Nutritious Food Foresight:

Twelve ways to invest in good food for emerging markets

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Global Alliance for Improved Nutrition

Global Knowledge Initiative

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Global Alliance for Improved Nutrition

About the Global Alliance for Improved Nutrition

The Global Alliance for Improved Nutrition (GAIN) is a Swiss foundation launched at the UN in 2002 to tackle the human suffering caused by malnutrition. Working with partners, GAIN aims to transform food systems so that they deliver more nutritious food for all people, especially the most vulnerable. Toward this goal, GAIN is making strategic investments in nutritious food systems and has partnered with the Global Knowledge Initiative to identify innovations with transformative potential.

Global Knowledge Initiative

About the Global Knowledge Initiative

The Global Knowledge Initiative (GKI) drives collaborative innovation to empower future change. A non-profit organization based in Washington, DC, GKI engages a systems approach, foresight, and innovation to co-creatively understand complex global challenges, envision futures, and mobilize stakeholders. As a long-time GAIN partner, GKI works to boost the degree to which innovation is used to improve the efficiency, effectiveness, and ultimately, the impact of interventions in food systems.

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FOREWORD

Saul S. Morris
Director,
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This report addresses a critical issue of our time – how can we exploit new ideas and new technology to nourish and feed a growing world, and do it sustainably?

Working on food systems reform, it is easy to underestimate the speed of change around us. But the reality is that even in the remotest corners of the globe, the drivers of food systems change are making their presence felt with storm-like force. Populations, especially in Africa, are growing and moving. Technology—particularly mobile telephones and off-grid power—is opening up new possibilities for doing things differently to reduce the price of safe nutritious food. Natural resource depletion and climate change are making life ever more difficult and precarious, especially in agricultural communities. And globalisation and trade mean that the sharing of ideas, products, and even institutions is growing exponentially.

Because the environment in which we operate is transforming so quickly, the Global Alliance for Improved Nutrition (GAIN) believes in continuous re-imagination for nutrition. We seek to look beyond the current configuration of players and value chains, and find ways to bring in new partners and novel solutions. This report is the fruit of one such effort, undertaken with our long-standing partner the Global Knowledge Initiative (GKI). It represents a conscious effort to bring into our subject area—nutrition—a diverse and experienced set of experts who have insights into technical and business model innovations that are not widely known in the nutrition community.

The report sheds light on twelve specific innovations which we judge can reduce the price of nutritious food, address food safety issues, and increase shelf life, in Low and Middle Income Country settings. In all cases, the primary beneficiaries of the deployment of these innovations would be the poor (or at a minimum, those on modest incomes). All twelve innovations are ready to be deployed at scale within the next five years. The report provides numerous concrete examples of how each concept has already been implemented in a relevant setting. We hope that social entrepreneurs, programme implementers and policymakers will take note of these innovations and incorporate them into relevant food systems initiatives going forward.

Equally importantly given the accelerated rate of innovation development, the report is intended to provide a methodology for screening and prioritising innovations. This methodology is available for others to use, perhaps looking at other important characteristics such as potential for gender transformation or mitigation of the effects of climate change.

Food systems are on the move, and fast. With these insights, GAIN and GKI hope that some of the drivers of change can be harnessed for better, rather than worse, nutritional outcomes.

A NOTE FROM GKI'S LEADERSHIP

Seema Patel
Chief Executive Officer
Global Knowledge Initiative

Addressing malnutrition in emerging markets will require not just innovation, but intentional and relentless collective action across the whole food system.

We can no longer accept the status quo. The food system we have today is failing to deliver affordable, safe, and nutritious foods to places and people that need it most. As a global society, we struggle to balance the needs of our rapidly growing population within the context of our rapidly declining planetary health. The challenge is complex, multi-faceted, dynamic and so our response must be filled with clarity, purpose and optimism.

Transforming a food system that has evolved into its current state over the past 4000 years will be no easy feat. It will require a wave of innovations aimed at key leverage points in the food system to catalyze long term change. In systems, a leverage point is an opportunity for intervention. It is where a challenge, solutions, and business case intersect, creating kindling for change. At these points, an innovation can spark a fire that reverberates across the system, disrupting the status quo to help move us to a better, more equitable and sustainable future.

In today's arena, there is no shortage of innovations in the food and nutrition space. The first challenge is how to surface and prioritize the most viable innovations most likely to produce systems change. GKI and its long-time partner GAIN set out to understand just this in this report. Rather than start with the long-range, technological, futuristic investments that attract attention, we purposefully focused on what is possible to scale and deliver meaningful impact in 5 years or less. This report documents the results of this exciting exploration, where techniques of systems-thinking, crowdsourcing, and Foresight, were used to engage a diverse set of world-class experts to select 12 innovations—the short list—to recommend as the most promising opportunities for innovation in the food system.

The second challenge, the one ahead of us, is how to inspire, mobilize and organize the multitude of actors necessary to support the journey to scale. How to find and support the innovators that drive change. How to build the networks of technical experts, researchers, storytellers and citizens to offer their time and skills to drive innovation forward. How to enable the multi-stakeholder collaborations from across agriculture, business, government and civil society to address the systemic barriers to scale that stand in innovations' way.

GKI and GAIN are hopeful that the short list will focus our efforts. That it will act as a trigger for action. That it will spark new collaborations and investments in innovations that have the power to reorient food systems in emerging markets towards nutritious foods, from the first mile to the last.

We would like to thank our partners at GAIN, the Panelists who committed their time to this Foresight study, and the entire food system innovation community for their efforts toward our common goals.

TABLE OF CONTENTS

EXECUTIVE SUMMARY

Meeting the SDGs requires balancing our food systems

Our global food system reinforces an imbalance between the world we have and the world we want. Bringing our haves and wants into balance with regard to the food system means encouraging it to meet the nutritional needs of people within the constraints of the environment we depend on. At this moment in the Anthropocene, human and planetary health face increasingly prodigious threats, while Sustainable Development Goal (SDG) 2, calls us to end hunger, achieve food security and improved nutrition, and promote sustainable agriculture, all by 2030. To achieve this urgent and multifaceted goal, we must course correct and evolve food systems with cognizance of the forces that brought them out of balance to begin with.

