SOLVING THE GREAT FOOD PUZZLE:

PLACE-BASED SOLUTIONS TO HELP SCALE NATIONAL ACTION

WWF Food Practice:

WWF is an independent conservation organization, with more than 35 million followers and a global network active through local leadership in over 100 countries. WWF's mission is to stop the degradation of the planet's natural environment and to build a future in which people live in harmony with nature, by conserving the world's biological diversity, ensuring that the use of renewable natural resources is sustainable, and promoting the reduction of pollution and wasteful consumption. The WWF Food Practice works to transform the global food system to support WWF's mission. The Food Practice's vision is a food system which provides nutritious food to all current and future generations while protecting our planet. To help achieve this goal, the Food Practice works across Sustainable Food Production, Healthy and Sustainable Diets and Food Loss and Waste.

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Great Food Puzzle series

This is the third study in the Great Food Puzzle series which explores the place-based nature of food system transformation. For more information on the first report, please visit here. For more information on the second report, please visit here.

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FOREWORD

Many people ask us why WWF, a conservation organization whose mission is to “stop the degradation of the earth’s natural environment and to build a future in which humans live in harmony with nature”, works on food systems.
The simple answer is because the way food is produced, consumed and wasted leads to 80% of biodiversity loss and approximately one third of greenhouse gas emissions. So, transforming the food system is mission critical for WWF.

The ongoing quest to provide a growing population with enough food has reshaped the face of our planet. We have rapidly degraded the environment, exploited natural resources, and sacrificed many of the Earth’s supporting and regulating processes on which life, including ours, depends. Indeed, food production is the leading cause of habitat conversion, biodiversity loss, water use and water pollution, and a significant contributor of the greenhouse gas emissions driving climate change. And yet, we are still far off track from eliminating hunger, with 1 out of 11 people in the world, and 1 out of 5 in Africa, going without enough food. Nearly one-third of the global population lacks access to nutritious foods and cannot afford a healthy diet, while 40% of all food produced is never eaten – it is lost and wasted.

It is clear that food systems must be transformed globally, not just to minimize the environmental footprint, but to unlock the potential to restore nature and nourish people. Through working in more than 100 countries, in ecologically critical landscapes and growing urban environments, with local communities and the farmers and fishers who produce our food, it is also clear to us at WWF that there is no one-size-fits-all solution. Food systems are local and deeply rooted in the cultural heritage and values of communities, and any action at the national (or indeed international or multilateral) level must deeply consider the place-based nature of food systems so that context-specific solutions can be found, shared, adapted and scaled to the extent feasible.

This is the “food puzzle” we are trying to solve. Over the past two years, we have worked with various stakeholders from around the world, including researchers, government officials, and civil society and business leaders to better understand what changes in their own food system are needed at the country and landscape levels. Solving the Great Food Puzzle is not merely a research report. It’s also a theory of change for inclusively identifying and implementing the solutions that can deliver the biggest impact in the shortest time, matching both the urgency and scale of problems to be solved, and helping to anticipate unintended consequences that can arise when action is not guided by context.

At times, the challenge of redesigning our collective approach to transform food and agricultural systems may feel overwhelming. But in this report, we offer a food systems typology with corresponding prioritization of actions as a means to reduce the complexity and aid the acceleration of such transformation. We don’t offer a prescriptive approach, rather an important entry point for further development of local solutions designed by each country. Critically, solving the Great Food Puzzle requires collaboration. Intense, sustained and purposeful collaboration.

Together, it is possible to realize the tremendous potential of food systems as a solution that can drive biodiversity gains, reverse the climate crisis, nourish everyone with healthy and sustainable food and bring humanity together around a shared and positive vision of the future.

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EXECUTIVE SUMMARY

Unsustainable food systems are currently the number one threat to nature and human health, but this also creates an opportunity for food systems transformation to be the primary solution to multiple crises facing humanity. Over several years, food systems transformation has begun to be widely recognized as critical to halting and reversing nature loss, limiting global warming to 1.5 degrees Celsius and adapting to climate change, and providing all people with enough healthy and nutritious food. Despite this, there remain critical gaps in ambition, strategy and implementation, and failure to close these gaps will preclude our chances of realizing the tremendous potential of food system transformation.

Although there is an urgent need to close these transformation gaps, there is no one-size-fits-all solution that can deliver impact in all countries around the world. Different regions and nations face diverse opportunities and challenges shaped by local ecology, culture and histories of development. This wide variation in local contexts, and the complexity of the global food system, creates a challenge in identifying priority actions and key levers necessary to transform food systems. To reduce this complexity, typologies can be used to help identify similarities between countries with similar contexts and actions that may have the highest impact for each Food System Type. This is important because identifying the highest impact actions for various local contexts will help to urgently scale implementation and prevent unintended consequences.

Six Food System Types (named 1-6 to avoid biases or assumptions about the food systems themselves) were identified in this study based on a set of key environmental and socio-economic variables, with patterns emerging across the six types. For example, Type 5 food systems tend to have higher levels of environmental performance and food security than other Types but lower levels of biodiversity, whereas Type 1 systems have lower levels of environmental performance but much higher levels of biodiversity and carbon. In addition, each Food System Type tends to have one variable that performs differently, either better or worse, from other Types, which differentiates the system from others. For instance, Type 6 systems have very high levels of self-sufficiency, Type 2 very low levels of environmental performance, and Type 4 very high levels of water risk.

These variable patterns help to explain the performance of the various Food System Types, both at the country and landscape levels, and aid the identification of actions that will have the greatest impact based on local context. Given countless hyper-localized actions can be taken, we have consolidated the multitude of solutions most commonly discussed by experts and in scientific literature into 20 top-level transformation levers across six strategic action areas: Natural resource management; Governance and institutions; Education and knowledge; Technology; Trade, and Finance. We then used local expertise to assess the impact potential of each transformation lever in the different Food System Types.

FROM THIS ANALYSIS, EIGHT IMPORTANT TAKEAWAYS EMERGED:

1.

Food system transformation is not possible without better natural resource management.

Natural resource management levers have been identified as having high potential for impact in most countries, but especially in Food System Types 1, 2 and 3, which also have many landscapes considered as food system hotspots with increased risk of nature being converted for agriculture.

2.

The potential of education to transform diets and nutrition must be unlocked.

Education and knowledge levers were ranked high across most Food System Types, with increasing public awareness about healthy eating and reducing food waste consistently identified as having higher transformation potential.

3.

Smallholder support must be scaled and amplified to create impact on the ground.

Smallholder needs and issues manifest in a number of ways across the 20 transformation levers, with support for these strategies a high priority in Food System Types 2, 3 and 4, which are home to the majority of the global population and where smallholders dominate food production.

4.

Implementation of food system transformation will be undermined if infrastructure is not improved.

Developing infrastructure shows highest potential in Food System Types 2, 3 and 4, where 'basic' infrastructures such as roads, transport systems and cold storage facilities are needed to facilitate efficient movement of goods and mitigate the risk of food spoilage and loss.

5.

Redesigning finance and trade is critical for all countries.

Finance and trade levers are ranked especially high in Food System Types 1 and 5, which are often countries that use deforestation - and conversion-free regulations. However, all countries have ranked redirecting subsidies and increasing de-risking investments as high.

6.

Strengthening the scientific evidence for sustainable food production can accelerate its adoption.

Strengthening research and improving data collection and measurement have high potential for impact in most Food System Types, but continued focus on existing, green-revolution era, high-input farming practices and lack of funding remain barriers.

7.

There are no silver bullets – high-tech solutions must be balanced with other actions.

Adopting high-tech food production methods is seen to have lower potential for impact than many other levers and the focus for food system transformation should be less about developing new technological solutions or innovations and more about investing in low-hanging fruit solutions or social innovations.

8.

Alternative proteins get attention but may need more time before driving global impact.

Developing alternative proteins, such as plant-based and cell-based meat alternatives, was ranked as one of the lower potential levers in most countries and was conspicuously absent from most expert rankings of top 10 levers in individual countries.

In a high-stake, high-uncertainty environment, a strategic and collaborative approach to selecting actions that will have the highest impact in the shortest time possible is crucial for achieving health and environmental goals. Potential actions abound, but selecting those that will truly help to transform a food system is difficult, especially given the overwhelming complexity of food systems. The *Great Food Puzzle* is designed to make this process easier for anyone working on food system transformation by reducing this complexity and offering all stakeholders a starting point. This report is not intended to be prescriptive and should not be used in that way. Local knowledge and expertise will always be the most important resource to ensure that actions taken will have the greatest impact for both people and the planet.

INTRODUCTION

SOLVING THE GREAT FOOD PUZZLE

The *Great Food Puzzle* series by WWF focuses on the imperative role of place-based approaches for winning the high-stakes race to transform food systems and nourish all people within planetary boundaries. Given the multitude of solutions available, many of which are touted as silver bullets, it's no wonder there is much confusion about what actions are needed to transform food systems. Collectively, the series focuses on simplifying the complexities of the global food system by using the best available science to identify place-based solutions with the highest potential for impact. In these reports, we use place-based solutions to refer to either country or landscape-level solutions that are dependent on local context.

Building on earlier work (Box 1), we have identified 20 levers critical to delivering food system transformation, and developed a global food systems typology that groups countries based on common characteristics. Through a combination of desktop research and hundreds of surveys and interviews with experts from 12 countries and a diverse range of fields, including the private sector, academia, non-profit and government agencies, we have identified the levers with the highest potential to deliver impact in each Food System Type (see Appendix 2 for more details on the methodology). We believe this novel way of thinking provides all stakeholders working on food system transformation with a valuable approach that helps them identify, prioritize, finance and implement place-based solutions that will deliver the most impact in the shortest amount of time.

BOX 1

Solving the Great Food Puzzle: 20 levers to scale national action[1] was the first report in the *Great Food Puzzle* series and helped to develop and test the concept of identifying high-impact levers across Food System Types. This report offered a detailed analysis of food system transformation in Colombia, Brazil, Kenya and the United Arab Emirates. From this analysis, three initial Food System Types were identified and 20 transformation levers tested across these Food System Types.

Key findings from this study that carried over in the current study were:

1) Higher potential transformation levers differed across Food System Types;
2) Sharing of certain characteristics between Food System Types creates overlap in transformation levers; and
3) All food system types can learn from each other.

Solving the Great Food Puzzle: Right innovation, right impact, right place[2] was the second report in the *Great Food Puzzle* series and provided guidance for all stakeholders working on innovation through the development of an innovation framework. The Right Innovation, Right Impact, Right Place framework can help all stakeholders design and support innovations in food systems that maximize impact and achieve national-level health and environmental goals. The innovation framework helps in choosing how to implement the highest potential transformation levers in each different Food System Type.

CHAPTER 1
MIND THE GAPS

Unsustainable food systems are currently the number one threat to nature and human health (Figure 1), but this also creates an opportunity for food systems transformation to be the primary solution to multiple crises facing humanity. Over the past several years, there has been much-needed progress in identifying the transformative actions needed and accelerating their implementation.

The EAT-Lancet report proposed global targets for healthy diets from sustainable food systems [3] and has quickly become one of the studies most cited by policy documents. [4] The United Nations Food Systems Summit brought the world together to rally support for a healthy and sustainable food system. Both the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) and the Intergovernmental Panel on Climate Change (IPCC) have highlighted the central role food systems play in achieving biodiversity and climate goals. [5, 6] In the Global Stocktake at the UN Framework Convention on Climate Change Conference of the Parties 28 (UNFCCC COP28), food systems were finally included in a cover decision of a global climate summit. [7]

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FOOD SYSTEMS ARE THE MAIN THREAT TO PEOPLE AND PLANET

Food systems overexploit and inefficiently use natural resources...

LAND USE
40%
of habitable land is used for food production

WATER USE
70%
of freshwater withdrawals are used for food production

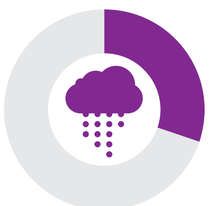
DIVERSITY
75%
of food comes from 12 crops and 5 animals

UNEATEN FOOD
40%
of food produced is lost or wasted

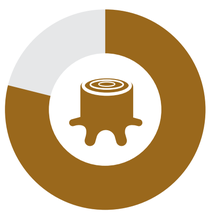
LIVESTOCK
38%
of croplands are used to grow feed for livestock

leading to an unhealthy planet...

BIODIVERSITY LOSS
70%
of terrestrial biodiversity loss is caused by food systems



CLIMATE CHANGE
30%
of greenhouse gas emissions are caused by food systems



NATURE LOSS
80%
of deforestation is caused by food systems

BIODIVERSITY LOSS
50%
of freshwater biodiversity loss is caused by food systems

and unhealthy people.

FOOD ACCESS
33%
of people lack regular access to adequate food

HEALTH
31%
of people are obese or overweight

HUNGER
10%
of people go hungry

Sources: (1) WWF Living Planet Report 2020, (2) WWF Driven to Waste 2022, (3) FAO State of Food Security and Nutrition 2023, (4) World Obesity Federation 2023, (5) Crippa et. al 2021 (6) FAO, 1999 (7) Scientific Group of the UN Food Systems Summit.

Figure 1.
Food systems are currently the number one threat to nature and people's health, which creates an opportunity for food systems to become the number one opportunity for restoring both nature and human health.

Despite this progress and the tremendous opportunity posed by food system transformation, there remain critical gaps in ambition, strategy and implementation, and failure to close these gaps will preclude our chances of achieving biodiversity, climate and health goals. In this study, we found there was widespread pessimism in progress toward food systems transformation (Figure 2). Only experts from China were positive on the current status of four aspects we measured: ambition, strategy, implementation and overall progress.

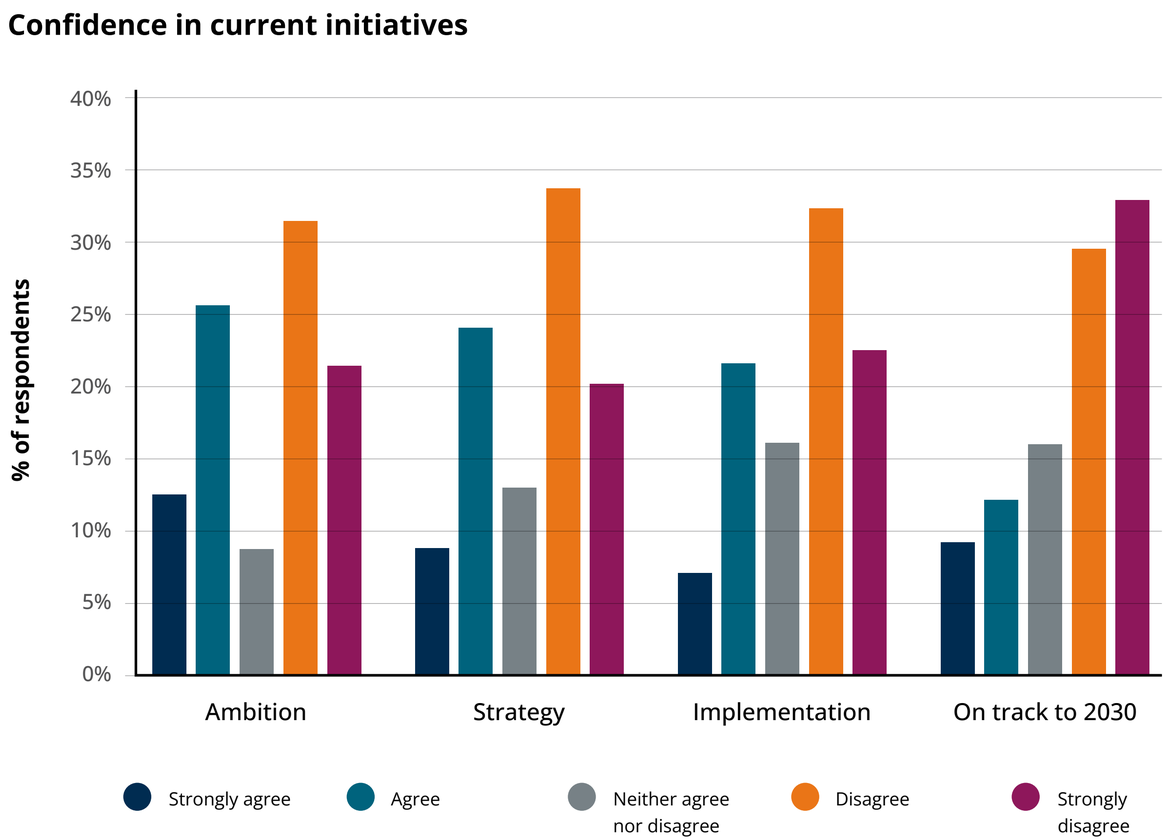


Figure 2.

