small-island states. The biggest losers are smallholder farmers who struggle to cope with extreme and unpredictable weather, as well as the millions of people earning a living downstream in the food system who provide goods and services to those same

				smallholder households. This puts rural livelihoods under severe pressure, leading many smallholders to abandon farming altogether and migrate to urban areas. The outcome is a shift of most arable land into the hands of a few large-scale agricultural producers. The lack of resilience of production means that yields, efficiency and profit are prioritised over sustainability and biodiversity, worsening the environmental degradation still further. The result is a shift to cash crops, produced on a vast scale for the world market. Monocropping provides economies of scale and higher profits, but more nutrient-rich crops such as tomatoes, beans, and leafy vegetables have become riskier and more expensive to grow and buy. Price spikes are common, causing social unrest. Food is a globally traded commodity and a flashpoint for geopolitical tensions. The unpredictability and volatility of global food production is mirrored in public health and nutrition outcomes. In the world of 2040, disease pandemics have become more frequent due to antimicrobial resistance, vector-borne diseases and cross-species transmission. The continued R&D, investment and subsidy concentration on commodity crops ensures that the world is calorie-rich but remains nutrition-poor. There is a wide and growing gulf between those who can afford healthy diets, and those who cannot, but these diets are unsustainable and contribute a growing share to resource degradation and climate change. Warnings about the double burden of undernutrition and obesity have proven accurate. Every country around the world is now grappling with some form of malnutrition and diet-related disease. In this profit-driven world, anyone can be left behind, and many are. There is little in the way of social safety nets, employment is less secure, and social mobility has slowed down.
		28	Scenario 2: Volatile, but inclusive	As in the first scenario, global temperatures have risen and the world in 2040 is experiencing extreme weather events on a more regular basis. But now the prevalent economic model is one aimed at inclusive growth, encompassing many objectives other than profit. Growth is measured in broad terms, not just financially, and the goal of national policies is that no one be left behind. Climate costs, and other environmental risks, have increased. To cope with the dual burden of malnutrition, governments have acknowledged that old ways of working are untenable. Many countries have restructured their economies to ensure inclusivity and

				sustainability as policy priorities, as opposed to profit-taking by and for the better off. Smallholder farmers in LMICs are facing the brunt of erratic weather patterns, as they are the least resilient to droughts, floods, soil erosion and pests. More nutrient-rich crops are riskier to produce which means they have become more expensive, adversely affecting the diets of the wider population. While opportunities to limit the extent of climate change were missed decades ago, this is also a world that believes in inclusive growth above anything else. This means that the worst impacts of climate change on the rural poor have been mitigated to some extent. For example, at the start of the 21st century, the problem of weak or non-existent land tenure had been recognised as a threat. Through land reform, the development of large-scale farming has worked in tandem with smallholder farmers, rather than simply displacing them. Smallholders have benefited from the provision of public extension services as well as private support when they work as contract suppliers to larger agricultural producers. Women farmers, in particular, have benefited from these changes and have been able to significantly increase their productivity and income earning potential.
		29	Scenario 3: Green, but unequal	In this scenario early action to tackle environmental breakdown leads to a world resembling today's, but one in which the climate crisis has been somewhat abated. At the same time, a rising GDP is still the top priority and the sole measure of growth, leading to more extreme inequality and a wide spectrum of sub-optimal health outcomes. The environmental warnings issued in the early part of the 21st century have been heeded, so weather extremes have been somewhat muted. However, social objectives are largely irrelevant. Agriculture is focused on extracting the most value, but through relatively clean, hi-tech efficiency and economies of scale, with larger farms dominating the picture. We might think of it as a new Green Revolution, but genuinely green, rather than one that prioritises yields. In 2020, certain Asian countries already had a growing presence in sub-Saharan Africa. This raised questions about how far foreign ownership of land and resources was desirable. In 2040, smallholders with weak or non-existent land rights have been evicted or bought out with relative ease. Some still work as farm labourers for large foreign owned producers, while others have migrated to cities. Inequality manifests itself in extremes