Modern societies, riding a wave of low cost and high convenience, looked to food systems to meet their needs and invested in new ways to increase yields and reduce the effort of food preparation. As a result, food has become fuel not just for our bodies but also for the engine of continuous economic growth. Globally, as the price of food became tethered to the price of oil, food price volatility led to social volatility.

Emerging markets are essential leverage points

The objective of this study was to identify innovation opportunities that have the potential to increase access to safe and nutritious foods in emerging markets in the next five years. We focused on emerging markets because they are a complex and rapidly growing point of systemic leverage.

In Sub-Saharan Africa and Asia, one in three children suffers from stunting as a result of undernourishment. Simultaneously, more people are becoming overweight or obese in these regions, as urbanization brings consumers closer to highly processed, convenient foods. Together, these realities increase the threat of noncommunicable diseases and pressure on public health systems.

These pressures are on a trajectory to worsen between now and 2030. Sub-Saharan Africa is forecasted to more than double its population, adding 1.3 billion people over the next 30 years, while Asia will add another 700 million[1]. How might food systems of the future manage this growth?

[1] UN Population Prospects

Promising options for renewable energy and off grid solutions are becoming affordable, increasing access to energy, and opening up the potential for energy dependent food processing to happen in areas where it was previously impossible. Might this increase the availability of local, diverse, nutritious food choices?

Population and economic growth are a pressing tax on local food systems in emerging markets. Because systems change is a function of incentives, causality and leverage, the radical change we require will be achieved through myriad forces such as regulation, increased efficiency and investment in emerging markets. The transformation needed in these systems takes time, but the time to start is now.

Innovation is a force for systems change

The Global Alliance for Improved Nutrition (GAIN) and the Global Knowledge Initiative (GKI) believe that innovation is a force for positive change in food systems. In this report, we explore on-the-cusp innovation opportunities in the food system landscape and summarize the results of a six-month, expert-driven research process. This process harnessed the collective wisdom of some of the best minds in international development, academia, and the private sector. Our goal was to identify innovations that could change food systems in emerging markets to improve access to safe and nutritious foods, but our broader intent was to start a powerful global conversation about innovation and investment in nutritious food systems.

Identifying opportunities to spark the world we want

Balancing food systems will require substantial changes in the way we grow food, choose food as consumers, and process and distribute food in the global marketplace.

We asked a panel of experts, referred to as our Delphi Panel, to think about how innovation might catalyze the changes required. The innovations we talk about in this report are those that our Delphi Panel felt represented the greatest opportunities to begin to reorient food systems toward sustainable balance. As a group, the innovations strengthen local food systems to more effectively manage and distribute nutritious foods from the first mile to the last.

The twelve innovation opportunities that the Delphi Panel prioritized share a central tenet: context-appropriate innovations aimed at inefficiencies and waste reduction can do more to make local markets work in the near term than exceedingly radical or disruptive innovations might.

The innovation opportunities deemed most promising by the Delphi Panel combat inefficiency and focus on specific changes at select leverage points along traditional value chains. We refer to these priorities as the Delphi Directives. They are:

1. **Start with sustainable, nutritious foods.** Production, processing and consumption of sustainable local foods reduces long-term reliance on imports and can yield planetary and human health benefits.

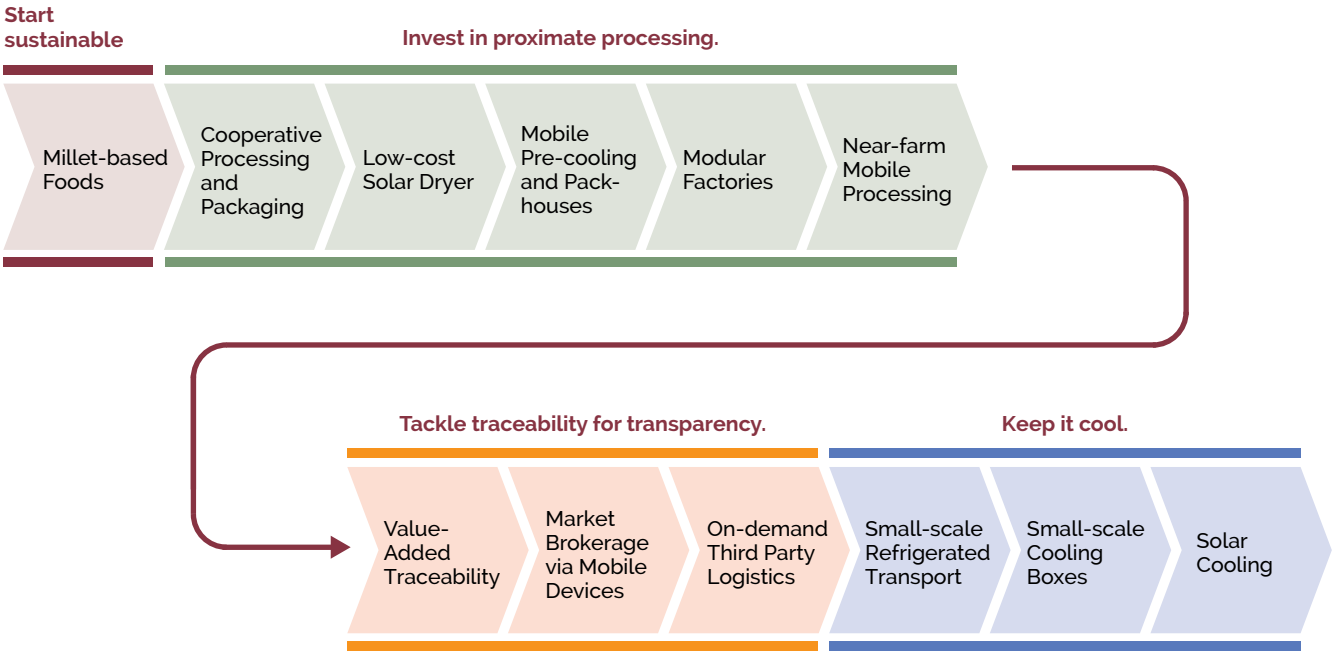
2. **Invest in proximate processing.** Processing and value addition closer to the point of production reduces postharvest loss, ensures nutrient retention, and increases the volume of nutritious foods on the market.