Globally, experts feel that we are not on track to achieve 2030 goals or have sufficient ambition, strategies, or implementation to achieve these goals.

We are facing an apparent "transformation gap" between where countries are, regarding current levels of ambition, ongoing strategies and support for implementation, and where they need to be in order to feel confident of achieving 2030 goals for biodiversity, climate and health (Figure 3). Specifically, the three parts of the transformation gap are:

1. AMBITION GAP

Refers to whether the targets and goals being set by stakeholders are ambitious enough given the scope and magnitude of the challenges at hand. Ambition gaps can be seen, for example, in relationship to planetary boundaries or social foundations[8] – many goals are not being set high enough to keep our food systems in a safe and just operating space for people and planet.

2. STRATEGY GAP

Refers to whether the policies, actions and innovations[2] currently in place to achieve climate, biodiversity and health policies are optimal to create change with the urgency needed. In other words, even if sufficiently ambitious targets and goals have been set, and implementation sufficiently supported, if the policies, actions and innovations in place are suboptimal, achieving biodiversity, climate and health goals will remain out of reach.

3. IMPLEMENTATION GAP

Refers to whether policies and actions are sufficiently funded, resourced and supported. In other words, even if sufficiently ambitious targets and goals have been set, and optimal actions and innovations put in place, if their implementation is not sufficiently supported, achieving biodiversity, climate and health goals will remain out of reach. This includes well-resourced and supported projects that never reach their end target or those on the ground.

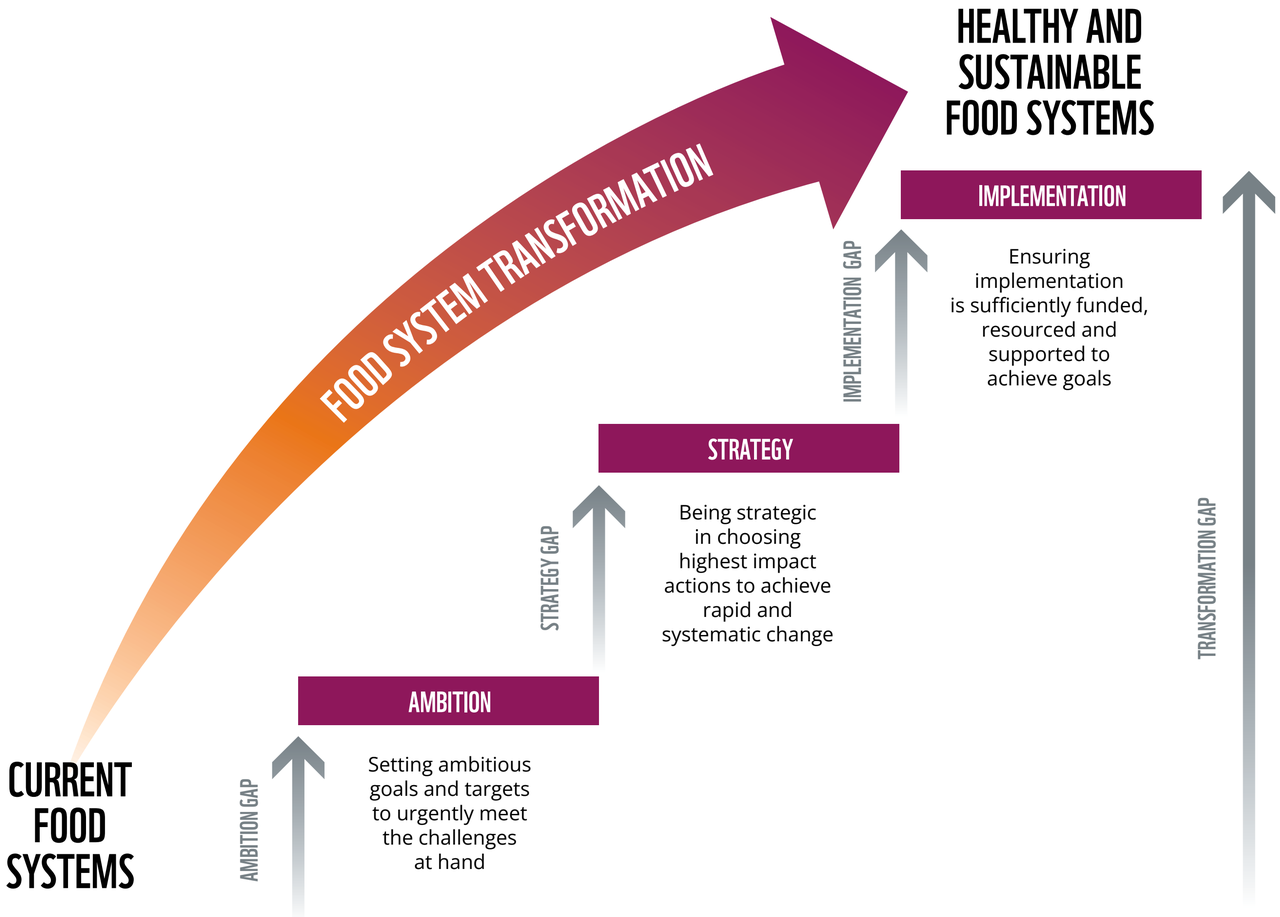


Figure 3.

Achieving food systems transformation requires closing the three parts of the transformation gap: the ambition, strategy and implementation gaps.[9]

1. AMBITION GAP

Throughout this research, we identified a lack of political will to set targets and goals that would promote more ambitious and radical change. For example, a reluctance by some political leaders to promote nature-positive food production practices,[10,11] including regenerative agriculture and agroecology. In many countries, policymakers were often aware of the need to adopt more sustainable practices but ambition for substantive change was often lacking. For instance, there was evidence of some hesitancy from policymakers to set targets and goals that would radically change current food production practices through a fear that yields may drop, negatively impacting food security or their economies. In addition, the transformative potential of nature-positive approaches is often being lost in watered-down framings of regenerative agriculture that focus only on soil carbon and carbon markets.

A common ambition gap was expressed in reference to the widespread continued focus on production-oriented interventions (Figure 4). That is, the vast majority of policy and investment focus continues to be on technological improvements or finding efficiencies in existing, unsustainable practices, rather than setting sufficiently ambitious targets and goals given the scope and magnitude of the challenges at hand.

> *There are slow movements within the government to start looking at agroecology policies. The policy for organic food is in its twelfth draft, but it has been blocked by the Department of Agriculture. [They are] not letting anything agroecological come through because there's fixed interests with agribusiness.*
>
> **South Africa**

> *Consumption is still very much the elephant in the room. And we see that politically. It's still very much a taboo to touch upon anything that relates to food consumption. Technical solutions have always been number one.*
>
> **Netherlands**

Pakistan is a meat-loving nation. In this part of the world, the shift we are seeing is not from meat to vegetables or other sources, but towards processed food. Healthy diets are more of an issue and topic for the upper-middle class and wealthy. A lot needs to be done on consumption patterns.

Pakistan

Food waste is a huge issue, individuals waste a lot of food. We prioritize the issue of food waste but food loss is often ignored. No specific data on food loss exists in China.

China

This focus on production-oriented interventions often appears to come at the expense of setting ambitious targets for reducing food loss and waste and shifting to healthy and sustainable diets. This is in contrast with the robust scientific evidence that shows the only way to achieve climate and biodiversity goals is to focus on all aspects of the food system, from farm to fork.[3,12,13]

The identification of a focus on production-oriented interventions is supported by a recent analysis of Nationally Determined Contributions (NDCs) which showed that out of 134 updated NDCs, 75% included adaptation measures at the production level and 70% included mitigation measures at the production level, but only 14% included any measures for food loss and waste; and even fewer – 3% – included measures on sustainable diets. Just two NDCs had measures for production, consumption, and loss and waste. A holistic approach is a very rare exception.[14]

Food system transformation goal areas

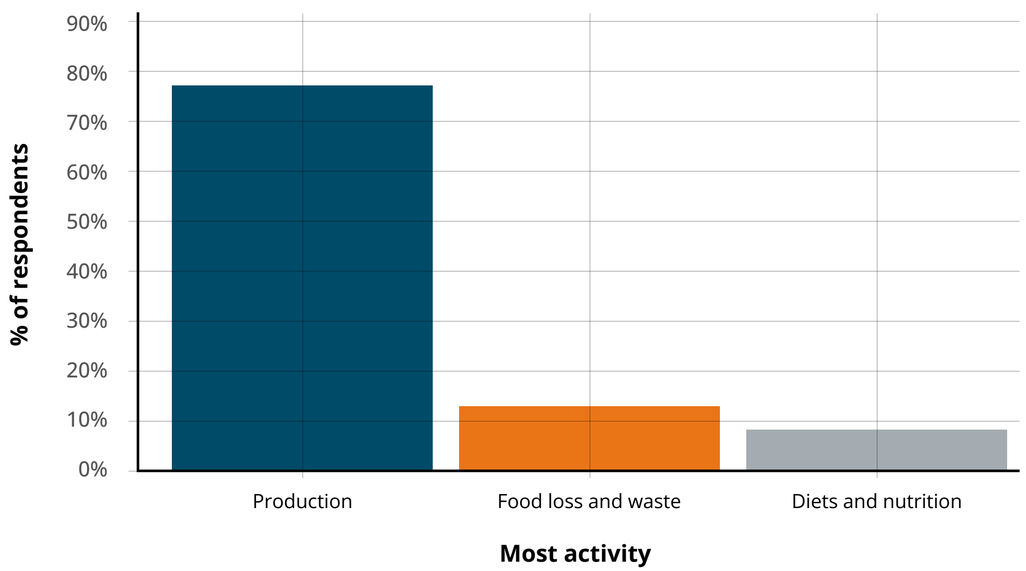


Figure 4.

Percentage of experts who believe that food system transformation in their country focuses on a particular goal area (production, food loss and waste, diets and nutrition). A key aspect of closing the ambition gap is adopting a food systems approach, however, production currently dominates initiatives in most countries.

In the 1950's the green revolution came, which told us to use more inputs to get more outputs. But now people are advocating for turning back the clock which makes farmers nervous. Farmers are worried about what will happen if they change their practices.

Pakistan

Most farmers are aware of more sustainable production systems and the negative impact of conventional farming. Awareness and suitable mechanization will help to expand more sustainable practices. But natural farming requires a lot of labour and we are not receiving any incentives to do this type of farming. Most farmers feel this risk is too high to try this type of farming.

India

The agriculture research system in india is the largest research system in the world. The problem is that most scientists learned farming with chemicals and are not doing any research on agroecological farming. The government is pushing for more natural farming but the scientists are still supporting industrial farming.

India

There is no market that will acknowledge higher quality foods. Food companies could play a big role.

South Africa

I think there needs to be a far stronger focus on food consumption. Because in the end we can change the farming system but what we really need is a different food consumption pattern, especially in Western Europe and the United States. In the Netherlands, specifically, there are hardly any policies or regulations geared towards food consumption and the need to change our diets.

Netherlands

2. STRATEGY GAP

Strategy gaps appear to be driven by a variety of challenges, such as lack of awareness of local context or a failure to create the necessary enabling conditions for disruptive actions to thrive. Too often, the actions and innovations that are adopted are not those that will have the highest impact.

From a production perspective, most policies in place favour large-scale industrial production practices, even if the ambition from the government is to transition to more sustainable forms of production. For example, in some countries we have seen an ambition to adopt more sustainable production practices, but the mechanisms to support farmers to do so are lacking, leading to increased risk for farmers and slow adoption of nature-positive practices.

There also exists a large strategy gap on consumption-related actions. For example, although the need to produce more healthy and sustainable foods is widely acknowledged, it must be paired with other efforts to grow markets and educate consumers on the benefits of these foods. Promoting healthy foods through on-farm diversification of crops and creative use of trade and finance to further grow market share are other examples of strategies needed to help scale and promote more diverse, healthy and sustainable production practices.

3. IMPLEMENTATION GAP

Implementation gaps are often driven by what seem to be mundane issues – funding, administrative challenges, inadequate extension and outreach – but the ubiquity of implementation challenges suggests that these issues are easy to overlook and difficult to address. Policies and approaches are needed to increase collaboration, incentivize continuity, reduce bureaucracy and put funding where it is most needed (often proper project management and place-based research).

Adequate support for smallholders, whether through financial schemes for small-scale agriculture or targeted science and extension, is a common concern in many countries. For example, a critical weakness in the science for food system transformation relates to a lack of effort and resources to investigate smallholder issues and challenges. Where good science and technical guidance is available, underfunded or poorly executed extension programmes frequently limit the translation and adoption of that knowledge.

Other types of financial incentive and resourcing challenges for implementation involve the long-term stability of projects. Administrative issues created by politics and administrative turnover, and resulting in abandoned or underfunded projects, can be seen regularly.

Finally, basic issues such as infrastructure and logistical challenges can also create implementation gaps. Production and supply chain innovations, for example, can be stymied by poor roads and limited access to reliable energy. Basic infrastructure upgrades, as well as more ambitious investments in small-scale renewable energy, are two examples of common missing pieces.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The extension models are the problem. The people that use the training don't have the expertise to help farmers do the new types of farming practices. There are not enough extension officers within the government ecosystem.

South africa

The problem is the inability to implement projects within an integrated approach. Usually, there are no monitoring and evaluation systems and no needs assessments conducted prior to implementation of programmes/projects. There needs to be continuity, less red tape, proper project management and institutionalization of programmes and accountability..

Philippines

The other major issue is again whatever innovation happens in the country, like, for example, drought-resistant varieties of crops or some universities have experimented with crops that will survive in saline environments and waterlogged areas. However, this innovation doesn't go down to the farmers. So there is a huge gap between the innovation and research and development, and then bringing it down to the implementation level with the people who actually get most affected.

Pakistan

China is very advanced in policymaking but there is a big gap between policy and implementation. For example, how do we support farmers to take action on scientific evidence? How can we use farmers' experience to reduce methane emissions and nitrogen pollution?

China

I think our present situation in South Africa is that the rural population is not visible. It changed slowly over time. Whatever support systems were in place for them are gone after COVID. A lot of the programmes just never, never happened again. They closed up during COVID and didn't come back afterwards. What little bit of development money there was, was spent on emergency funding.

So you still have programmes. You have officials sitting in those programmes, but they actually don't have any money to do anything except pay themselves.

South Africa

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CHAPTER 2
CLOSING THE GAPS

BUILDING A GLOBAL FOOD SYSTEMS TYPOLOGY

There is clearly an urgent need to close the ambition, strategy and implementation gaps to achieve food system transformation. However, there is no one-size-fits-all solution that can deliver the food systems transformations needed in all countries around the world. Different regions and nations face a range of diverse opportunities and challenges shaped by local ecology, culture and histories of development. Given the urgent and high stakes race to solving global problems, a rigorous place-based approach [15] is needed to identify actions that will have the most impact in the shortest time possible.

The wide variation in local contexts creates a challenge in identifying consistent actions and key levers necessary to transform food systems, to improve human health while reducing environmental impact. Given this, typologies can help us to identify different sets of actions relevant to groups of countries with similar contexts. The use of typologies to better understand food system transformation has been gaining momentum recently. The World Economic Forum [16] and Food Systems Dashboard [17] have used typologies to compare countries and understand meaningful trends, both building on the Marshall et al. typology. [18] However, one limitation of these typologies is that environmental variables were not front and centre when developing them.

In the global food system typology developed in this study, (Table 2) we used both social and environmental variables (Table 1). Considering the environment within which a food system is situated is critical given that food systems are the single greatest driver of environmental degradation [3, 5, 6] but are also centrally dependent on the health of local ecosystems and biodiversity. [19] These variables were then used to identify Food System Types for a cohort of countries and expanded to build a global food systems typology (Figure 5). See Appendix 2, Table A2.7 and Figure A2.1 for more information on methodology.

Table 1.

Seven variables were used for building a global food systemGr typology given they may have a disproportionate impact on a country's ability to achieve climate and biodiversity goals and can also influence the trade-offs that a country must contend with when implementing policy.