				of wealth and poverty at a national level, but also globally, with a greater and rising gap between rich and poor countries. Poorer countries in 2020 saw agriculture as an engine of development, and expected over time to diversify their economies and move into services and value addition. Instead, today they are still largely producers of raw materials exported to HICs. They have a natural advantage as producers of rice or other staples, especially under the stable environmental conditions, but they are not capturing most of the value. In poorer countries, power and wealth are concentrated narrowly at the top. Health and nutrition are also treated much more as commodities than as public goods. With less crop diversity, fewer people working in agriculture, and a weaker social safety net, it is more difficult for many to access a good diet. Local farming still exists, but small-scale farmers are excluded from the skills, inputs and technologies that large producers use. Those that grow leafy vegetables for the local market must sell at high prices. A good diet is still available, but only to those who can afford it, and overall, the nutritional outcomes are poor.
		30	Scenario 4: Perfect calm	This represents the most positive scenario. The effects of climate change have been mitigated, or even reversed, thanks to measures put in place long ago and natural resources are managed in optimal ways. Successful economic growth is measured in broad terms, not just financially, and no one is left behind. It was recognised that progress towards the SDG 2030 agenda had stalled, leading to a resurgence of effort to deal with many development problems. It was recognised that GDP-based growth, and 'trickle down' economic policies, underpinned the inequality which undermined progress towards the goals. Significant actions were taken in the 2020s to achieve the objectives of the Paris Agreement. Global warming remains comfortably below the most extreme projections, and economic restructuring has also reduced inequality. There are farms of all sizes (including urban and peri-urban production). Some large farms do exist, but they grow a variety of crops. This is because there have been shifts in a range of factors which influence diets (subsidies, tax structure, public procurement, and health, agricultural, and trade policies) to facilitate adoption of healthy diets. Demand for fruit and vegetables has risen while the demand for processed grains has declined – partly because people eat fewer ultra-processed

				foods based on traditional commodity crops, and partly because, on average, livestock produce is eaten less, so demand for livestock feed globally has fallen. Agriculture is thus more geared towards diversity than it had been in 2020. Smaller farms are economically viable. They have access to appropriate forms of financing, and invest in inputs and technology. Farmers have market information and infrastructure is in place, meaning they can respond to demand and access the market for their crops. Well-planned urban development means there is strong demand in cities for healthy, varied agricultural products. A diverse diet is both accessible and affordable. Fair trading terms are in place for overseas markets, providing reliable income earning opportunities. Environmentally harmful production processes are a thing of the past. Agroecological farming systems are common, with many farms using 'closed loop' systems as much as possible to reduce the need for artificial fertilisers and pesticides. Economic, ecological and social factors are all measures of success and well-being in this scenario. Equality is particularly important. As a scenario it suggests the achievement of health and resilience through diversity in all sorts of different ways: a diversity of localised farming landscapes, environmental biodiversity, and social diversity with maximum opportunity for nutrition achieved through dietary diversity.