3. **Tackle traceability for safety and transparency.** Efficient and transparent distribution enables access to wider markets, stabilizing demand and reducing price volatility, while ensuring food safety.

4. **Keep it cool.** Cold storage options at the last mile extend the life of nutritious food and make more nutrients available to vulnerable rural populations such as mothers, children and adolescent girls.

The Delphi Directives incorporate the twelve innovation opportunities profiled in this report and provide a blueprint for maximizing investment impact at systemic leverage points where innovation can improve food systems, as illustrated below.

Figure 1: Innovation Opportunities by Delphi Directive



Collaboration will help us unlock change

While our Delphi Panel believes these twelve opportunities represent areas where innovation can improve access to nutritious foods, achieving this goal will require action. Innovations do not scale up in a vacuum. They must contend with real-world systems, including the people, norms, policies, and infrastructure, that can either enable or hinder widespread adoption.

The journey of balancing our food system with the needs of people and planet will require the creativity and action of a multitude of stakeholders across the system. Civil society, development organizations, financial institutions, governments, businesses, and consumers - all have a role to play to unleash the potential of these innovations to achieve a tipping point toward scale. Going forward, mobilizing the champions of change and enabling meaningful opportunities for collaboration and continued learning will be the key to move the global community from innovation to impact.

INTRODUCTION

We depend on food systems to deliver the nutrition essential for healthy human development and empowerment in all corners of the world. Nutrition is central to our ability to achieve our ambitions for improved health, education, employment, poverty and inequality reduction and female empowerment through the Sustainable Development Goals.[2] But our food systems are not delivering enough safe, affordable, and nutritious food to those who need it most.

An estimated one in three individuals is malnourished globally.[3] The double burden of malnutrition – the coexistence of undernutrition and obesity – affects society at every level, from a single household or individual to whole nations, leading to a challenge of pandemic proportions.[4] Diet and malnutrition are the biggest risk factors for the global burden of disease.[5] Increasingly, noncommunicable diseases are straining public health infrastructure in lower-income countries,[6] necessitating expensive therapies that are out of reach for most. Progress toward ending malnutrition, Sustainable Development Goal 2.2,[7] has been slow.

Global population is expected to increase by a billion people by 2030. The vast majority of births in the next decade will occur in lower income countries, where five servings of fruit and vegetables a day can cost more than half of household income.[8] Systemic transformations will be required to meet our global nutrition goals in the context of a growing population.

Innovation drives systems change

Innovation means different things to different people. GKI defines innovation as a new approach for solving a challenge. We believe this broad definition offers space for the many different kinds of innovation—for the radical new ideas and shiny gadgets that many people think of when they hear the word innovation, for the adjustments aimed at incremental improvements and efficiency gains that constitute the majority of innovation, and for the innovative adaptation of technologies, business models, and processes to new contexts where they have never been tried before.

[2] Food and Agriculture Organization of the United Nations. (2018). *Transforming Food and Agriculture to Achieve the SDGs.*
[3] International Food Policy Research Institute. (2016). *Global Nutrition Report 2016: From Promise to Impact: Ending Malnutrition by 2030.*
[4] World Health Organization. *Double Burden of Malnutrition. Retrieved from https://www.who.int/nutrition/double-burden-malnutrition/en/*
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[6] International Food Policy Research Institute. (2016). *Global Nutrition Report 2016: From Promise to Impact: Ending Malnutrition by 2030.*
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[8] The Economics of Ecosystems and Biodiversity (TEEB). (2018). *Measuring what matters in agriculture and food systems: a synthesis of the results and recommendations of TEEB for Agriculture and Food's Scientific and Economic Foundations Report.* UN Environment.

For the purposes of this study, we were interested in all these kinds of innovation, leaving the door open for any kind of innovation that might help with the long-term objective of food systems change. At GKI, we understand transformational systems change as a multifaceted process, where innovation applied at the right leverage points can shift the underlying structures of the system, and thus shift the outcomes we observe in the world. In the context of our current global food system, both the scale and the complexity of the challenges we face require that we optimize leverage points through innovation to deliver high impact.