Typology variable	Justification	Description
Environmental performance [20]	Assessing a country's performance on environmental sustainability is a good indicator of their ability to be able to govern, manage and protect the environment. This variable measures how close a country is to meeting internationally established sustainability targets for specific environmental issues.	Environmental Performance Index from Yale 2022.
Self-sufficiency [21]	Having sufficient land and water resources to produce enough food to meet domestic demand of a Planet-Based Diet* has a large influence on where land conversion and environmental impacts are felt. It also can have a large influence on the type of production system needed to become less import dependent.	Ratio of hectares of available agricultural land to agricultural land needed to produce an EAT lancet diet for all country residents from Navarre et al. 2023.
Food security [22]	The levels of food security within a country can have a large influence on the priority placed on achieving either human health or environmental goals. The often competing demands many countries contend with can force difficult trade-offs between achieving either health or environmental goals in the short term.	Global Food Security Index from Economist Impact 2022.
Water risk [23]	Water availability for food production may be one of the most pressing issues in the near future, especially as climate change continues to impact countries. In addition, continued use or overuse of available freshwater resources can have a large impact on biodiversity and ecosystem services.	Basin physical risk score from WWF's Water Risk Filter 2021.
Biodiversity hotspot [24]	Biodiversity hotspots are regions characterised both by exceptional levels of plant endemism and serious levels of habitat loss. These areas are important because they contain high levels of biodiversity richness and endemic species.	Ratio of hectares hotspot to total country hectares from Conservation International's hotspot GIS data.
Irrecoverable carbon [20]	There are some natural places that we cannot afford to lose due to their irreplaceable carbon reserves. Irrecoverable carbon is ecosystem carbon that if lost, could not be recovered by mid-century, by when we need to reach net-zero emissions to avoid the worst climate impacts.	Total irrecoverable carbon (tons)/ Total hectares land area in the country from Noon et al. 2022.
Level of industrialization [18]	The level of industrialization of a country's food system has a large impact on diets, nutrition, health and environmental outcomes, as well as various supply chain and food environment variables.	Level of food system industrialization (1=traditional, 5=fully industrialised) from Marshall et al. 2021.

* WWF's Planet-Based Diet [21] is modeled after the EAT-Lancet Planetary Health Diet. [1]

Table 2.

Descriptions and country examples for each Food System Type.

Food System Type	Country examples	Description
1	**Brazil, Colombia, Ecuador, Indonesia, Peru, Russia**	Countries that have some of the highest concentrations of biodiversity hotspots and irrecoverable carbon. When coupled with moderate levels of environmental performance, this puts natural areas at medium risk for conversion. Food production is a mix of industrialized and smallholder and artisanal production. These countries have enough or nearly enough land and water resources to produce enough food to meet domestic demand for a Planet-Based Diet. Food security remains too low and must be addressed.
2	**Ethiopia, Guatemala, Madagascar, Morocco, Philippines, Viet Nam**	Countries that have the highest concentrations of biodiversity hotspots but lower concentrations of irrecoverable carbon. When coupled with weak environmental performance, this puts natural areas at high risk for conversion. Food production is driven by smallholder and artisanal production, but industrialized agriculture also exists. These countries do not have enough land resources to produce food to meet domestic demand for a Planet-Based Diet and freshwater risk is moderate. Food security is very low and remains a key priority.
3	**Bolivia, Egypt, India, Kenya, Pakistan, Paraguay, Ukraine**	Countries that have some key biodiversity areas but, overall, lower concentrations of biodiversity hotspots and irrecoverable carbon. When coupled with weak environmental performance, this puts natural areas at high risk for conversion. Food production relies predominantly on smallholders and artisans to produce food, but industrialized agriculture also exists. These countries do not quite have enough land to produce food to meet domestic demand for a Planet-Based Diet and water resources will become a major challenge in the future. Food security is very low and remains a key priority.
4	**China, Italy, Mexico, South Africa, Spain, Turkey**	Countries that have significant key biodiversity areas but, overall, moderate concentrations of biodiversity hotspots and lower concentrations of irrecoverable carbon. Coupled with strong levels of environmental performance, this puts natural areas at lower risk for conversion. Industrialized agriculture is the main method of food production, although smallholder and artisanal production does produce food for personal or domestic consumption. These countries have enough land resources to produce food to meet domestic demand for a Planet-Based Diet, but water resources could become a big issue in the future. Food security is comparatively high but must continue to be addressed.
5	**Chile, Japan, Netherlands, Norway, United Kingdom, United States**	Countries that have lower concentrations of biodiversity hotspots but quite high concentrations of irrecoverable carbon. When coupled with stronger levels of environmental performance, this puts natural areas at low risk for conversion. Industrialized agriculture dominates food production. These countries have enough land and water resources to produce food to meet domestic demand for a Planet-Based Diet. Food security is high.
6	**Argentina, Australia, Kazakhstan, New Zealand, Saudi Arabia, Uruguay**	Countries that have lower concentrations of biodiversity hotspots and irrecoverable carbon. When coupled with moderate levels of environmental performance, this puts natural areas at lower risk for conversion. Industrialized agriculture dominates food production. These countries have an abundance of land to produce food to meet domestic demand for a Planet-Based Diet and water risk remains comparatively low. Food security is high.

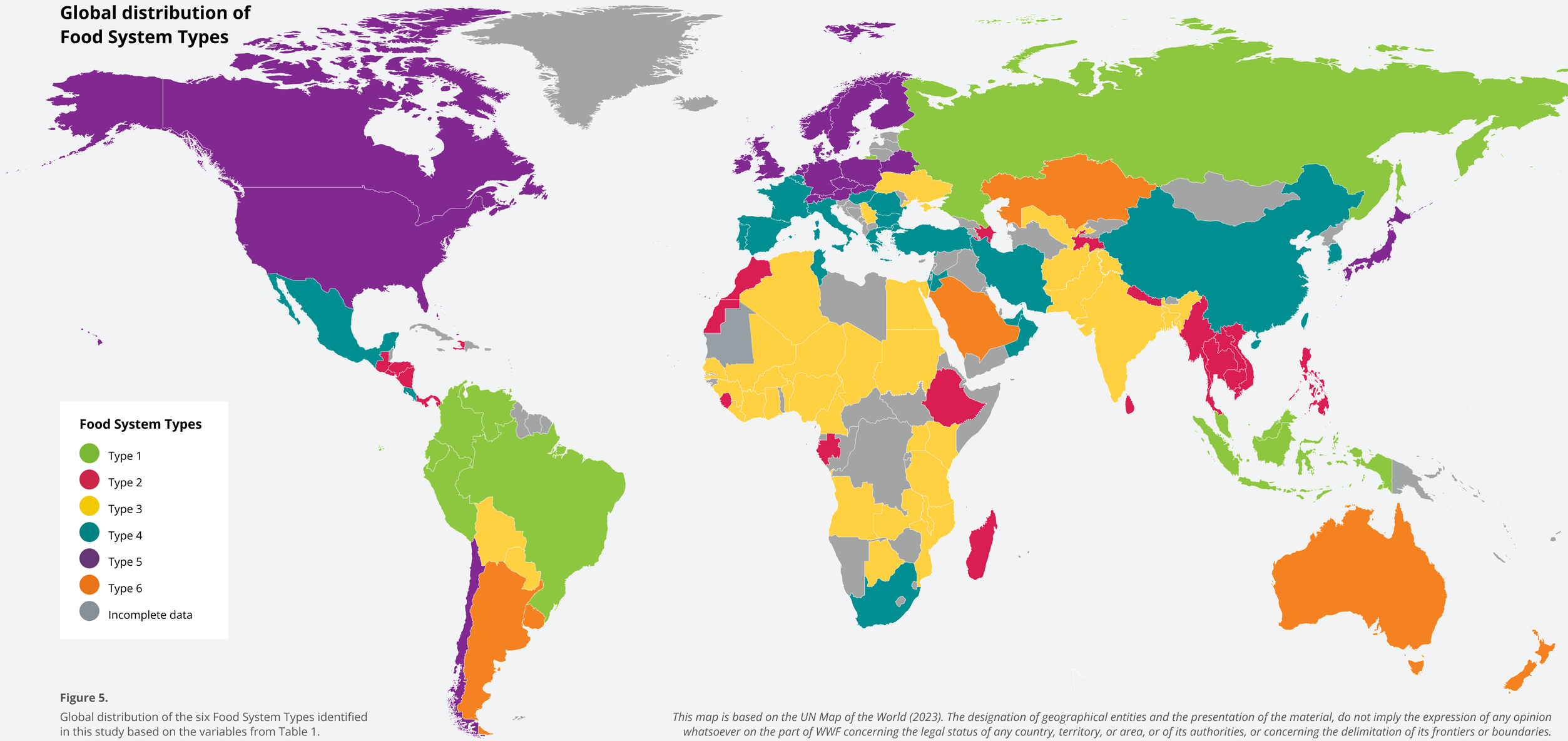

Figure 5.

Global distribution of the six Food System Types identified in this study based on the variables from Table 1.

This map is based on the UN Map of the World (2023). The designation of geographical entities and the presentation of the material, do not imply the expression of any opinion whatsoever on the part of WWF concerning the legal status of any country, territory, or area, or of its authorities, or concerning the delimitation of its frontiers or boundaries.

Through analysis of these variables, we identified six Food System Types. While other researchers have named each Food System Type in their typologies, we opted for using a simple numbering from 1–6 to avoid any biases or assumptions about the food system itself. Figure 6 demonstrates the characteristics of each Food System Type and its specific profile across the seven variables used in the analysis (Table 1). Please see Appendix 2, Table A2.7 and Figure A2.1 for more details on the Food System Type analysis.

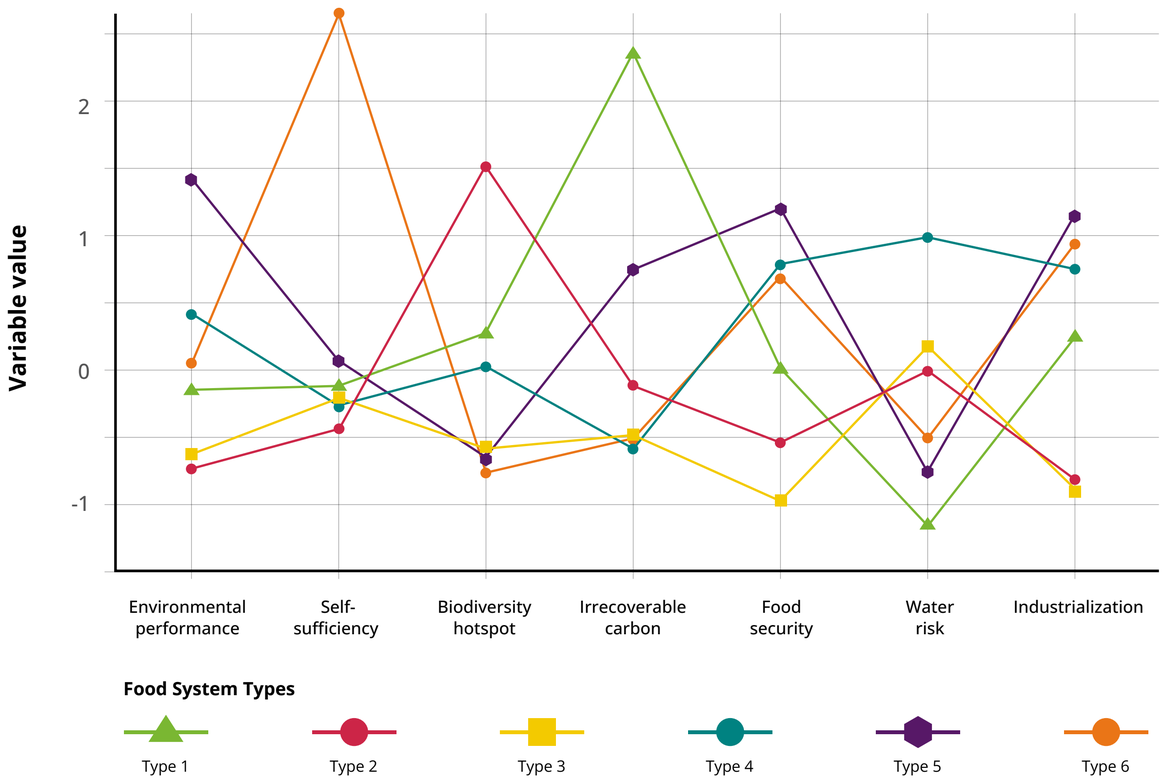

Figure 6.

The scaled values across the seven typology variables for each Food System Type for relative comparison. Values represent standard deviations away from the mean (0) value of the variable for all countries.

We see from Figure 6 that certain patterns emerge for the various Food System Types. For example, Type 5 food systems tend to have higher levels of environmental performance and food security than other types but lower levels of biodiversity, whereas Type 1 systems have lower levels of environmental performance but much higher levels of biodiversity and carbon. In addition, each Food System Type tends to have one variable that performs differently, either better or worse, from other types, which differentiates the system from others. Type 6 systems have very high levels of self-sufficiency, Type 2 very low levels of environmental performance, and Type 4 very high levels of water risk. These variable patterns help to explain the performance of the various food systems, especially regarding the environment and the level of threat to ecosystems in each country. Table 2 offers descriptions of and country examples for each Food System Type.

FOOD SYSTEM HOTSPOTS

All countries are home to rich and verdant ecosystems that provide society with numerous direct and indirect benefits. Conservation of these systems is of utmost importance for human health and environmental sustainability. However, some countries have **food system hotspots,** which are landscapes, freshwater scapes and seascapes that are simultaneously blessed with some of the richest reservoirs of carbon, plant and animal life on Earth, and threatened by food system activities. Although all countries must transform their food systems, we believe these "hotspots" represent landscapes that are uniquely important for achieving global climate and biodiversity goals yet continue to face increasing rates of conversion of natural areas for food production, coupled with weak levels of environmental protection.

For example, our threat assessment of landscapes finds that, in general, food system hotspots are most prominent in Food System Types 1, 2 and 3 followed by Types 4, 5 and 6 (Table 3). This is mainly because Food System Types 1, 2 and 3 contain high levels of biodiversity and carbon reserves coupled with weaker levels of environmental performance, moderate to low levels of food security (which tends to drive policies to increase production) and, specifically in Food System Type 2, insufficient land area to support domestic consumption of food (which can influence how existing land is used, for conservation or food production) (Figure 5). Together, these variables can drive deforestation and conversion for food production. Many countries in these Food System Types are also countries where deforestation fronts exist.[27] Deforestation fronts are landscapes that have a significant concentration of deforestation and where large areas of remaining forests are under threat.

Table 3.

The percentage of 50 highest impact landscapes by Food System Type that face the greatest threats from agriculture.