Annex C: List of Critical Uncertainties Identified in Scenario Studies

Uncertainty Clusters	Uncertainties	Article	Author
Biological shocks	Biological shock	Exploring global food system shocks, scenarios and outcomes	Global-Hamilton et al 2023
	COVID	Scenarios for UK Food and Nutrition Security in the wake of the COVID-19 Pandemic	UK- James Hutton Institute
Business Structure	Degree of centralisation of food production	Three scenarios for Europe's food sector in 2036	Europe- Fraunhofer Institute for Systems and Innovation Research ISI
	Publica and private investments in food and agriculture	Three scenarios for Europe's food sector in 2038	Europe- Fraunhofer Institute for Systems and Innovation Research ISI
	Food supply chain structure (local vs global)	Scenarios for UK Food and Nutrition Security in the wake of the COVID-19 Pandemic	UK- James Hutton Institute
Climate	Measures to reduce climate change in the food sector	Three scenarios for Europe's food sector in 2035	Europe- Fraunhofer Institute for Systems and Innovation Research ISI
	Progress on climate change	Three scenarios for Europe's food sector in 2035	Global- FAO 2019
	Weather shock	Exploring global food system shocks, scenarios and outcomes	Global-Hamilton et al 2022
	Climate response	Scenarios for UK Food and Nutrition Security in the wake of the COVID-19 Pandemic	UK- James Hutton Institute
	Climate impacts	Four Futures for the Global Food System	Global- BCG 2022
	Climate	The future of food and agriculture- Drivers and triggers for transformation 2023	Global- FAO 2022
Diets	Appreciation of products promoting ecosystem services	Three scenarios for Europe's food sector in 2035	Europe- Fraunhofer Institute for Systems and Innovation Research ISI
	Purchasing behaviour related to food	Three scenarios for Europe's food sector in 2037	Europe- Fraunhofer Institute for Systems and Innovation Research ISI
	Diets and food system sustainability	Using scenario analyses to address the future of food	Global- Tim Benton
	Food values	Scenarios for UK Food and Nutrition Security in the wake of the COVID-19 Pandemic	UK- James Hutton Institute
	Diets healthier - 2 tier system poor health for poorer consumers	Scenarios for UK Food and Nutrition Security in the wake of the COVID-19 Pandemic	UK- James Hutton Institute
	Nutrition	The future of food and agriculture- Drivers and	Global- FAO 2022

		triggers for transformation 2022	
Environment	Resource efficiency	Shaping the Future of Global Food Systems: A Scenarios Analysis	Global- World Economic Forum 2017
	Environmental breakdown	Future Food Systems: For people, our planet, and prosperity	Global- Global Panel 2020
Equity	Equity of wealth distribution	The future of food and agriculture Alternative pathways to 2050	Global- FAO 2018
	Inequality	Scenarios for UK Food and Nutrition Security in the wake of the COVID-19 Pandemic	UK- James Hutton Institute
	Food sector labour market	Scenarios for UK Food and Nutrition Security in the wake of the COVID-19 Pandemic	UK- James Hutton Institute
	Inclusivity	Future Food Systems: For people, our planet, and prosperity	Global- Global Panel 2020
Globalisation	Globalisation	Using scenario analyses to address the future of food	Global- Tim Benton
	Global connectivity	Shaping the Future of Global Food Systems: A Scenarios Analysis	Global- World Economic Forum 2018
	International trade	Scenarios for UK Food and Nutrition Security in the wake of the COVID-19 Pandemic	UK- James Hutton Institute
	Geopolitical cooperation	Four Futures for the Global Food System	Global- BCG 2022
Technology	AI in the Value chain	Three scenarios for Europe's food sector in 2039	Europe- Fraunhofer Institute for Systems and Innovation Research ISI
	Automation shock	Exploring global food system shocks, scenarios and outcomes	Global-Hamilton et al 2020
Uncategorised	Financial speculation shock	Exploring global food system shocks, scenarios and outcomes	Global-Hamilton et al 2021
	Food standards	Scenarios for UK Food and Nutrition Security in the wake of the COVID-19 Pandemic	UK- James Hutton Institute