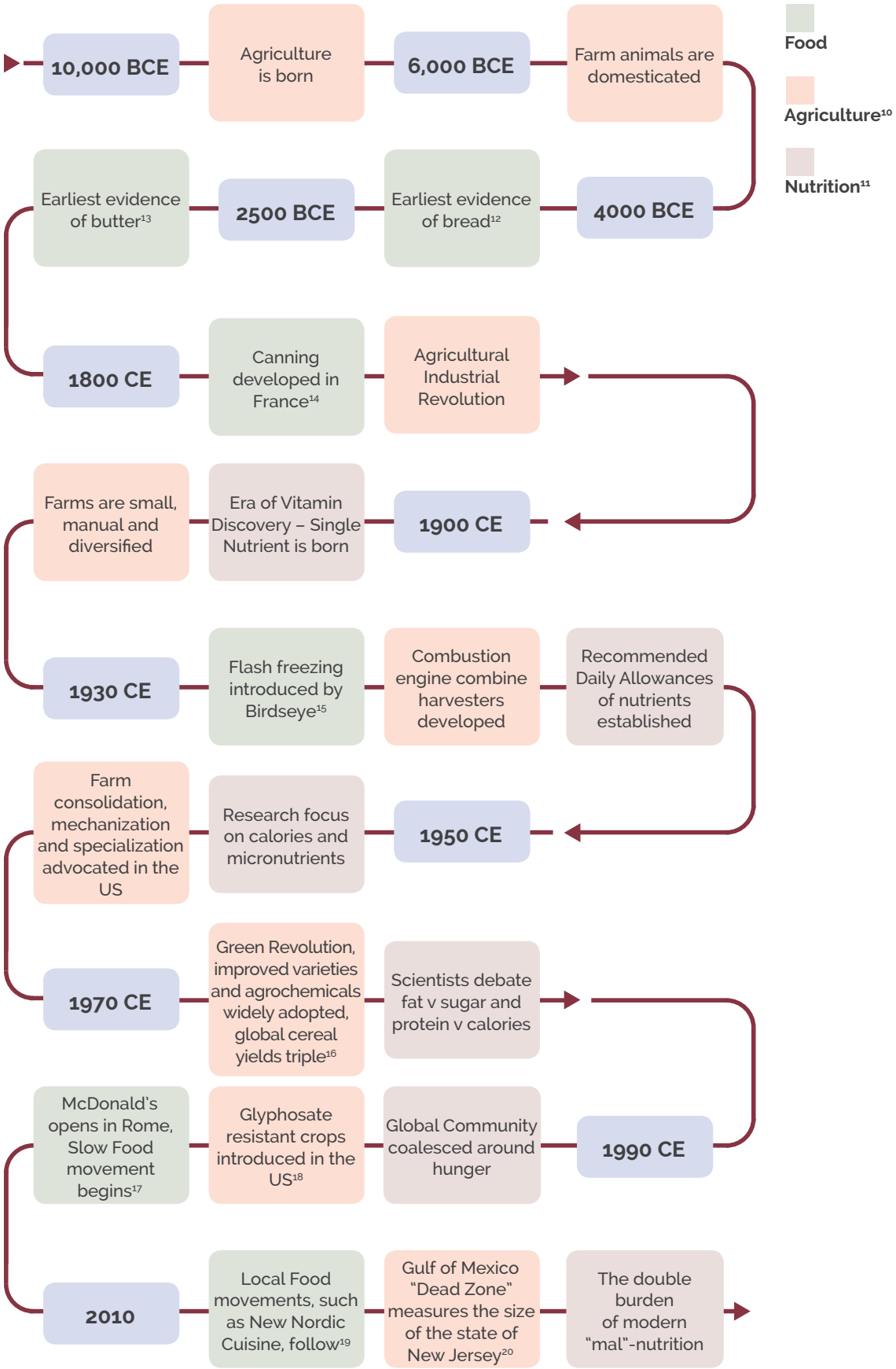
A study launched by UN Environment zeroes in on the interlocked systems attached to our food and also speaks to this need. It concludes that balancing food systems requires interventions that account for interdependent ecosystems, infrastructure, technology, policy, institutions, and cultures and traditions involved in producing, processing, distributing and consuming food. The long-term challenge of reshaping food systems to operate within the constraints of the planet in the context of climate change is likely to require deep transformations in our relationship to food.[9] But we should recognize that in the near-term there are many potential solutions available to improve the outcomes that food systems are producing, including their environmental and human impacts.

Food systems change comes in waves

Our food systems are a function of our history and shared knowledge of agriculture and nutrition. Taking a long view of the history of food production illuminates historical waves of innovation that increased efficiency in order to better meet human needs and wants. Developments in modern nutritional science in the early 20th century also shaped food systems. From the birth of agriculture to today's global commodity trade, the figure below depicts how waves of innovation have optimized food systems to produce calories in high quantity rather than a diversity of high-quality food.

[9] The Economics of Ecosystems and Biodiversity (TEEB). (2018). *Measuring what matters in agriculture and food systems: a synthesis of the results and recommendations of TEEB for Agriculture and Food's Scientific and Economic Foundations Report.* UN Environment. (2018).

Figure 2: Food Systems Evolution



The realities of present-day food systems offer cause for concern, but historical trends in innovation and consumer preference suggest that sustainable evolution is possible. Our challenges are rooted in our history. Large-scale production of a limited number of crops has allowed us to efficiently feed a rapidly growing population and fuel economic specialization and growth. This strategy was effective. So effective, in fact, that today just 50 crops account for 90% of calories, protein, and fat consumed around the world.[21] This narrowing of global crop diversity is a complex reality of our present global food system, as is the failure of many local food systems to meet the needs of mothers, children and adolescent girls.

The much-discussed 2019 EAT-Lancet Commission Report suggests a dramatic shift is required to meet the needs of these populations and all others as well. The EAT-Lancet Commission calls for a shift in focus from the production of large quantities of commodities for processing to the production of diverse, healthy, and environmentally sustainable foods for eating. It is this shift, they say, that will spur food systems that are good for both people and the planet.[22] The Planetary Health Diet proposed by the Commission includes a 50% reduction in the global consumption of less healthy foods like meat and starchy vegetables and a greater than 100% increase in consumption of healthy foods such as nuts, fruits, vegetables, and legumes.

Conscious consumers are also calling for change in the food industry, demanding greater transparency, local and plant-based food, and products that further health and wellness but don't hurt the environment. These trends in higher income countries have created momentum, as well as an opportunity to begin disrupting the way food is produced, packaged, distributed, and consumed.

In emerging markets, access to safe, affordable, and nutritious food is often limited by the high levels of food loss that occurs between the farm gate and market.[23] According to supply chain analyses conducted by GAIN in Kenya, India, and Nigeria, issues such as food spoilage combine with limited transparency and competition to drive up prices and keep nutritious foods out of reach. Yet, younger demographics in these countries are spurring technology adoption in the agriculture sector, rapidly introducing new solutions which could shape the future in inspiring new ways.

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We asked a diverse set of experts to spot the next wave

This report is a synthesis of primary, qualitative and quantitative research. The research was done as part of a Futures Foresight study conducted by GKI between November 2018 and March 2019. The aim of a Foresight study is not to predict the future, but rather to envisage many alternative and shape a primary desired future. The desired future in this study is near-term and specific; it is a future in which access to safe and nutritious foods in emerging economies increases in the next five years.

To determine how innovation might make this future a reality, we employed the Delphi Technique. This technique is a structured process in which experts share their opinions and iteratively respond to the opinions of others, ultimately coming to a designed consensus. We convened a Panel of experts in the fields of nutrition, agriculture, business, and sustainable food systems to participate in this collaborative, virtual research process over the course of five months. A detailed description of the methodology we followed can be found in Annex: Research Process.