Food System Types					
Type 1	Type 2	Type 3	Type 4	Type 5	Type 6
28%	18%	26%	12%	4%	4%

We use the term **food system hotspots,** given that agriculture is the leading driver of environmental degradation including deforestation in these areas and also globally.[6] A growing global population and increased food consumption has led to many natural areas being converted into farms. The type of agriculture varies, but includes predominantly industrial agriculture, smallholder farming and cattle ranching in Latin America; both subsistence and commercial smallholder farming in sub-Saharan Africa; and industrial agriculture and vast plantations in Southeast Asia.[27]

Figure 7 highlights some landscapes that are under the most direct threat from agriculture and which also contain high levels of irrecoverable carbon and biodiversity. Landscapes that are found in Food System Type 1 and 2 countries face some of the highest threats and also contain high levels of carbon and biodiversity. These landscapes include the Cerrado (Brazil - Type 1), Mekong (Vietnam - Type 2), and areas of Kalimantan (Indonesia - Type 1). Landscapes in Food System Type 3 countries also face high threats from agriculture, including the Kaziranga Karbi Anglong (India - Type 3), Chiquitano Dry Forest (Bolivia - Type 3), and the Northern Highlands Landscape (Madagascar - Type 3). For more information on the methods used in this analysis, please see Appendix 2, Table A2.7 and Figure A2.1

In addition to deforestation, other natural ecosystems such as grasslands and mangroves are facing high rates of conversion for food production. In the United States, conversion of grasslands to croplands has resulted in high rates of biodiversity and carbon loss and results in only marginal yields.[28] Brazil is in danger of losing the Pampas grasslands due to agricultural expansion at great loss to wildlife[29] and conversion is surging in the Cerrado.[30] In fact, our analysis shows that the Cerrado is the most threatened landscape in which WWF works (Figure 7). On a positive note, in the Philippines, mangrove conversion has slowed and mangroves are now considered a key ecosystem for fighting climate change through "Blue Carbon" conservation.[31]

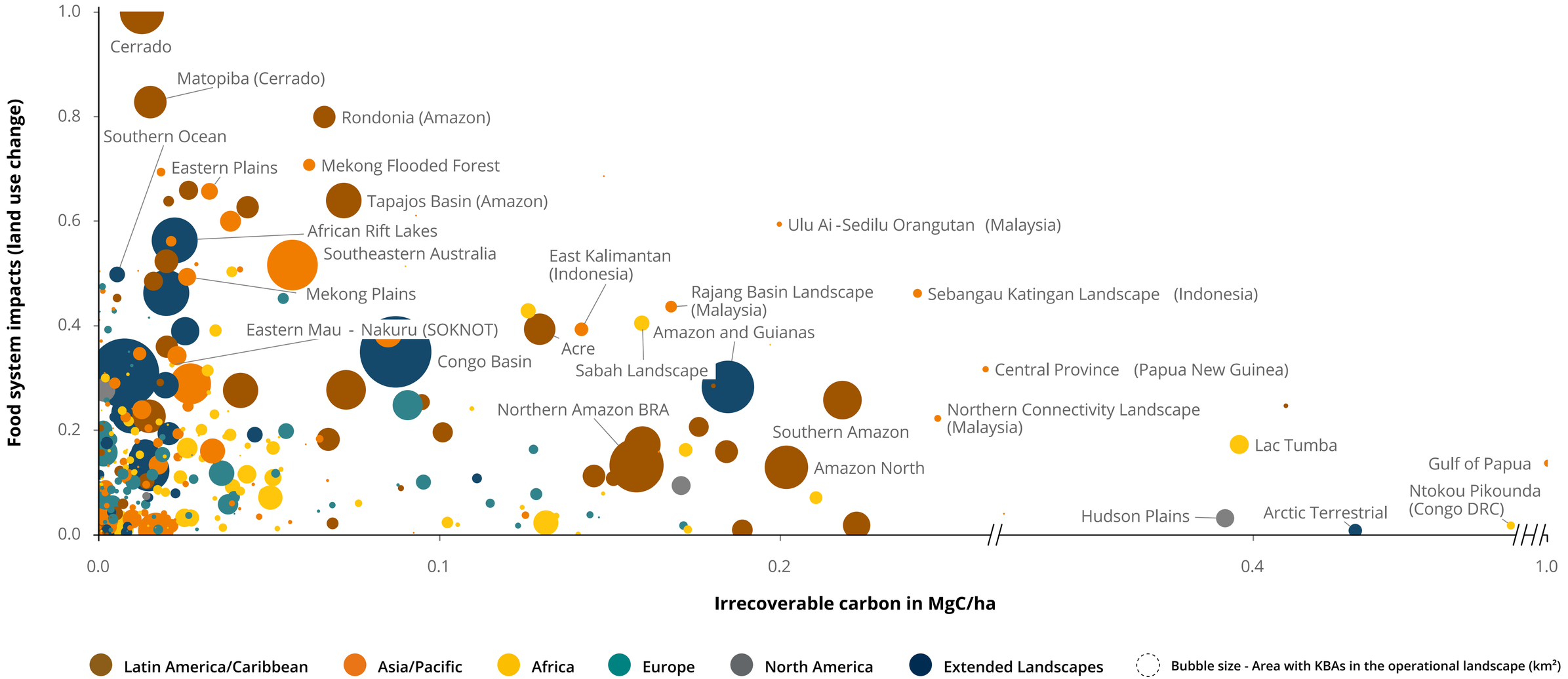

Figure 7.

Landscapes that face high impacts (y-axis) from food systems and also contain high levels of carbon (x-axis) and biodiversity (size of circle).

CHAPTER 3

TWENTY LEVERS TO HELP CLOSE THE TRANSFORMATION GAP

TRANSFORMATION LEVERS

In this chapter, we explore the potential for using the above Food System Types to identify actions that may be more relevant or of higher priority in certain countries, depending on local context. This is an important step in advancing work on food system transformation at the national level, starting the process of building a suite of tools and actions that work in various countries. There is no one-size-fits-all approach to transforming food systems across all countries. A wide range of actions could help achieve national-level food system transformations. To effectively analyze the similarities and differences in actions needed, and their potential impacts across Food System Types, 20 transformation levers [1] (Table 4) have been identified through a comprehensive literature review and expert consultations.

It's important to note that dietary shifts, reducing food loss and waste, and adopting nature-positive production practices, all of which need to be addressed to achieve health and environmental goals [12,13], can all be achieved through the levers. For example, to achieve healthy diets, a country may need to implement a combination of levers below, such as increasing the diversity of what is produced (NRM4), strengthening commitments for implementation (GOV3), increasing public awareness (ED3), and providing financial incentives to improve consumption (FIN3). Dietary shifts, reducing food loss and waste, and adopting nature-positive production practices are the goals and the levers are the actions needed to achieve these goals (Table A3.1 in Appendix).

TRANSFORMATION POTENTIAL

Table 5 outlines the potential of a lever to transform a particular Food System Type. All 20 levers will have some transformation potential, could be important for national-level food system transformation and could be used by a variety of stakeholders in decision-making (e.g. policymakers, businesses, funders, NGOs). However, unless significant resources are available to invest in full implementation of all levers to varying degrees, a means of assessing the potential impact of individual levers in a particular Food System Type can be useful for decision makers. The rankings outlined here are not meant to be prescriptive but instead are meant to guide decision makers in identifying solutions that, according to country-level experts and the best available science, will have the greatest impact in the shortest time possible. Identifying the highest impact levers by Food System Type can be used, for example, whether developing a national food systems roadmap, integrating food systems in NDCs to the Paris Agreement and National Biodiversity Strategies and Action Plans (NBSAPs), deciding which project or innovation to implement and commit resources to as a funder, organization or business working on food system transformation, or helping to develop conservation plans for individual landscapes.

Table 4.

Twenty transformation levers that have been identified as having a high degree of potential to transform food systems. These levers are important across all food system types but their potential for transformational change varies across food system types.

Strategic action areas	Transformation levers	Definition
Natural resource management	Optimize land use (NRM1)	Use all agricultural lands to their maximum potential including using existing agricultural land to feed humans and optimizing crop yields on these lands through better food production practices that more efficiently use water and fertilizers, reduce pollution from chemical inputs, preserve ecosystem functions, and contribute to resilient landscapes.
	Restore biodiversity (NRM2)	Develop and implement food production practices that restore biodiversity in active food producing land/waters and restore less productive areas to natural habitat for biodiversity conservation.
	Increase carbon storage (NRM3)	Develop and implement food production and blue foods management practices that increase carbon stores in below- and above-ground biomass and blue carbon.
	Increase food and agri- diversity (NRM4)	Support the production and consumption of a diversity of terrestrial and aquatic foods and protein sources (e.g. legumes, nuts and nutri-cereals) through agrobiodiverse systems including agroecology and regenerative agriculture.
Governance and institutions	Support smallholders (GOV1)	Redesign development and extension programmes to all farmers/fishers, including women, to provide financial assistance, develop new business models, infrastructure, and agricultural assets to grow/catch nutritious and sustainable, traditional foods and access to markets.
	Improve land tenure rights (GOV2)	Improve land tenure rights and develop actions that encourage collective ownership and Indigenous land rights.
	Strengthen commitments and implementation (GOV3)	Coordinate and strengthen national-level commitments and implementation on shifting to healthy diets, reducing food loss and waste, and scaling nature-positive food production.
	Foster multi-stakeholder collaboration (GOV 4)	Supporting multi-stakeholder collaboration using a multi-level and participatory approach for addressing interrelated issues across economic, social and environmental dimensions.
Education and knowledge	Strengthen research & development (ED1)	Increase research and development opportunities with food producers, and domestic universities, to expand nature-positive food production practices that support production of healthy foods.
	Improve data collection and measurement (ED2)	Improve data collection and measurement of current behaviours, environmental impacts and progress of national-level commitments contributing to international health, climate and biodiversity targets.
	Increase public awareness (ED3)	Launch engaging and compelling communication and behaviour change campaigns about healthy and sustainable eating and reducing food loss and waste.
	Promote healthy, sustainable and traditional foods (ED4)	Promote healthy, sustainable and traditional food cultures associated with good nutrition by supporting and protecting healthy and traditional foods and protein sources (e.g. legumes, nuts and nutri-cereals), providing information about healthy and traditional dishes and protein sources and through public awareness campaigns.
Technology	Adopt high-tech methods (TECH1)	Adopt high-tech nature-positive food production methods such as the sustainable use of non-conventional water sources and controlled environments for food production, and precision and digital agriculture technologies.
	Develop supply chain infrastructure (TECH2)	Develop supply chain infrastructure (e.g. roads and transport systems) and post-harvest storage technologies, packaging, and processing techniques for nutritious foods to reduce loss and waste of nutritious foods.
	Develop alternative proteins (TECH3)	Develop and promote healthy alternative protein sources such as plant-based and cell-based meat alternatives that are high in nutritional value.
Trade	Support healthy food imports and exports (TRD1)	Design trade policies to prioritize the supply of nutritious foods over manufactured foods high in fats, sugars and salt.
	Develop nature-positive supply chains (TRD2)	Develop trade policies (e.g. deforestation- and conversion-free) that support nature-positive food production, such as trade agreements and traceability tools, and changes in markets.
Finance	Redirect subsidies and increase de-risking investments to improve production (FIN1)	Redirect agri-food subsidies and from staple crops and harmful production practices and increase de-risking investments to increase nature-positive production of nutritious foods.
	Finance school food and public procurement programmes (FIN2)	Finance school food and public procurement programmes that promote and enable healthy and sustainable foods.
	Provide financial incentives and taxes to improve consumption (FIN3)	Provide financial support that increases the availability, affordability and appeal of nutritious foods and implement taxes that decrease the affordability of foods high in fats, sugars and salt.

Table 5.

The potential of individual transformation levers to transform different Food System Types are ranked from higher (dark green) to lower (light green) potential.

		Food system types*				
Strategic action areas	**Transformation levers**	**Type 1**	**Type 2**	**Type 3**	**Type 4**	**Type 5**
Natural resource management	Optimize land use (NRM1)					
	Restore Biodiversity (NRM2)					
	Increase carbon storage (NRM3)					
	Increase food and agri-diversity (NRM4)					
Governance	Support smallholders (GOV1)					
	Improve land tenure rights (GOV2)					
	Strengthen commitments and implementation (GOV3)					
	Foster multi-stakeholder collaboration (GOV4)					
Education and knowledge	Strengthen research and development (ED1)					
	Improve data collection and measurement (ED2)					
	Increase public awareness (ED3)					
	Promote healthy, sustainable and traditional foods (ED4)					
Technology	Adopt high-tech methods (TECH1)					
	Develop supply chain infrastructure (TECH2)					
	Develop alternative proteins (TECH3)					
Trade	Support healthy food imports and exports (TRD1)					
	Develop nature-positive supply chains (TRD 2)					
Finance	Redirect subsidies and increase de-risking investments (FIN1)					
	Finance school food and public procurement programmes (FIN2)					
	Provide financial incentives and taxes to improve consumption (FIN3)					

* Type 6 countries are expected to perform similar to Type 5 countries but no Type 6 countries were assessed for this study.

Lower potential of lever to transform a particular Food System Type

Medium to lower potential of lever to transform a particular Food System Type

Medium potential of lever to transform a particular Food System Type

Medium to higher potential of lever to transform a particular Food System Type

Higher potential of lever to transform a particular Food System Type

EIGHT IMPORTANT TAKEAWAYS

In this study, we conducted an in-depth analysis of eight countries, (Mexico, United States, Netherlands, South Africa, Pakistan, India, China and Philippines), representing a range of geographies, cultures and food system types. In addition, we incorporated the four countries from the first *Great Food Puzzle* report, (Colombia, Kenya, Brazil and United Arab Emirates) and have updated the original analysis of these countries to align with the analysis done for this report. From this in depth analysis of 12 countries (Table 5), important takeaways have emerged.

1.

NO TRANSFORMATION WITHOUT BETTER NATURAL RESOURCE MANAGEMENT

Natural resource management (NRM) levers (interventions that directly aim to enhance nature-positive production to reduce environmental impact and increase ecosystem services) have been identified as having high potential for impact in most countries, but especially in Food System Types 1, 2 and 3. This aligns with the status of these Food System Types as having landscapes considered as food system hotspots, since adopting nature-positive production practices will decrease the pressure to convert natural areas for agriculture. However, this pressure will only decrease as long as global consumption patterns also change (see strategy gap for more details).

Agroecology and regenerative practices (NRM 4) are seen to have higher impact potential, especially in India and South Africa (see Appendix Table A4.1 for countries divided by Food System Type). In the Netherlands, there is potential to become a leader in sustainable food systems by combining agroecological or organic practices with technological innovations. However, this also raises concerns about labour-intensive farming practices as unrealistic due to the high cost of labour in high-income countries. Improving efficiencies in food production was also highlighted, but it is noted that this should not be the main area of focus.

Interestingly, increasing strategies that target carbon storage (NRM3) have not been identified as a higher impact action lever for all countries, despite scientific evidence that this is a key intervention, particularly in four of the countries analysed in-depth: China, Philippines, Pakistan and South Africa (see Chapter 5 for more detail).

A major movement happening in Indian agriculture is a huge prioritization of natural farming. It started with these great model farmers who did their own thing with natural farming about a decade ago. Then civil society took it up, and now the State has taken it up on a large scale. From the Prime Minister to the governors to State governments, there is a huge effort to transition Indian agriculture away from the conventional high-input agriculture towards regenerative agriculture, which replaces chemical fertilizers and pesticides and also looks back at traditional seeds, less tillage and more crop cover.

India

Increasing diversity is important, opening up the markets and trying to expand the market to enable new types of foods and more diverse foods to be more readily available to people.

South Africa

The top issue is working on consumers - shifting diets and creating demand for good food. If the shift in diets is there, the rest of the food systems will follow. The second is food environments are extremely important, what kind of food can be sold and if people have access to healthy foods. Demand is the most important side.

India

[We should be] educating and reorienting our taste buds. Moving away from artificial flavouring, fast foods, and increasing awareness of the fading knowledge of traditional cultivation methods, eating habits and indigenous foods.

Philippines

2.
THE POTENTIAL OF EDUCATION ON DIETS AND NUTRITION MUST BE UNLOCKED

Collectively, the education and knowledge levers work across the food system to ensure nature-positive production thrives and that there is a demand and markets for healthy and sustainable foods.

Increasing public awareness about healthy eating and reducing food waste is consistently identified as having higher transformation potential, with an emphasis on changing consumer behaviour and promoting the consumption of diverse, healthy foods. In Type 5 countries, such as the Netherlands, consumer education has already been quite successful in raising awareness of the need to eat more sustainable and healthier foods, while in other countries, like India and South Africa (Type 3 and 4 food systems), COVID 19 sparked a huge increase in public awareness around the need to eat healthier foods.

Despite the fact that improving knowledge on healthy and sustainable diets and consumption has a high potential for impact across all food systems types, there is currently little focus on diets and nutrition in national initiatives (Figure 3). In some countries, such as India and South Africa, diets and nutrition are sometimes seen as only urban or wealthy topics of focus. This seems to indicate a strategy gap that clearly links changes to food production with dietary shifts. Closing this strategy gap, by adopting a food systems approach from farm to fork and bait to plate, is essential to achieving healthy and sustainable food for all.

For instance, it is noted that promoting healthy, sustainable and traditional foods (ED4), an important lever in Types 2, 3 and 4, must be complemented by incentivizing farmers to grow these crops sustainably. In India, where the government launched a millet mission in 2023, it is noted that this campaign isn't being supported on the ground to scale consumption and production of these grains.

Most of the support that has been coming to the farmers has been in terms of subsidies on fertilizers. But smallholders do not realize the fruit of those policies, they are not what farmers need at the moment as they don't solve the problems. Capacity building and the right markets for their produce [are critical]. It shouldn't be the subsidized inputs. It should be the right price at the right time. Building the market channels and getting the right price for their produce is most important. Too often they don't get the right price or they don't get a market channel. So streamlining the market would help.

Pakistan

The extension models are the problem. The people that do the training don't have the expertise to help farmers do the new types of farming practices. There are not enough extension officers within the government ecosystem.

South Africa

Our extension department has to be revived. And they may need to see how they can support the small farmers and how they can change the perspective of a farmer on using inputs. Because currently, this major task is being carried out either by the pesticide companies or by the input companies which also includes the fertilizer and the seeds. So these are the companies who are basically playing the role of the extension service providers.

Pakistan

There is a lot of research on new and fancy production methods and technologies but most of this doesn't work for smallholders. And so when we are talking about technology, it's not something that's really working out in rural areas.

South Africa

3.

SMALLHOLDER SUPPORT MUST BE SCALED TO CREATE IMPACT

Smallholder needs and issues manifest in a number of ways in our set of 20 transformation levers, including in governance levers explicitly about building support for smallholders and addressing challenges regarding land tenure (GOV1, GOV2), education for promoting knowledge of healthy, sustainable and traditional foods (ED4), and redirecting subsidies and increasing de-risking investments (FIN1). In addition, strengthening science, research and development (ED1) is particularly important for smallholders.