Annex D: Clustered Scenarios

Cluster	Scenario	Article	Author	Scale	Scenario number
Not much change	Scenario 1- BAU	The future of food and agriculture Alternative pathways to 2050	FAO 2018	Global	4
	Scenario 1-More of the same (MOS)	The future of food and agriculture- Drivers and triggers for transformation 2022	FAO 2022	Global	23
	Scenario 2- Adjusted future (AFU)	The future of food and agriculture- Drivers and triggers for transformation 2023	FAO 2022	Global	24
Uncontrolled Chaos	Scenario 1- Unchecked consumption in a globalised world	Using scenario analyses to address the future of food	Tim Benton	Global	11
	Scenario 2 – Unchecked Consumption	Shaping the Future of Global Food Systems: A Scenarios Analysis	World Economic Forum 2017	Global	16
	Scenario 3- Race to the bottom (RAB)	The future of food and agriculture- Drivers and triggers for transformation 2024	FAO 2022	Global	25
	Scenario 1- Perfect storm, business as usual	Future Food Systems: For people, our planet, and prosperity	Global Panel 2020	Global	27
Global Sustainability	Scenario 2- Towards sustainability (TSS)	The future of food and agriculture Alternative pathways to 2051	FAO 2018	Global	5
	Scenario 3- Global, green and healthy	Using scenario analyses to address the future of food	Tim Benton	Global	13
	Scenario 3 – Open-source Sustainability	Shaping the Future of Global Food Systems: A Scenarios Analysis	World Economic Forum 2017	Global	17
	SCENARIO 2: THE RISE OF AFRICA	Four Futures for the Global Food System	BCG 2022	Global	20
	SCENARIO 4: COORDINATED STEP FORWARD	Four Futures for the Global Food System	BCG 2022	Global	22

	Scenario 4-Trading off for sustainability (TOS)	The future of food and agriculture- Drivers and triggers for transformation 2025	FAO 2022	Global	26
	Scenario 4: Perfect calm	Future Food Systems: For people, our planet, and prosperity	Global Panel 2020	Global	30
Rising inequity	Scenario 3- Stratified societies (SSS)	The future of food and agriculture Alternative pathways to 2052	FAO 2018	Global	6
	Scenario 1 – Survival of the Richest	Shaping the Future of Global Food Systems: A Scenarios Analysis	World Economic Forum 2017	Global	15
	SCENARIO 1: UNEVEN PROGRESS	Four Futures for the Global Food System	BCG 2022	Global	19
	Scenario 3: Green, but unequal	Future Food Systems: For people, our planet, and prosperity	Global Panel 2020	Global	29
Local solutions Local	Scenario 2 - **Society drives sustainability-**	Three scenarios for Europe's food sector in 2035	Fraunhofer Institute	Europe	2
	Scenario 2- communal food system	Scenarios for transforming the UK food system to meet global agreements	Maia Elliott & Riaz Bhunnoo	UK	8
	Scenario 2- Sovereign (in)sufficiency	Using scenario analyses to address the future of food	Tim Benton	Global	12
	Scenario 4- Localised and sustainable	Using scenario analyses to address the future of food	Tim Benton	Global	14
	Scenario 4 – Local Is the New Global	Shaping the Future of Global Food Systems: A Scenarios Analysis	World Economic Forum 2017	Global	18
	SCENARIO 3: EVERY COUNTRY FOR ITSELF	Four Futures for the Global Food System	BCG 2022	Global	21
Unclustered	Scenario 1 **Strong regulation puts the brakes on entrepreneurship and public trusts government**	Three scenarios for Europe's food sector in 2035	Fraunhofer Institute	Europe	1
	Scenario 3 A CO2-currency and retailers	Three scenarios for Europe's food sector in 2035	Fraunhofer Institute	Europe	3

	dominate trade and consumption		Innovation Research ISI		
	Scenario 1- Automation	Exploring global food system shocks, scenarios and outcomes	Hamilton et al 2020	Global	11
	Scenario 2- extreme weather	Exploring global food system shocks, scenarios and outcomes	Hamilton et al 2020	Global	12
	Scenario 3- financial speculation	Exploring global food system shocks, scenarios and outcomes	Hamilton et al 2020	Global	13
	Scenario 4- monoculture vulnerability	Exploring global food system shocks, scenarios and outcomes	Hamilton et al 2020	Global	14
	Scenario 2: Volatile, but inclusive	Future Food Systems: For people, our planet, and prosperity	Global Panel 2020	Global	36