The Delphi Technique is useful for achieving rapid consensus and for tapping into a wide range of expertise. It is one of the most effective methods to harness the collective knowledge as it relates to a defined research question. In our case this question was: **What innovations are most likely to improve nutrition outcomes in emerging markets over the next five years?**

The Delphi Panel of experts that powered this study helped us illuminate innovations that promise high potential for improving access to nutritious foods, and to ascertain what is required for these innovations to scale. These innovations target specific pain points in emerging market food systems and have the potential to catalyze near-term improvements that address inefficiencies, enhance transparency, and ultimately deliver food that is more sustainable for people and planet.

While our findings do not point to a panacea for improved food systems, they do reflect a broad consensus on the importance of investing in efficient and responsive local food systems.

VIABLE INNOVATION OPPORTUNITIES

On the following pages, we provide an overview of our process for uncovering a long list of innovation opportunities that could improve food systems in emerging economies over the next five years. These opportunities are best considered a class, or stream, of innovation, rather than a specific technology or solution. We provide an overview of how the Delphi Panel assessed each innovation opportunity, and profiles of those that were seen as high potential by the Panel. The profiles highlight how each innovation opportunity can improve food systems, offering example use-cases, broad projections of impact potential, and likely requirements to scale.

As mentioned in the introduction, the insights offered in this section are derived from an analysis of data gathered through the application of the Delphi Technique. As such, these insights represent perceptions of the potential for innovative business models, processes, and technologies to address challenges in food systems in the geographies of interest. Given the nature of this study as a process in considering the future, which is inherently unknown, all of this information should be considered in that light, as there are inherent uncertainties about what the future will ultimately hold.

Still, we believe the insights can be instructive for a variety of food system stakeholders. Think of these innovation opportunities as hotspots. They represent clusters of innovation springing up around leverage points in food systems. Further, these opportunities have been scrutinized and analyzed by a panel of world class experts who, together, have agreed that these twelve innovation opportunities represent the best path forward for improving food systems in emerging markets over the next five years.

An innovation scan surfaced opportunities

Our work began with a foresight and strategic planning workshop held with a cross-section of stakeholders in Washington, DC in the fall of 2018. In this workshop, we envisioned how current, emerging, and aspirational trends in food system innovation could translate to a world without malnutrition. The outputs of this workshop pointed the GKI team to areas where innovation in the food system was happening. The workshop informed an Innovation Scan, which was largely driven by desk research, that surfaced over 65 compelling opportunities to advance the supply of, and access to, nutritious foods. In the first round of the Delphi process, GKI's initial list was expanded upon by the Panel, who added an additional 20 innovations for a total of 87 innovations, spanning food design and materials science to supply chain technologies and market connectivity.

The full list of innovations is shown below in Table 1.

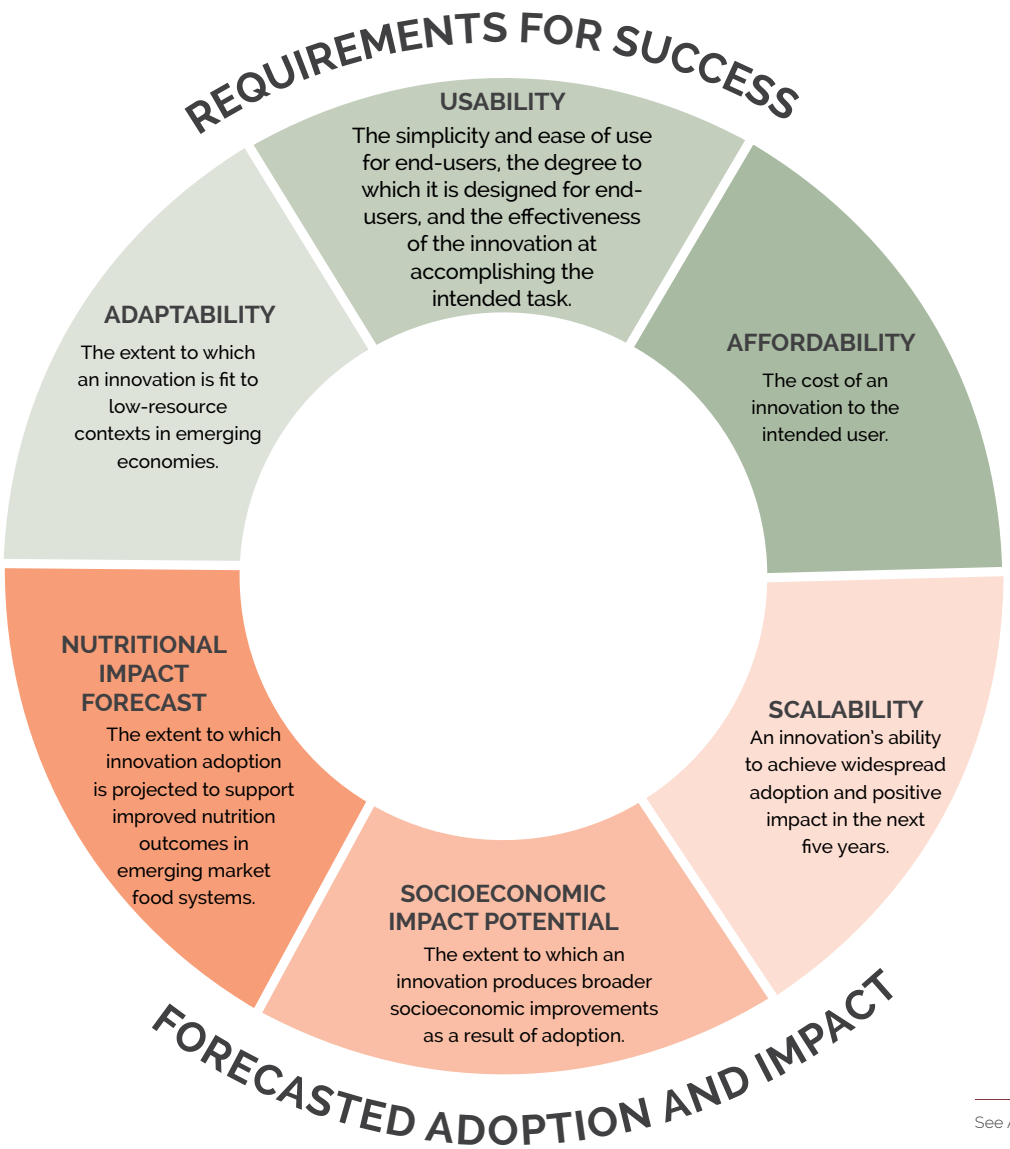
Table 1: Surfaced Innovations by Technical Category