Collectively, we see support for these strategies as a high priority in Food System Types 2, 3 and 4, which are home to the majority of the global population and where smallholders dominate food production. Focus on support for smallholders decreases in Food System Types with more industrialized food systems (Type 5). The need to support smallholders through various mechanisms came up more in conversations with experts than any other single topic. Additionally, extension and other education services are often lacking for smallholders and extension officers are often trained in more industrial forms of food production (i.e. Green Revolution models), even though the government might be promoting more natural farming practices. Expanding the reach of extension services and increasing training opportunities can empower smallholders, improve their farm management skills, and enable them to adopt integrated crop-livestock-agroforestry systems and other sustainable practices.

THE NEED TO PAIR LEVERS IS CRUCIAL FOR SUCCESSFUL FOOD SYSTEM TRANSFORMATION

Often, food systems solutions such as the 20 levers discussed here are explored and evaluated individually. However, we found that strategic pairings or bundlings of levers often must work in tandem. One example is the constellation of levers identified as being important for supporting smallholders. Smallholder support from governance (GOV1) often also requires new science focusing on agroecology and smallholder issues (ED1). Further, supply chain innovations (TECH2), finance (FIN1&2) and trade (TRADE1) actions can work together to improve market access for smallholders.

With respect to consumer-side changes, such as the uptake of alternative proteins, the importance of financial incentives and taxes, alongside awareness and education campaigns to encourage healthier choices are all needed. Strategies were suggested including changing food environments and trying to nudge social norms around meat eating, improving food literacy and skills, and providing tools and information to help consumers make more informed choices.

Public distribution of food is old fashioned, controlled by the government and highly inefficient. By simple changes to how food is distributed, we could drastically reduce food loss and tackle food insecurity. The low hanging fruits to addressing food insecurity are production, transportation and distribution.

India

The main problem is not the producer. The main problem is the supply chain, our inability to move fruits and vegetables even from state to state in Mexico. We have enough production of goods for stores. The problem is the inability to transport it to the places people need these foods. For example in Chiapas we produce a lot of vegetables and fruits, but we don't have the support to transport them to other states in Mexico. Or to export to Africa is too expensive.

Mexico

4.

IMPLEMENTATION WILL BE UNDERMINED IF INFRASTRUCTURE IS NOT IMPROVED

Food systems rely on a variety of hard and soft infrastructures and transformation gaps can often be closed by developing infrastructure (TECH2), though in notably different ways in different Food System Types. The potential for impact is highest in Food System Types 2, 3 and 4, where 'basic' infrastructures are needed. For example, in low-income countries, improving physical infrastructure such as roads and transport systems is fundamental to facilitating the efficient movement of goods from farms to markets, reducing the time and cost associated with transporting produce and thereby mitigating the risk of spoilage and loss. While these technologies are not novel or innovative per se, the need for redoubled investments in these areas is important, as well as for technologies like better cold storage facilities for fisheries, extending both marketability and reducing waste.

In Type 5 food systems (United States, Netherlands), infrastructure discussions tended to focus on 'new' technologies, such as desalination plants, and how the use of big data and artificial intelligence can help reduce waste and improve forecasting in the food industry. However, the transformative potential of these solutions is deemed to be lower than those 'basic' developments needed elsewhere.

Most farmers are aware of more sustainable production systems and the negative impact of conventional farming. Awareness and suitable mechanisation will help to expand more sustainable practices. But natural farming requires a lot of labour and we are not receiving any incentives to do this type of farming. Most farmers feel this risk is too high to try this type of farming.

India

The private sector does not always let the smaller companies and the smaller farmers develop and adapt because they also rule the legislation and the new policies that are brought in.

Pakistan

In Mexico there are a lot of monopolies, and this kind of system makes it very tough for the producer. It's very unfair for them because they have to sell their products with the same people. These intermediaries do not do anything, and they are winning the most, while the producers are doing the most.

Mexico

5.

REDESIGNING FINANCE AND TRADE IS CRITICAL FOR ALL COUNTRIES

Finance levers are ranked especially high in Food System Types 1 and 5, which are countries that produce a lot of commodities. However, all countries have ranked redirecting subsidies and increasing de-risking investments as high. Presently, subsidies support the intensive production of a narrow range of foods, degrading the environment. Agriculture subsidies alone are responsible for the loss of 2.2 million hectares of forest per year – or 14% of global deforestation.[32] Repurposing government subsidies (FIN1) towards healthier crops and nature-positive farming practices is very important, along with incentivizing farmers to switch to nature-positive methods. Too often, the up-front costs and risks of transitioning to more nature-positive production practices are a barrier to greater adoption. This can be overcome by the liberal use of subsidies to facilitate the transformation to nature-positive practices and offset farmers' initial risks and costs.

In addition, Type 1 and 5 countries can use financial incentives and trade policies to improve consumption (FIN3 and TRD2). For instance, Type 5 countries have a history of using deforestation and conversion-free (DCF) regulations to help promote the consumption of deforestation-free products. This includes the proposed EU Regulation 2023/1115 on deforestation-free products.[33] Another crucial platform is the UK and Indonesia-led Forest, Agriculture and Commodity Trade Dialogue and its upcoming business platform. Other multi-stakeholder opportunities, sectoral or landscape/jurisdictional approaches can deliver impact at scale and at pace, following the examples of the Forest Positive Coalition or the Amazon Soy Moratorium, in which civil society and the private sector worked together to rapidly scale their efforts.[34] Despite these positive developments, the true positive impact for DCF can only come from the production countries themselves through strict regulation and enforcement as all other strategies may inevitably lead to freeriders and/or illegal land-use change.

CORPORATE CONSOLIDATION AND POWER IS A MAJOR BARRIER TO FOOD SYSTEM TRANSFORMATION

The role of corporate power and monopolies in industrialized food systems was frequently highlighted during the research. The implication was often that financial supports, such as subsidies and research funds, were captured by industry, and that as a result, too much focus was being given to supporting the status quo and making small incremental changes to existing systems as opposed to exploring more disruptive alternatives to the status quo.

I'd love to see a complete revitalization of public support for agricultural research. Particularly with respect to emissions reduction, sustainability and resilience and also for nutrition research. There are groups beating the drums for all of those things. But until you repurpose the Department of Agriculture and the Farm Bill toward more transformative action, I just don't think it's going to get us to where we need to be.

United States

What would need to happen, for example, is that the government would say, OK our research budgets are now this. We stop with investing all these millions and even billions of Euros yearly into [science for] the old system, and we're going to push it towards the new system.

Netherlands

There is a lot of research on new and fancy production methods and technologies but most of this doesn't work for smallholders. And so when we are talking about technology, it's not something that's really working out in rural areas.

South Africa

6.

STRENGTHENING THE SCIENTIFIC EVIDENCE FOR SUSTAINABLE FOOD PRODUCTION CAN ACCELERATE ITS ADOPTION

Strengthening the research and development opportunities with food producers, and domestic universities, to expand nature-positive food production practices that support production of healthy foods (ED1) has high potential for impact in all types except Type 1. However, barriers to scaling nature-positive production include the continued focus of many agricultural research systems on existing, green revolution, high-input farming practices and also a lack of funding support for research into the efficacy of more nature-positive types of food production.

In addition to better research and development in nature-positive food production, knowledge transfer remains a big issue, that is meaning the translation of information from researchers and universities into action on the ground and in the water.

7.

THERE ARE NO SILVER BULLETS – HIGH-TECH SOLUTIONS MUST BE BALANCED WITH OTHER ACTIONS

Adopting high-tech food production methods (TECH1) is seen to have lower potential impact than most other levers. In many countries, it is often noted that the focus for food system transformation should be less about developing new technological solutions or innovations and more about investing in low-hanging fruit solutions or social innovations, such as support for smallholders or securing land tenure. That said, some countries, including China, do display strong support for high-tech solutions.

In addition, solutions that have too narrow a focus on high-tech, production-oriented solutions – and could be construed as 'silver bullets' – should be treated with caution, as a portfolio of strategies is needed. Often, a tension exists between high-tech solutions (e.g. digital agriculture) and rights-based approaches (e.g. agroecology and food sovereignty reform). However, a better approach is striking a balance between the amplifying potential of technological solutions and the importance of social justice, equity and community empowerment. Our findings underscore the need for nuanced discussions that bridge these seemingly opposing paradigms.

China has a lot of plant-based protein foods, soy foods. For example, my hometown Xi 'an, breakfast tofu, lunch tofu, bean sprouts, dinner soy products. Soybean products are low in price and convenient in purchasing channels. We often go to vegetarian restaurants to eat, and have many choices. We do not need artificial meat. There are also many concerns about artificial meat, such as the high cost, whether the process introduces new chemical additives, and whether the taste is better.

China

8.

ALTERNATIVE PROTEINS GET ATTENTION BUT MAY NEED MORE TIME BEFORE DRIVING GLOBAL IMPACT

Surprisingly, developing alternative proteins (TECH3) was ranked as one of the lowest potential levers. This lever is defined as protein sources such as plant-based and cell-based meat alternatives that are high in nutritional value. Despite their widespread mention in global narratives surrounding promising transformation potential, alternative proteins were conspicuously absent from all but one (Netherlands) country's top 10 ranked levers.

Lab-grown solutions have been described as being in conflict with promoting traditional foods and increasing diversity. Poverty and cultural factors were also raised as critical when discussing the reduction of meat consumption. Even for the Netherlands, where alternative proteins are a high potential lever, there is still scepticism about their overall potential for food system transformation.

In the Philippines and China, there is widespread scepticism or opposition to lab-grown meat alternatives. In China, meat alternatives were described as an unnecessary innovation given the wide variety of plant-based proteins already in existence, while fisheries are seen as being a bigger priority in the Philippines.

CHAPTER 4

THE ROLE OF INNOVATION IN CLOSING THE STRATEGY GAP

Humans are an inherently innovative species. Innovation comes in many forms, from creating new tools or science and technology, to finding creative new approaches with solutions already in hand. In food systems, innovation can occur in a variety of settings, from research laboratories to rural communities, and can take many forms, from changes in infrastructure to business models, finance, new cultural practices and new policies or legislation (Figure 8). Following the 2021 UN Food Systems Summit, widespread action is being taken to accelerate public and private-sector funding for sustainability-focused innovation, at a scale never before attempted for food systems. [35]

However, innovations alone won't be enough to achieve a healthy and sustainable food system for all. Innovations are catalysts that can accelerate national-level food system transformation by helping to amplify the impacts of actions.

In a high-stake, high-uncertainty environment, a strategic and collaborative approach to selecting innovations is crucial. Potential innovations abound, but at this time there is limited robust scientific evidence that many proposed innovations can effectively transform food systems to achieve our environmental and health goals. Even where there has been research, it can be difficult or misleading to assume that what works in one place will work in the same way elsewhere. Local knowledge and expertise are essential to ensuring that innovations will have the greatest impact for both people and the planet.

Nevertheless, we need to act. Given the urgent and high stakes race to solving global problems, a rigorous place-based approach is needed to identify the **Right Innovation** with the **Right Impact** in the **Right Place.** [2]

RIGHT INNOVATION

means choosing innovations that amplify the impacts of transformation levers and ideally can be applied to affect one or more levers to accelerate change

RIGHT IMPACT

means anticipating the kind of change and impact any proposed innovation might have in a particular place

RIGHT PLACE

means paying close attention to the social and ecological context in which the innovation is to be implemented

The **Right Innovations** are those that can amplify the impact of a specific action or one of the 20 transformation levers (Figure 8). For example, if your goal is healthy diets for all citizens in a country, then one action might be to provide financial incentives to improve consumption of healthy foods. A financial innovation, such as a consumer tax on junk food/ultra-processed food,[36] can help to amplify the impact of your action. In another case, the goal might be to reduce food loss and one action might be to develop infrastructure to address food loss. A technological innovation to amplify this action might be to apply new post-harvest storage technologies.

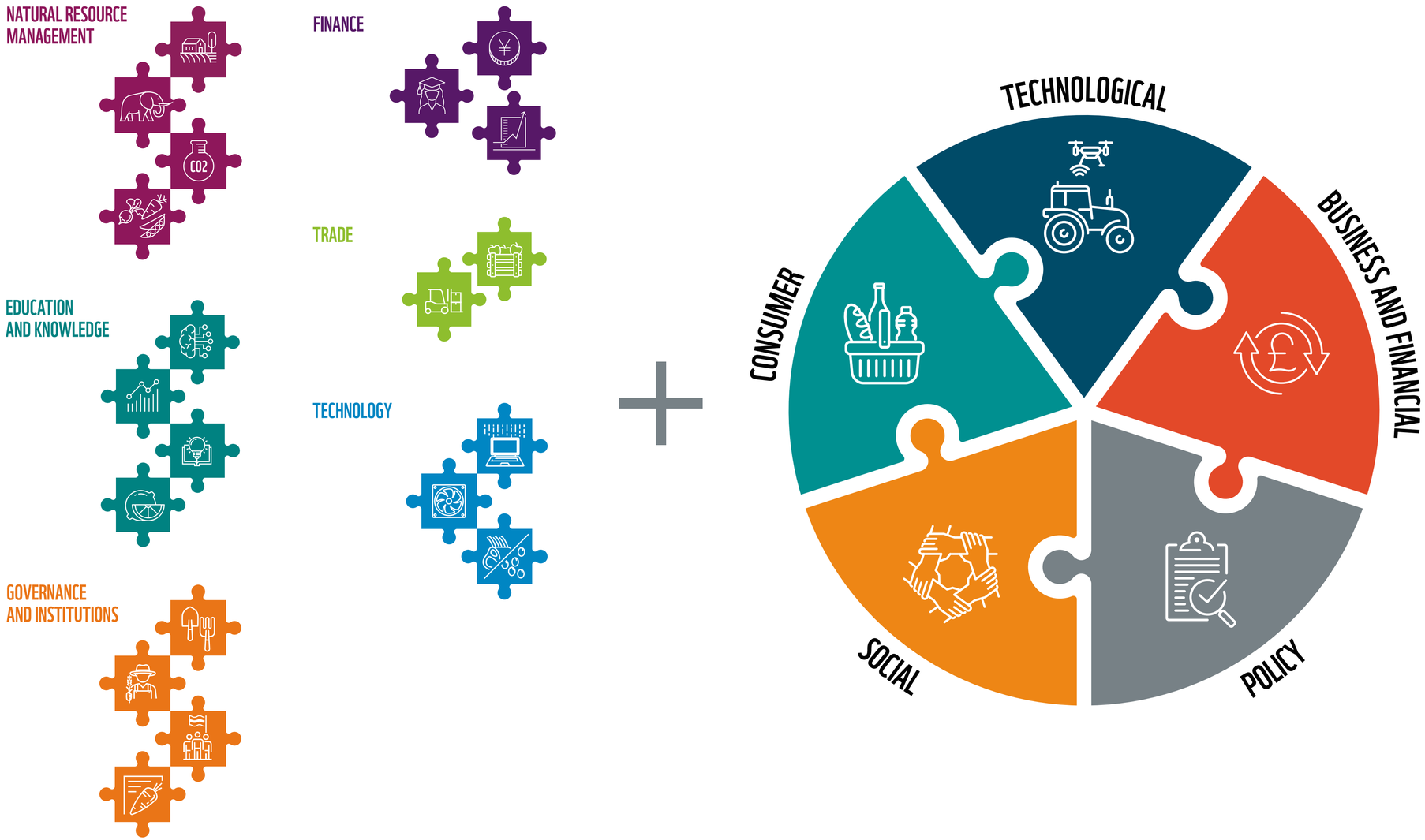

Figure 8.

Innovations can take many forms including social, consumer, technological, business and financial, and policy innovation. When the right innovations are paired with the highest impact action levers in a country, they can greatly amplify and accelerate the impact of that lever. It's likely that this will only be achieved by pursuing a suite of innovations that work together in different parts of the food system and society at large.

I am excited about the technology revolution in agriculture that might create a more open and equitable system. Big data is a great innovation.

China

The other major issue is whatever innovation happens in the country, like crops that are drought resistant or those that will survive in saline environments and waterlogged areas, never gets down to the farmers. So there is a huge gap between the innovation and research and development, and then bringing it down to the people who are most affected.