Food Design	Information Connectivity	Market Connectivity	Materials Science	Processing Solutions	Supply Chain Connectivity	Supply Chain Technology	Other
3D-printed Food	Alflotoxin Detection	Augmented Reality for Product Information	Bioplastics for Agriculture	Cooperative Packaging	Mobile Pre-cooling and Packhouses	Autonomous Transport	Financing of Innovations
AI-powered Nutrition	Algorithmic Nutrition Apps	Frozen Food Delivery System	Cellulose Crating and Packaging	Farm-level Sorting, Grading, and Packaging	On-demand Mechanization	Automated Supply Chain Services	Nutri-gardens
Alternative Fish Feed	Blockchain	Kickstarter Support-ed Agriculture	Cold Plasma	Food Safety Robots	On-demand Third Party Logistics	Smallholder Milk Container	Promoting Local and Indigenous Crops
Cellular Agriculture	Crop Disease Diag-nostic Apps	Last-mile Milk Dispensing	Edible Films and Coatings	Cassava Curing Bag	Online Freight Forwarding	Commercial Drones	Training and Certification for Informal Markets
CRISPR Gene Editing	Crowdsourced Information Sharing	Market Brokerage via Mobile Devices	Edible Packaging	Ethylene Absorption	Predictive Supply Chain Analytics	Harvest Robots	
Data-driven Vertical Farming	Hyperspectral Imagery	On-demand Food Shopping	Edible RFID Tags	Low-cost Solar Dryer	Real-time Freight and Logistics Services	Evaporative Cooling	
Fortified Crops	Ingestible Sensors	Online Farmers' Markets	Nanomaterials	Modular Factories	Logistics Services	Micro-scale Ice Cooling	
Mushroom and Fun-gus Cultivation	Microbial Data-based Interventions	Pricing Models based on Freshness	Smart Packaging	Near-farm Mobile Processing	Smart Contracts	Small-scale Cooling Boxes	
Microalgae- and Seaweed-based Foods	Mobile Ethylene Monitoring	Sharing Economy for Produce Delivery	Starch-based Coatings	Solar Mills		Small-scale Refrigerated Transport	
Microbiota-directed Foods	Neural Networks and Deep Learning	Secondary Markets for Food Waste		Zerofly Storage Bags		Solar Cooling	
Minimally Processed Pre-cooked Foods	Nutrigenetics	Subscription-based Food Delivery Services				Solar Pumping	
Millet-based Foods	Nutrigenomics	Value-added Surplus Products					
Plant-based Protein Alternatives	Personalized Nutrition						
Ready-to-use Bean Flour Products	Real-time Food Safety Analysis						
Synthetic Proteins	Smart Refrigerators						
	Smart Sensors						
	Soil-health Monitoring						
	Taste Intelligence						
	Value-added Traceability						

2.2 Investable Innovations meet key criteria

To move from this long "innovation wish list" to a short list of innovations that could be impactful and investable in the near-term, the Delphi Panel evaluated each innovation through a collaborative, virtual process. Though GAIN and GKI provided fodder for evaluation, the process was largely shaped by input and direction of the Panelists, as they determined the selection criteria through their consensus. The primary criteria used by Panelists are illustrated below.

Figure 3. Key Criteria



See Annex for more details

In addition to these criteria, which were used explicitly to rank innovations, another layer of assessment was used to ensure that innovations were environmentally sustainable. With the criteria and assessments in place, and a common understanding of each established, a final round of inquiry was performed. The result was the short list of the 12 most promising innovations as assessed by our multi-stakeholder panel.

Figure 4. Selected Innovations by Technical Category

Food Design	Information Connectivity	Market Connectivity	Processing Solutions	Supply Chain Connectivity	Supply Chain Technology
Millet-based Foods	Value-added Traceability	Market Brokerage via Mobile Devices	Cooperative Processing and Packaging	Mobile Pre-cooling and Packhouses	Small-scale Cooling Boxes
			Low-cost Solar Dryer	On-demand Third Party Logistics	Small-scale Refrigerated Transport
			Modular Factories	Near-farm Mobile Processing	Solar Cooling

While these innovations were considered most promising, we know that other technological shifts may also be coming our way, though they may be less applicable to the target markets of this study. Technologies like blockchain, CRISPR, data-based vertical farming, and 3D printing of food are truly exciting and may find purchase in developed markets very soon. Ultimately, though, our Panel they deemed these innovations unlikely to achieve high impact within geographic and time frame of this study. We encourage visionary organizations to explore ways to use these technologies to maximize their benefits for our food system.

2.3 The Short List

The pages that follow provide a deep dive into the 12 innovations recommended by the Panel in the form of Innovation Profiles that present an aggregated view of the data collected over the process. Each Innovation Profile includes a Snapshot of the innovation, how it would target challenges in value chains of nutritious foods, and real-world examples of the innovation in action. The Profiles also offer insights into the contextual considerations that accompany each innovation, such as the infrastructure requirements, the target end users, partnership needs, and considerations for optimizing business models that would promote improved access to nutritious foods.

Finally, the profiles present the potential nutritional impact of each innovation, as judged by the Panel. This Results Dashboard includes aggregated data from the final round of the Delphi process, related to the nutritional impact criteria described previously in this section—including target population segments, potential price reduction, increase in shelf life, and percent of food safety issues addressed. The information presented here is meant to provide a relative qualitative judgment of the potential impact that an innovation could have on our primary concerns about nutritious food systems and provide insight the issues it would be most effective in addressing.

MILLET-BASED FOODS

INNOVATION SNAPSHOT

Delphi directive	Target nutritious food
Start with native, nutritious foods	Millet, sorghum, amaranth, and other high-quality nutritious grains and seeds

Millet is a group of small-seeded grasses that has been grown over the past 7000 years in both Africa and Asia. These crops are require less water to grow than other grains, making it more efficient and drought-resistant. Packed with nutrients comparable to that of whole wheat, millet can be scaled to replace less nutritious grains, especially those that are harder to grow. However, for this to be achieved, millet would need to disrupt parts of food systems where traditional grains, like maize, rice, and wheat have traditionally dominated. Processing millet into end-products that mimic traditional grain products, such as bread or tortillas, offers an opportunity to do just that.

ICRISAT's Smart Food initiative is accelerating international support for the research and development of millet-based products and value chains. Hybrid and open pollinated varieties have taken off in India in particular, where population is dense and infrastructure stable. There, more millet-based food products are even showing up in schools and university hostels. In Malawi, millet has also been cultivated successfully to meet the needs of local populations. The key to increasing the accessibility and affordability of millet-based foods is to increase consumer demand, support millet value chains, and orient supply toward local markets rather than export markets.

NEEDS

Context and Infrastructure

Millet-based foods would require little additional infrastructure development, as it would rely on already existing systems for implementation. For this reason it would be suitable for deployment in a variety of geographic contexts, including rural villages, towns, and peri-urban areas.

End User Considerations

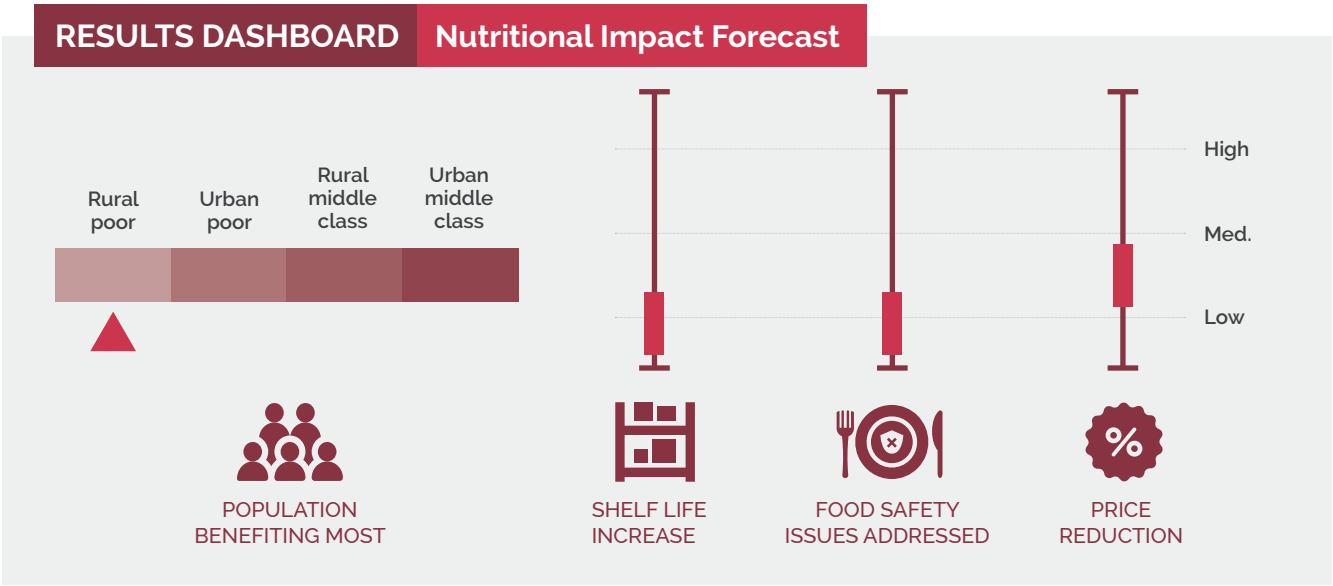
Millet-based foods could be deployed for adoption by end users with a variety of economic and institutional profiles, ranging from smallholder subsistence farmers to individual entrepreneurs and cooperatives. In addition, adoption would require limited additional capacity development for adoption, as the innovation is relatively simple in nature and thus easy to explain.

Collaborations and partnerships

A variety of partnerships at the local-level could support the adoption and eventual scaling of millet-based foods. For instance, marketing campaigns and facilitators such as civil society organizations and NGOs can introduce local communities to adaptations of ancient nutritious foods within local cuisines. These activities could help increase demand, and targeted agricultural policies could incentivize farmers to grow millet on less productive land. A minimum consideration to increase adoption is the need to develop stronger market linkages between producers, processors, distributors, and retailers, to ensure supply and demand of various millet-based products is coordinated effectively.

Considerations for business models

Business models for millet-based foods would need to take into account a variety of considerations. First, demand must be created for millet-based products in the appropriate consumer segments. Millet-based foods resembling traditional wheat, rice, and maize products could replace less nutritious products if they could be produced at the right price. In addition to this, farmers will require quality inputs to produce millet-based foods, including seeds of improved millet varieties, which may benefit from millet seed companies who provide these inputs at affordable prices.



VALUE-ADDED TRACEABILITY

INNOVATION SNAPSHOT

Delphi directive	Target nutritious food
Tackle traceability for transparency	Perishables and cash crops such as nuts

Traceability is a supply chain tool that tracks the path of food from farm to fork. If made available to consumers and the public, data collected can enable consumer education around the origin of foods purchase din markets and aid the identification of goods affected by food safety concerns. Value-added traceability captures transaction data across value chain operations, allowing for transparency among different supply chain stages as related to price increase and added value. By utilizing data to increase the value of product delivery and sale across each transaction, this innovation incentivizes the adoption of traceability systems, enables value chain efficiency, and promotes accountability for how goods are handled throughout the supply chain. This information on supply helps reduce post-harvest loss, a systemic issue in food systems in emerging markets.