Pakistan

The **Right Impact** means anticipating the kind of change and impact any proposed innovations might have in a particular place. Do they sustain or disrupt the existing food system, and are they expected to make smaller refinements or major changes (Figure 9). Sometimes, disruptive innovations with path-breaking impacts may be needed in food systems that are entrenched, hard to change and very unsustainable. Other times, sustaining innovations with incremental impacts may be needed in food systems that are less entrenched and more sustainable.

The **Right Place** means paying close attention to the social and ecological context in which the innovation is to be implemented. This is outlined in detail in Chapter 2 on Food System Types. What is yet to be determined is whether innovations act in a similar way to the transformation levers, that is, if innovations have a similar impact in different Food System Types. Our hypothesis is that they will perform in a similar way, yet this question remains to be answered. Boxes 2 and 3 highlight two case studies that outline the relationship between the transformation levers and different types of innovation to amplify change.

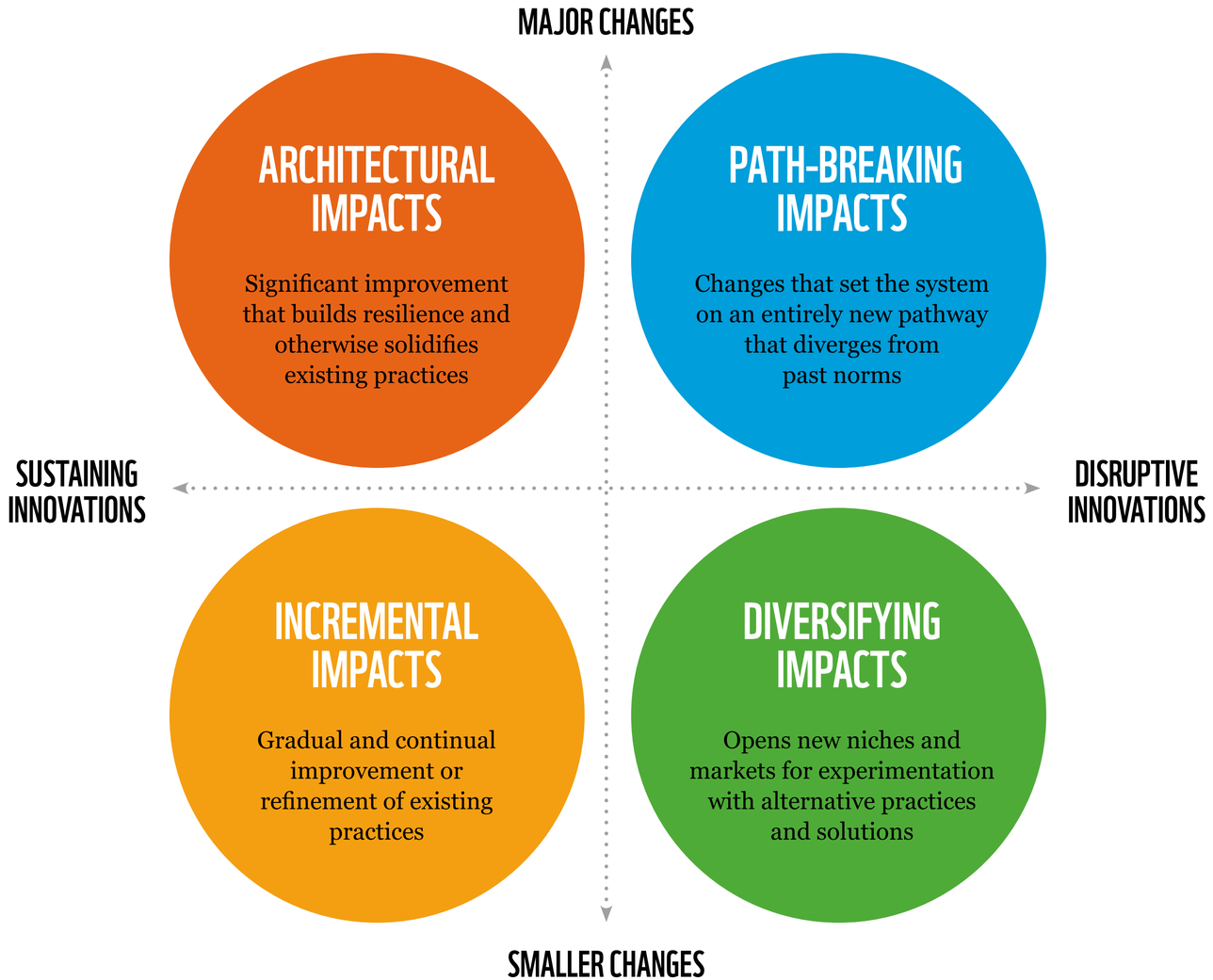

Figure 9.

Innovations can create different kinds of impact, either sustaining or disrupting existing ways of doing things and creating space for something new to emerge. These impacts can be smaller and introduce new ideas or approaches to already sustainable practices, or they can be major, representing investments in the architecture and infrastructure of existing systems or completely reorienting people's practices, habits and goals.

BOX 2

ADOPTING NATURE-POSITIVE PRACTICES AND INCREASING SUGAR YIELDS

COUNTRY:
Pakistan

LEVERS:
Optimize land use

TYPE OF INNOVATION:
Social

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Pakistan is the fifth largest sugarcane producer in the world with an annual production of 81 million tonnes sown on an area of 1,040 thousand hectares. Small-scale farmers account for around 64 percent of sugarcane cultivation but they face multiple challenges including the high cost of inputs, water scarcity, non-availability of high-yielding varieties, diseases, pests, weeds infestation, and marketing issues. Using brokers to sell harvests to millers often prevents farmers from getting a fair price and can even lead to delays in payments. As a result, Pakistan has low sugarcane productivity (yield per hectare) compared to the global average, 46 tonnes compared to the global average of 60 tonnes, and lower recovery of sugar from the cane, compared to major cane-growing countries.

Sugarcane producers are further threatened by climate change. Pakistan has been ranked the fifth most vulnerable country to climate change in the Global Climate Risk Index. Studies have shown that the yield of sugarcane decreases by 10 percent for every 1°C temperature increase. Smallholder sugarcane farmers are hit hardest by these impacts due to low adaptive capacities.

To minimize the impacts of climate change, build resilience and sustainably increase yields, WWF-Pakistan worked with smallholder farmers to increase the adoption of nature-positive production practices. Through Farmer Field Schools, in which groups of smallholder farmers work together and 'learn by doing', 2100 smallholder farmers received daily training on sowing techniques, the efficient use of water, usage of natural insect control agents, harvesting, storage and transportation to the mill.

The improvements in land preparation and irrigation, and reduction in synthetic inputs, led to lower input costs, larger and higher quality yields and increased profits. Across farms, 25% less fertilizer and 10% less pesticides were applied. The amount of water used for irrigation also went down by 25%. Input costs decreased by more than 35% and crop productivity increased by 12%, with some farmers reporting increases as high as 40%.

KEY LEARNING

Practical training and supporting farmers to learn new skills by implementing them in demonstration plots is more effective than theoretical or 'classroom' training alone.

BOX 3

INCREASING THE CONSUMPTION OF HEALTHY, INDIGENOUS, UNDER-USED FOODS

COUNTRY:
Mexico

LEVERS:
Increase public awareness

TYPE OF INNOVATION:
Consumer

More than 100 ingredients central to the global diet originated in Mexico, yet the diversity of iconic endemic products like corn, beans, chilli peppers, and squash has fallen in the past fifty years. Globally, we rely on just 12 plants and 5 animals for 75 percent of our food, with our reliance on genetically uniform crops threatening biodiversity and reducing resilience to disease and climate change. At the same time, as much as 40 percent of all food produced globally is lost or wasted. Mexico wastes an average of 94 kg of food per person annually, higher than the global average of 74 kg, contributing to climate change and overexploitation of natural resources. Low public awareness of both the value of biodiversity and impact of food production contributes to consumer behaviour.

In 2019, WWF-Mexico launched the **#DaleChamba** campaign to spotlight the critical connection between Mexican gastronomy and biodiversity. Recognizing that biodiversity loss poses a threat to Mexican cuisine, which is UNESCO Intangible Cultural Heritage, the campaign focused on endangered ingredients. Collaborating with renowned chefs, cooks and leading gastronomy faculties, it gained widespread popularity with engaging visuals and the slogan “Dale Chamba” (“give him/her a job”). In 2020, the campaign expanded its scope to tackle food waste, evolving into an educational initiative that included university courses designed to change behaviour. It aimed to empower youth leadership in finding solutions, particularly among students of gastronomy, hospitality, tourism and communication.

The #DaleChamba campaign effectively reached 68 million people in just a few months. This achievement facilitated enduring partnerships with universities, chefs and traditional cooks, while catalyzing the launch of projects with more ambitious objectives. These initiatives focus on empowering youth, promoting environmental education and utilizing social marketing and psychological strategies to drive behavioural change. In 2023-2024, the campaign partnered with Unilever to advocate for healthier diets that benefit both people and the environment, highlighting endemic ingredients known for their high nutritional value and minimal environmental footprint. Universities, cooks and chefs joined the effort by contributing recipes that are also an exercise in combining culinary traditions and gastronomic innovation.

KEY LEARNINGS

- Raising public awareness of biodiversity challenges requires engaging language and visual elements that relate to people’s everyday lives and can evoke different emotions - technical and scientific language isn’t enough.
- Food is not only central to biodiversity protection and climate change mitigation, but also a topic that helps connect with large audiences who are not interested in environmental issues

We need science that can deal with high levels of chaos, but the South African academic sector is very conservative and capacity for research on agricultural innovation is very low.

South Africa

CHAPTER 5

IT'S NOT QUITE SO SIMPLE - DIFFERENCES EXIST

Food systems are complex, and global- or country-level data can only get us so far when trying to make sense of that complexity. The *Great Food Puzzle* typology reduces some of this complexity by clustering countries into Food System Types (Figure 4) based on their similarities and differences across a number of social and environmental variables (Table 1). And yet, even with these clusters, the place-based nature of food systems challenges still makes it difficult to say, with certainty, that an action lever will have the same impact in countries in the same Food System Type.

From the analysis done for the *Great Food Puzzle* over several years, important lessons have emerged: that there can be similarities in high-impact levers across Food System Types (Table A4.1 in Appendix) and, in some cases, important differences between countries within the same Food System Type.

Given this, in addition to the quantitative data used to develop the Food System Types, we also need to lean into the contextual knowledge of experts, who can apply that knowledge to think about key actions in the context of local food systems and their histories, politics and culture. There are also opportunities for experts from different countries to learn from each other. By looking not just at the objective data classifications of food systems but also looking for patterns in expert rankings of various action levers, we can identify learning cohorts – pairs or clusters of countries that may benefit from learning from one another's experiences. However, sharing similar expert rankings on one or more categories of levers does not mean that people's experiences with those interventions will be identical, but that there may well be shared aspects worth exploring and learning from.

SIMILARITIES ACROSS FOOD SYSTEM TYPES

Environmentally and socially, food systems in India (Type 3) and South Africa (Type 4) are significantly different. However, we also heard from experts that they both are deeply divided, with inequities and starkly different circumstances facing wealthy large-scale farmers and smallholders. In India, this split is a legacy of the Green Revolution, which benefited wealthy farmers but had tremendous negative impacts on smallholders. Wealthy farmers had better access to the high-yield varieties as well as fertilizers and water, leading to increased productivity and income. In contrast, smallholders often lacked the resources to adopt these new methods. In South Africa, the split is a legacy of apartheid and land policies that concentrate land and resources in the hands of a small number of wealthy farmers. Today, smallholder farmers in both nations face land tenure insecurity, challenges with irrigation and water access, and have limited access to credit and extension. Despite other noteworthy differences that result in them being classed in different Food System Types, there may be opportunities for decision makers and experts in these two countries to learn from one another's experiences using education, governance and finance strategies to support smallholders and mitigate the continued challenges created by these histories.

DIFFERENCES WITHIN FOOD SYSTEM TYPE

Restoring biodiversity (NRM2) does not rank highly for all the nations in food systems Type 3. Whereas Kenya and Pakistan experts rank the lever high, it ranks much lower for experts in India. This may be driven by contextual issues related to current land use and politics surrounding development and ecosystem restoration – in a general sense

it illustrates the caution that needs to be taken when applying Food System Type insights described earlier. A similar challenge is seen for addressing land tenure (GOV2). In Food System Types 3 and 4 you see single countries, Kenya and South Africa respectively, where experts differ from the pack by ranking this lever in the top quintile.

LEARNING COHORTS

Enter our notion of learning cohorts: there may be cases, such as with Kenya and South Africa, where similarities with respect to one or two levers may indicate an opportunity for learning and collaboration among countries of different food systems types. Other examples include the shared support for strengthening national commitments (GOV3) in Food System Type 5 and the UAE in Type 4, support for supply chain innovations (TECH2) for Food System Types 2, 3 and 4, and nearly across-the-board support for consumer-facing education (ED3). Experts working with specific levers are encouraged to use Table 6 to identify other nations where similar opportunities exist as there may be opportunities for shared learning.

Table 6.

Learning cohorts divided by Food System Type. Learning cohorts are groups of countries whose Food System Types are similar where there may be opportunities for learning and collaboration around solutions for food system transformation.

Food system types					
Type 1	Type 2	Type 3	Type 4	Type 5	Type 6
Learning Cohort 1					
	Learning Cohort 2				
		Learning Cohort 3			
			Learning Cohort 4		
				Learning Cohort 5	

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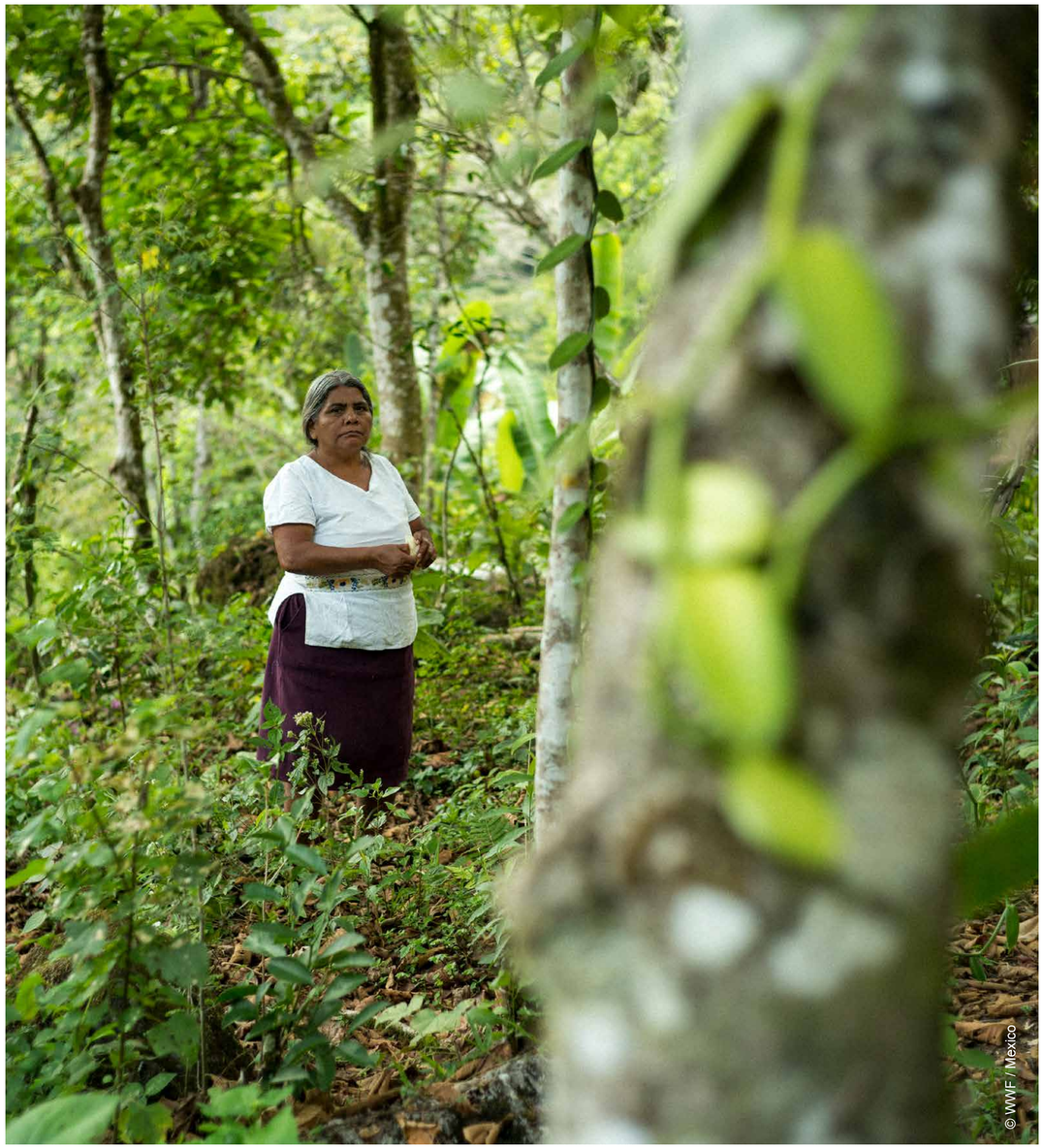
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CHAPTER 6

HOW TO USE THIS REPORT TO CLOSE THE GAPS

In a high-stake, high-uncertainty environment, a strategic and collaborative approach to selecting actions that will have the highest impact in the shortest time possible is crucial for achieving health and environmental goals. Potential actions abound, but selecting those that will truly help to transform a food system is difficult, especially given the overwhelming complexity of food systems. The *Great Food Puzzle* is designed to make this process easier for anyone working on food system transformation by reducing this complexity and offering all stakeholders a starting point. This report is not intended to be prescriptive and should not be used in that way. Local knowledge and expertise will always be the most important resource to ensure that actions taken will have the greatest impact for both people and the planet.

SIX STEP APPROACH FOR OPERATIONALIZING THE GREAT FOOD PUZZLE

Operationalizing the *Great Food Puzzle* can be done at various scales, including the country or landscape levels. Figure 10 outlines the steps that should be considered when using the *Great Food Puzzle* at either the country or landscape level. These steps will work for a wide range of stakeholders, from policymakers to business to civil society organisations and funders.

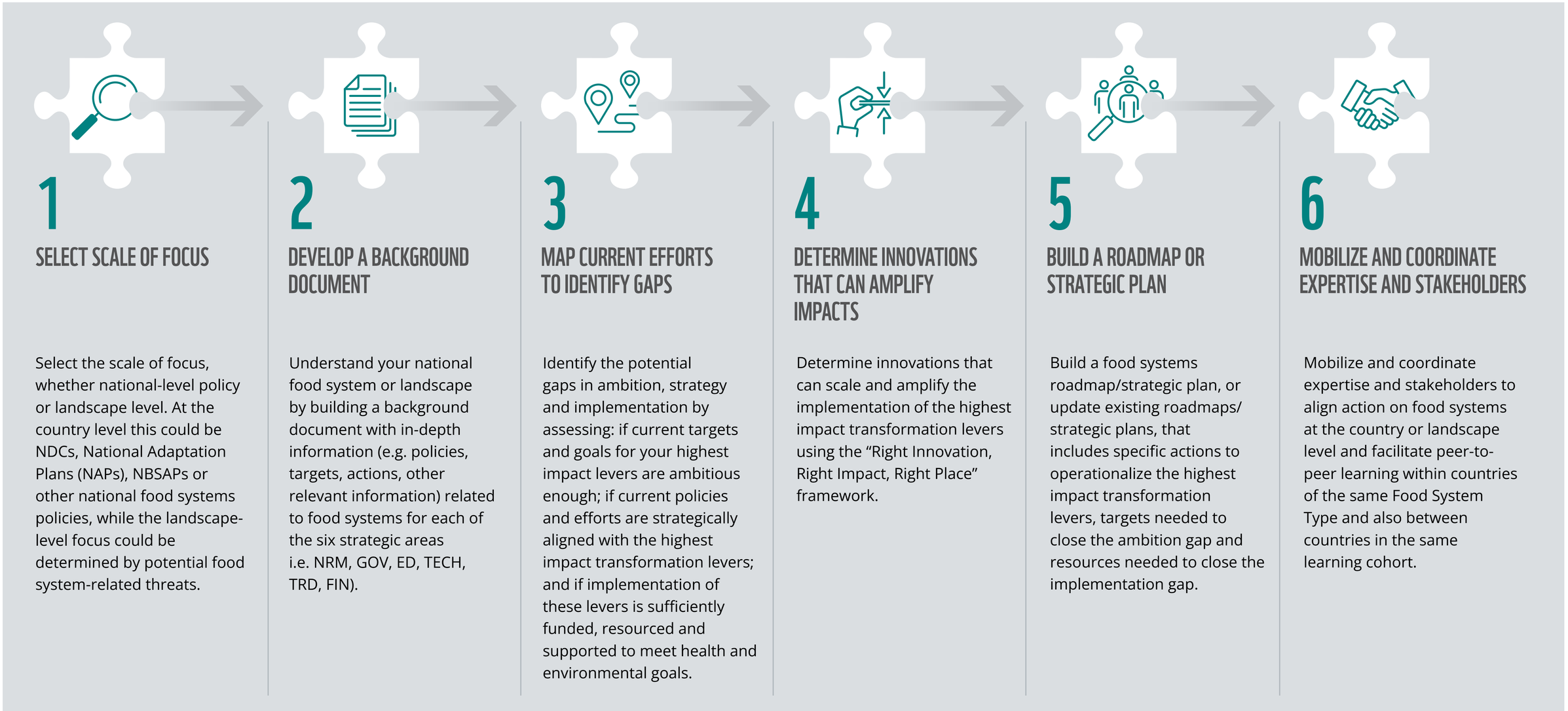


Figure 10.

A six-step approach to operationalizing the *Great Food Puzzle*. This suggested approach can be used by a variety of stakeholders and in either countries or landscapes.

IDEAS FOR HOW VARIOUS STAKEHOLDERS CAN USE THIS REPORT:

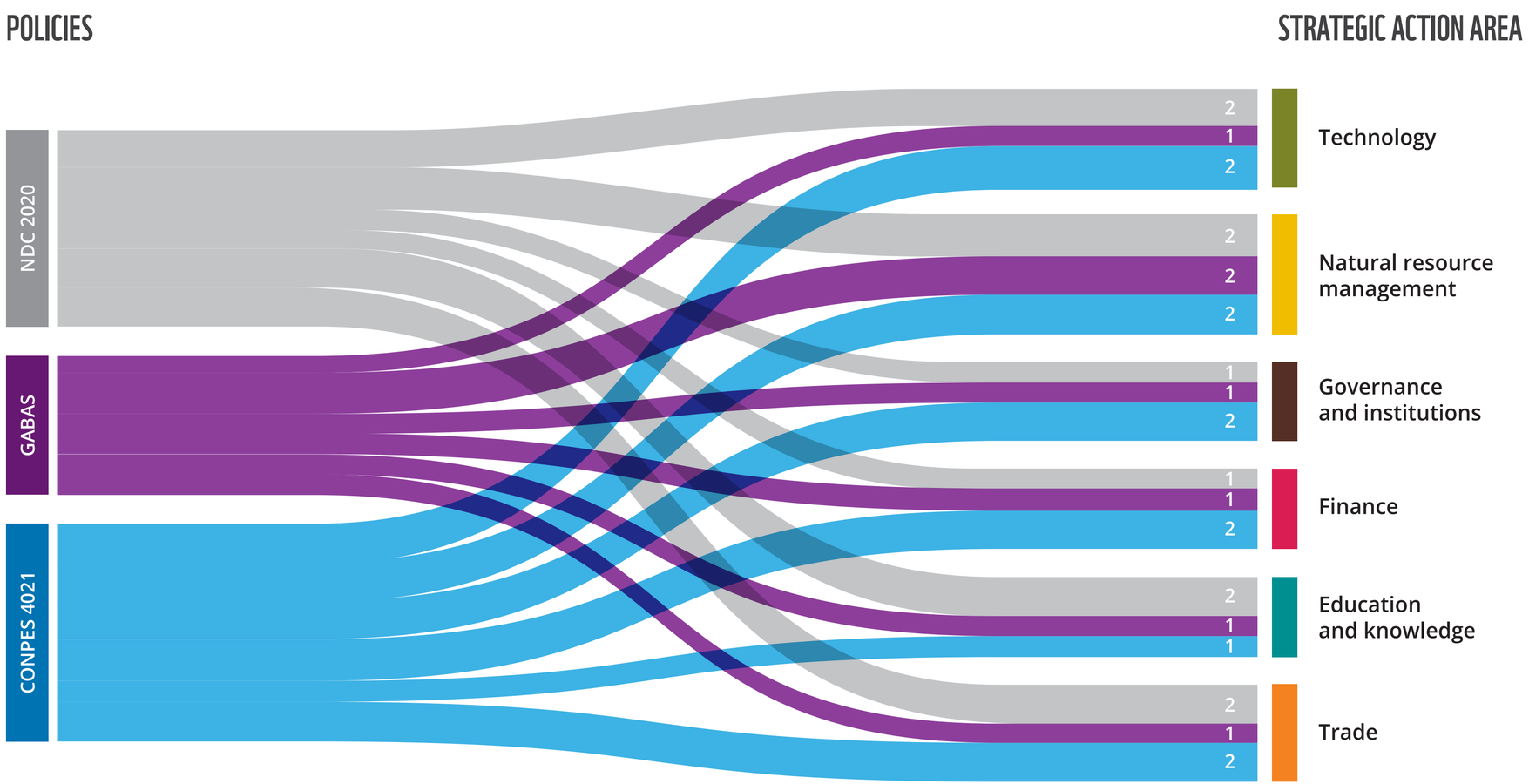
1.
POLICYMAKERS

can use this report to assess consistency between existing policies and the highest impact actions in climate, biodiversity and health plans. This includes assessing consistency of various policies across the six strategic areas and then identifying the highest impact actions for the entire food system when NDCs, NAPs, NBSAPs and any other relevant national climate and biodiversity policies. Figure 11 is an example of how national policies can be measured for policy consistency and strength for each of the six strategic action areas. For example, a policymaker can test whether their current NDCs or National Dietary Guidelines use a food systems approach and are robust (i.e. effectively advance) across all 20 transformation levers.

Figure 11.

Consistency of various national policies in Colombia across different strategic areas. Policy Consistency: 2 Strong. 1 Weak/Neutral. 0 Omitted. Nationally Determined Contributions (NDCs); National Policy for Deforestation Control and Sustainable Forest Management (CONPES 4021); Food-Based Dietary Guidelines for the Colombian Population over Two Years of Age (GABAs).

(Source WWF Colombia and Alliance Bioversity International)



2.
BUSINESS & FINANCERS

can use this report to ensure that investments in food system transformation are made on the highest impact transformation levers in the countries where they are present. This will ensure that investments are strategically targeted to deliver the most impact in the shortest time possible.

3.
INNOVATION LEADERS

can use this report to help identify the right innovations that will help to amplify the highest impact transformation levers in a given Food System Type. Using the "Right Innovation, Right Impact, Right Place" framework will help guide businesses and financers when deciding which innovations to invest in.

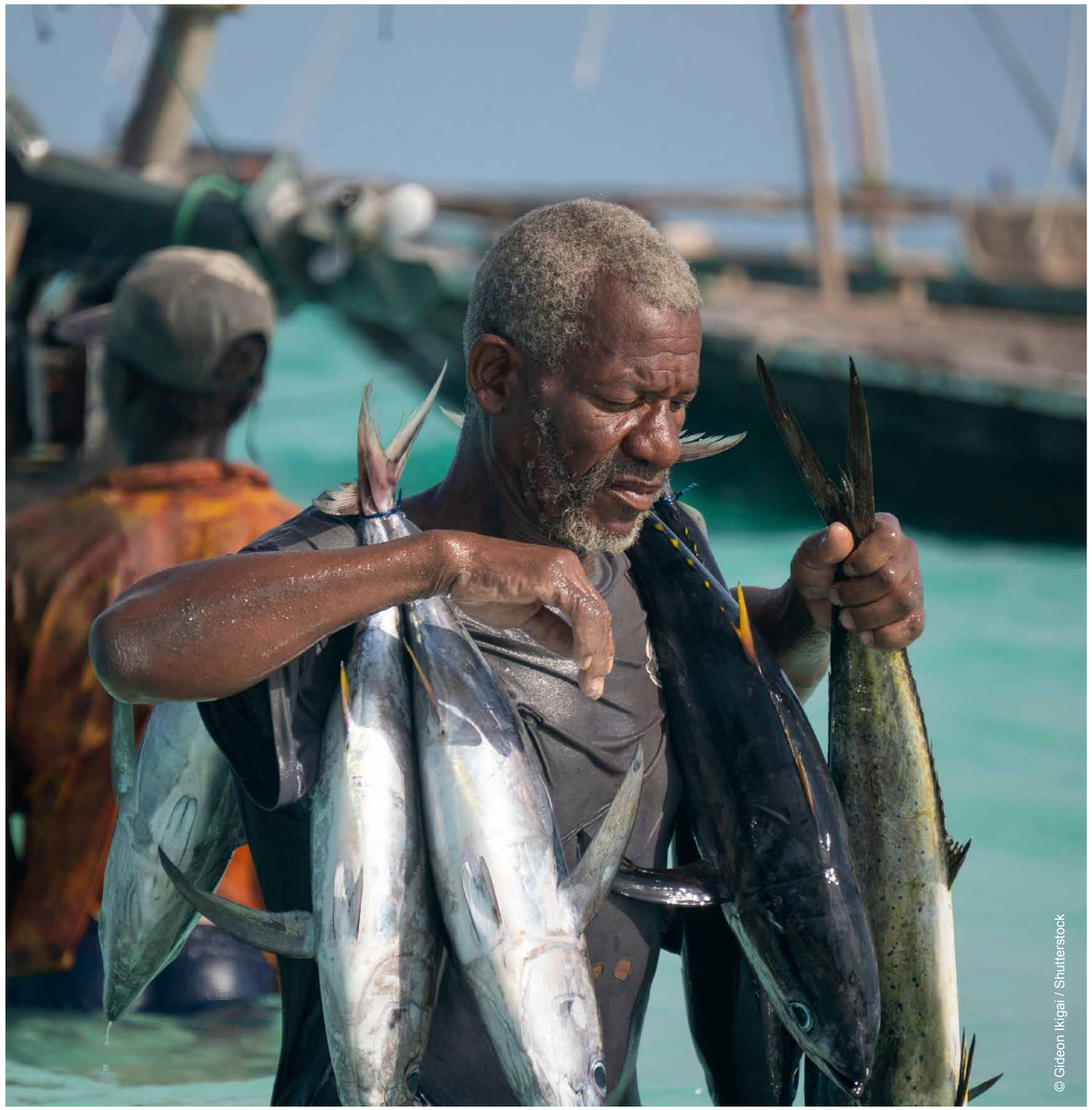
4.
NON-GOVERNMENTAL ORGANISATIONS

can use this report to help co-create food system roadmaps and projects in countries that focus on actions that will have the greatest impact in the shortest time possible. This report can also help guide NGOs in better integrating food systems in all climate and biodiversity conservation targets and goals in countries where the NGO is present. This includes more alignment on how conservation goals (e.g. tiger conservation) are connected to actions on food systems.

5.
INDIVIDUALS

can use this report to advocate for policies that have the most impact in their country. This report can serve as a guide for identifying key levers of action depending on a country's Food System Type. This will help to ensure that mobilized action will have the most impact depending on local context.

While the stakes for rapid food system transformation are high, there is no shortage of energy and support for action. But we need to avoid the mistakes of the past and avoid solutions that are designed without attention to local needs, rights or control. Food systems transformations must happen from within. Implicit in the *Great Food Puzzle* framework is an acknowledgment of the importance of self-determination and collaboration in determining the future of food, and humanity, on this planet.



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APPENDICES

APPENDIX 1
CAVEATS AND LIMITATIONS

1. **There are limits to a national-level approach to food system transformations.** Thinking of food systems at the national level can help reveal important insights about the role of national policy in food system transformations. However, there are important limitations to this approach, both in failing to capture *intra-country heterogeneity* and also the *globalized nature* of food systems.

    a. **First, food policy also needs to account for sub-national variance in food systems within each country.** Just as there is considerable variation between the food system challenges, solutions and trade-offs *between* countries, so there exists considerable variation within each country. Some stakeholders in each country think about multiple food systems *within* their focal countries, based on sub-regions that have very different characteristics. So, while researchers and others are correct to point to the limitations of a global-level analysis of food system needs, that does not make a national approach a perfect level of analysis.

    b. **Second, national food systems are part of a globalized food system.** No country is completely food self-sufficient or independent, nor is it clear that that would be a desirable goal in terms of food security or environmental goals. Some foods grow optimally in other parts of the world, and are better transported from one country to another. When analyzing food system transformations as we do here, it is important to remain cognizant of the complex and necessary global trade (both imports and exports) and reliance on other countries.

2. **The use of a food systems typology is promising and still in the early stages of development.** There is an important need to reduce the analytical complexity of identifying policy actions that are needed to improve both human health and environmental sustainability in countries around the world. Many stakeholders ramping up efforts to work with individual countries to transform various aspects of their food systems and a shared framework for doing so would help to facilitate these efforts. We encourage all stakeholders to help in the efforts of building a robust global food systems typology and identifying a set of key levers that work across countries.

3. **Expert bias may exist which would influence the final results.** The analysis for the Great Food Puzzle relied heavily on experts from each country. The selection of experts was done with great care to ensure that a broad and representative range of stakeholders were consulted to ensure an appropriate representation of the food system for each country. Despite this careful selection of a diverse set of respondents, each expert may have biases that could impact the final results of this study.

APPENDIX 2
METHODS & ANALYSIS

Research for this report involved mixed methods, including an expert survey, key informant interviews and workshops or extended questionnaires where interviews were logistically unfeasible. Our goal was to elicit expert sentiment about food systems transformation in their nation, as well as perceptions of the potential impacts of, and strength of science behind, 20 food system transformation levers (Table 3). The 20 levers are a peer-reviewed subset of those identified by Hawkes et al. (2020), for the initial *Great Food Puzzle* report.

Eight WWF country offices opted into this project: China, India, Mexico, the Netherlands, Pakistan, Philippines, South Africa, and the United States. Working with WWF leadership in each country office, we first identified key resources describing the food systems and food systems challenges in each nation. Country leadership also identified lists of candidates for distribution of the survey and for one-on-one interviews.

The survey was deployed in two rounds and made available in English, Spanish and Cantonese. Questions included four designed to elicit expert sentiment about overall progress in their nation towards food systems transformation as well as three additional sentiment questions related to ambition, strategy and implementation.[9] Additional questions asked respondents to rank their understanding of the potential impact and strength of science in support of the 20 transformation levers using Likert scales. A second, follow-up survey asked respondents to further prioritize the top 10 levers for their country as found in the first round with a budget-allocation method–allocating $100USD in any way they saw fit across the top 10.

Basic statistical methods for comparison and correlation were used, such as Spearman's correlation for Likert items, ANOVA to identify between-country variance in responses, and dendrogram cluster analysis to support the identification of learning cohorts. For the expert sentiment index (ESI), we first checked for reliability using Chronbach's alpha test of agreement among the four candidate variables. The ESI was calculated as a simple average of the four likert rankings, and performs well (α=0.9035).

To calculate rankings for the potential impact and strength of the science for each lever, we standardized (z-score) the coefficient of variation (calculated as the ratio of the standard deviation to the mean) for the average values for each country (for within-country rankings) and across all countries (for global rankings).

Interviews were conducted one-on-one, or in some cases in pairs to expedite scheduling. Interview questions followed a shared template for all nations, but some questions were tailored to highlight and probe around specific country-level findings in the Round 1 survey (Table A3). Interviewers had discretion to ask follow-up or adjust questions in response to interviewee responses. For China, our local partners preferred that we send the interview questions as a follow-up questionnaire to be answered textually. In the Philippines, logistical challenges such as access to reliable internet made it preferable to instead hold three workshops with Round 1 survey participants.

Details on our full sample can be found in Tables A4 and A5.

Qualitative thematic analysis was facilitated by the MaxQDA v24 software package. Interview transcripts were coded deductively for discussion of the 20 levers and four dimensions of expert sentiment, and also inductively for emergent themes. MaxQDA's built-in sentiment analysis and AI assist features were also used to further identify statements of positive or negative sentiment and elicit further sub-themes.

Table A2.1.
Round 1 Survey Questions.

Question	Type	Details
Please rate your agreement or disagreement with each of the following statements.	5 item Likert, Strongly Agree to Strongly Disagree	• Current policies in my country are ambitious enough to meet climate, biodiversity and health goals • The solutions currently being implemented in my country will be effective for solving the problems we face • The solutions currently being implemented in my country have the resources they need to succeed • The food system in my country is on track to meeting critical goals for health and the environment by 2030
What parts of the food chain are seeing the most activity with ongoing and new projects in your country? Drag the following statements into your preferred order, from most active to least active.	Rank order	• Production • Food loss and waste • Diets and nutrition
WWF has identified 20 transformation levers which will likely need to be applied across all types of food systems to achieve goals for environment and health. These levers span the three action areas of food systems transformation - shifting to healthier and more sustainable diets, reducing food loss and waste, and adopting nature-positive production practices at scale. In the next series of questions we will ask you to reflect on the potential of these transformation levers for creating major changes in your country's food system.		
Please rate the potential of each of the following [LEVER CATEGORY]-oriented actions to create major changes to food systems in your country.	5 item Likert (Highest Potential to Lowest Potential)	Broken down into sections for each of the lever categories, full description of lever offered Order of presentation of the categories was randomized.
How strong is the evidence (published science, ongoing trials, etc.) in support of these [LEVER CATEGORY-oriented strategies in your country?	3 item Likert (Weak, Average, Strong)	Presented for the levers in the lever category previously answered.

Table A2.2.
Survey Round 2.

Imagine you had to pick the most impactful solutions from the following list of 10, based on your understanding of their potential impact and the strength of the science behind them. You have $100 to allocate as you see fit. You can spread it out however you like, whether putting all 100 on one item or spreading it across several. But in the end you have to spend all $100. [Option order was random]
[List of top 10 levers for potential impact as identified in round 1, randomized] $_____
Total was automatically calculated and respondents were required to spend all $100.

Table A2.3.
Interview guide template, United States (US) example.

Q1.	Tell me/us a little bit about your background and experience with food systems.
Q2.	What do you think are the top 1 or 2 issues in food systems in your country that need immediate attention if your country is to meet health and environmental goals in line with international commitments (e.g. Paris Agreement)?
Q3.	What ongoing initiative or new innovation excites you most as having potential to transform your country's food system to meet health and environmental goals in line with international commitments (e.g. Paris Agreement). Why does this ongoing initiative or new innovation excite you?
Q3b.	Is there anything holding this initiative/innovation back? Any barrier that needs to be addressed?
Q4.	What do you think people get wrong when they think/talk about how to achieve transformative change in your country's food system?
Q5.	In the survey, US experts identified production innovations–and in particular those that optimize land use–as having the most potential for impact over other social levers. How do you interpret this finding of the survey?
Q5b.	A related question is why do you think these production-side innovations received more support than demand-side innovations?
Q6.	Another interesting finding was that transformation levers that promote more systemic and rights-based solutions, for example through empowering Indigenous communities, reforming land tenure, and increasing smallholder support were received less favorably, both in terms of their potential and the strength of science supporting their effectiveness. How do you interpret or respond to this finding?
Q7.	Where do you think new science could be most helpful in advancing food systems transformation in your country?
Q8.	Is there anything we haven't talked about that you think is important to add to this conversation?

Table A2.4.

Details of number and gender of experts during each round of the surveys and interviews.

Nation	n*	Gender †	Notes
China	23;17;9	12;11;0	Written responses submitted to interview questions
India	31;18;9	6;25;0	
Mexico	48;15;7	22;26;0	Interviews completed in English and Spanish
The Netherlands	25;17;9	10;15;0	
Pakistan	20;13;7	6;12;2	
Philippines	43;22;28	26;17;0	Interviews held as workshops
South Africa	18;10;7	3;15;0	Small sample
United States of America	29;19;9	10;19;0	

* reported as: Round 1 n; Round 2 n; Interview n;
† reported as F;M;other/unspecified

Table A2.5.

Sector representation of experts for each round of the survey and interviews.

Industry	Round 1	Round 2	Interviews
Civil Society Org	40	21	15
Environmental NGO	40	28	10
Government / Policy	29	13	11
Private sector	33	12	14
Producer & producer orgs	20	13	11
Scientific body	13	9	3
University	49	35	17
Other / Unspecified	7	0	5

Table A2.6.

Sector representation of experts by country for round 1 of the survey.

Industry (Round 1)	China	India	Mexico	Pakistan	Philippines	South Africa	USA	Netherlands
Civil society Org.	6	7	3	4	7	2	8	4
Environmental NGO	1	3	2	4	10	4	10	4
Government/policy	1	5	5	3	12	2	0	3
Private sector	5	8	5	2	4	3	4	2
Producer & producer Orgs	0	4	7	2	3	2	2	2
Scientific body	3	1	4	1	0	2	2	1
University	5	2	21	9	5	3	3	9
Other/unspecified	2	1	1	0	2	0	0	0
Total	**23**	**31**	**48**	**25**	**43**	**18**	**29**	**25**

Table A2.7.

The scaled cluster centres of each Food System Type in the seven-variable space, with values representing standard deviations away from the mean (0) value of the variable for all countries.

Food System Type	Environmental performance	Self Sufficiency	Biodiversity Hotspot	Irrecoverable carbon	Food Security	Water Risk	Industrialization
1	-0.15	-0.11	0.27	2.35	0.01	-1.15	0.26
2	-0.72	-0.44	1.52	-0.11	-0.54	0.00	-0.84
3	-0.62	-0.21	-0.58	-0.49	-0.97	0.16	-0.87
4	0.42	-0.26	0.02	-0.58	0.74	0.98	0.75
5	1.42	0.08	-0.64	0.75	1.20	-0.74	1.16
6	0.06	2.63	-0.76	-0.50	0.69	-0.51	0.95

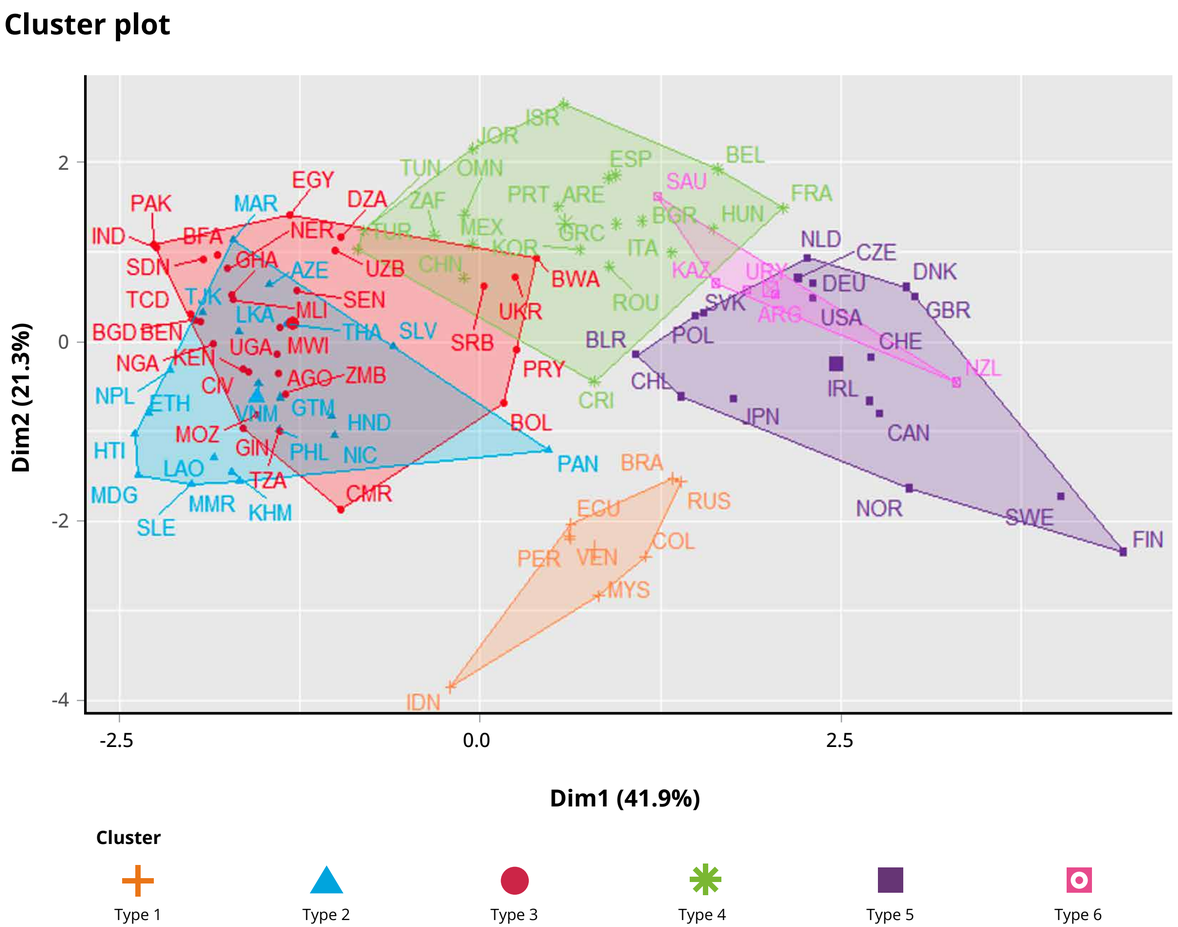

Figure A2.1.

Food System Type clusters plotted in multi-dimensional variable space. Each food type cluster centre is represented by a different large symbol and individual countries are plotted within food type clusters, indicated by small symbols and labelled with ISO code. Colour coding for each Food System Type are: 1 - orange, 2 - blue, 3 - red, 4 - green, 5 - purple, 6 - pink.

APPENDIX 3 - ALIGNMENT OF TRANSFORMATION LEVERS WITH EACH OF THE GOAL AREAS

Table A3.1.

Examples of how each of the 20 transformation levers are most aligned with the goal areas of Nature-positive production, Healthy diets and Reducing food loss and waste.

	Transformation lever	Nature positive production	Healthy diets	Food loss and waste
Natural resource management	Optimize land use (NRM1)	√	√	√
	Restore biodiversity (NRM2)	√		
	Increase carbon storage (NRM3)	√		
	Increase food and agri-diversity (NRM4)	√	√	
Governance	Support smallholders (GOV1)	√		
	Improve land tenure rights (GOV2)	√		
	Strengthen commitments and implementation (GOV3)	√	√	√
	Foster multi-stakeholder collaboration (GOV4)	√	√	√
Education and Knowledge	Strengthen, science, research & development (ED1)	√	√	
	Improve data collection and measurement (ED2)	√	√	√
	Increase public awareness (ED3)	√	√	√
	Promote sustainable, healthy, traditional foods (ED4)	√	√	
Technology	Adopt high-tech methods (TECH1)	√		√
	Develop supply chain infrastructure (TECH2)			√
	Develop alternative proteins (TECH3)	√	√	
Trade	Support healthy food imports and exports (TRD1)		√	
	Develop deforestation and conversion-free supply chains (TRD2)	√		
Finance	Redirect subsidies and increase de-risking investments to improve production (FIN1)	√	√	
	Finance school food and public procurement programmes (FIN2)	√	√	
	Provide financial incentives and taxes to improve consumption (FIN3)		√	

APPENDIX 4 - COUNTRY LEVEL RESULTS

Table A4.1

Country-level results of the potential of individual action levers to transform different Food System Types, ranked from higher (dark green) to lower (light green) potential as identified by food system experts in the countries that were part of this study. Ecological food system hotspots are also ranked for each Food System Type. Shaded countries are those that tend to straddle two different Food System Types.

Strategic action areas	Transformation levers	Type 1		Type 2	Type 3			Type 4				Type 5	
		Colombia	Brazil	Philippines	Kenya	Pakistan	India	South Africa	Mexico	China	UAE	USA	Netherlands
Natural resource management	Optimize land use (NRM1)												
	Restore Biodiversity (NRM2)												
	Increase carbon storage (NRM3)												
	Increase food and agri-diversity (NRM4)												
Governance	Support smallholders (GOV1)												
	Improve land tenure rights (GOV2)												
	Strengthen commitments and implementation (GOV3)												
	Foster multi-stakeholder collaboration (GOV4)												
Education and knowledge	Strengthen research and development (ED1)												
	Improve data collection and measurement (ED2)												
	Increase public awareness (ED3)												
	Promote healthy, sustainable and traditional foods (ED4)												
Technology	Adopt high-tech methods (TECH1)												
	Develop supply chain infrastructure (TECH2)												
	Develop alternative proteins (TECH3)												
Trade	Support healthy food imports and exports (TRD1)												
	Develop nature-positive supply chains (TRD 2)												
Finance	Redirect subsidies and increase de-risking investments (FIN1)												
	Finance school food and public procurement programmes (FIN2)												
	Provide financial incentives and taxes to improve consumption (FIN3)												

Lower potential of lever to transform a particular Food System Type

Medium to lower potential of lever to transform a particular Food System Type

Medium potential of lever to transform a particular Food System Type

Medium to higher potential of lever to transform a particular Food System Type

Higher potential of lever to transform a particular Food System Type

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