Kenya-based Virtual City has successfully rolled out a mobile application that enables real-time tracking and monitoring of agricultural value addition. By helping markets and farmers to understand how their products are being handled up- and down-stream in the value chain, this innovation offers an opportunity to bring more safe, nutritious foods to market.

NEEDS

Context and Infrastructure

Value-added traceability would require that geographies where this innovation is deployed have requisite ICT infrastructure in place, as examples of identified through this research require access to 3G networks via smartphones. Provided these networks are in place this innovation would be suitable for deployment in any geographic context, including rural, urban, and peri-urban areas.

End User Considerations

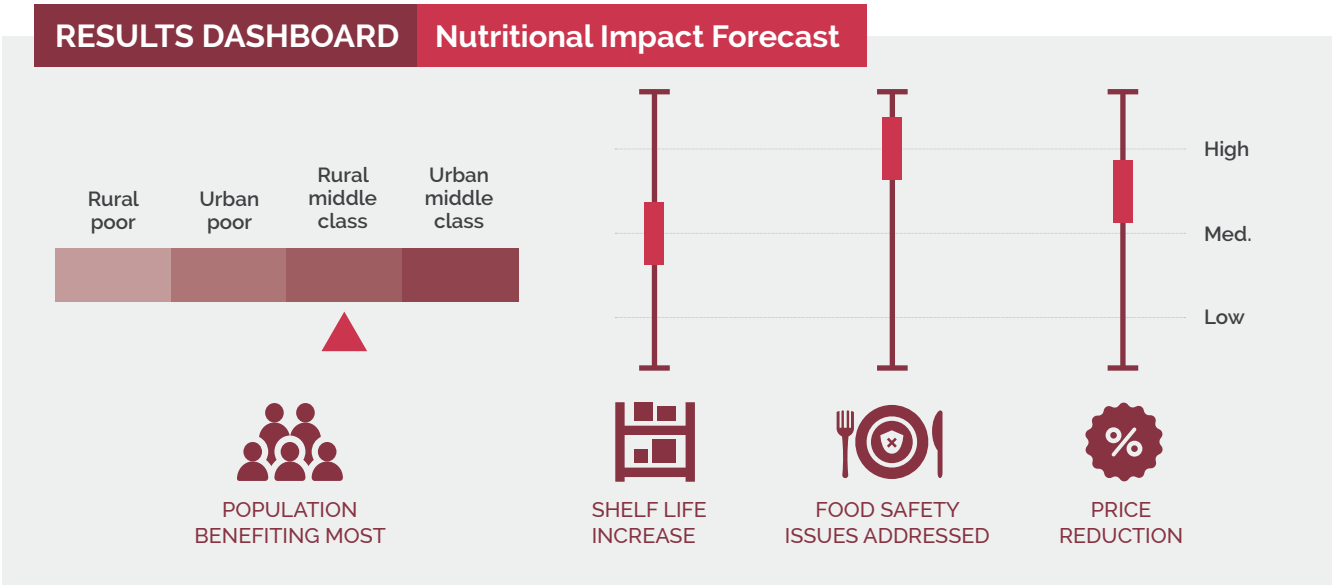
Value-added traceability innovations would be best targeted toward existing agribusinesses or agricultural cooperatives. The cost of such technologies would likely be a barrier to uptake by individuals in the near-term, and the benefits of this innovation are best suited for organizations that can use this product to differentiate themselves in the marketplace. In addition, uptake of this innovation would likely require sustained engagement or training for use by such businesses.

Collaborations and partnerships

As this innovation is aimed at promoting cooperation between actors at different stages of the supply chain, high levels of collaboration and partnerships among businesses would be needed. Governments can promote the benefits of traceability through policies and incentives, while external specialists could help businesses optimize the benefits of this innovation with their existing practices.

Considerations for business models

Business models for value-added traceability will benefit most of all from the development of consumer awareness about the importance of transparency and food safety, generating demand for increased traceability. On the supply side, entrepreneurs seeking to deploy this innovation will also need to communicate the income benefits to farmers and agribusinesses to incentivize adoption. There is also potential for this innovation to link larger companies with SMEs, who can promote their products based on the social impact benefits of a procurement model that prioritizes small-scale agriculture.



MARKET BROKERAGE VIA MOBILE DEVICES

INNOVATION SNAPSHOT

Delphi directive	Target nutritious food
Tackle traceability for transparency	Fresh produce, livestock, nonperishables
Link with:	Cooperative processing and packaging, On-demand 3PL, Small-scale refrigerated transport

From distinct buyer and seller requirements, automated market brokerage systems can determine best available buyer-seller matches. They provide a systematic source of information across supply gaps and price fluctuations within markets, creating a more efficient trading system in which nutritious foods are made available where and when they are needed. For valuable products varying in quality over seasons and across locations, market brokerage via mobile apps can connect supply and demand over distances, increasing access to nutritious foods, stabilizing prices, and even driving product diversification.

To adapt this market connectivity innovation to local contexts, market brokerage services such as Kudu and AgriNet Uganda, utilize SMS prompts rather than relying on smart phone capabilities. Yeelda in Nigeria offers similar services to both local industries and multinationals, while Cellulant's Agrikore employs blockchain-based smart-contracts to connect farmers, aggregators, financial institutions, and governments. In such cases, high user engagement with market demands can help drive collaboration across sectors to scale impact.

NEEDS

Context and Infrastructure

Market brokerage via mobile devices would require a minimum level of ICT infrastructure to be deployed effectively, but solutions such as those offered as examples may be adapted to differential levels of infrastructure development. In some countries a mobile application that uses 3G or 4G networks may be appropriate, while in others an SMS based service could be deployed. Depending on the level of infrastructure development, our panel believes this innovation would be suitable in rural and peri-urban areas as a means of connecting businesses to markets.

End User Considerations

Market brokerage via mobile devices would primarily be suitable for businesses and organizations already in operation in the agriculture sector. Depending on how the technology is adapted to the local context there is potential for uptake by a farmers cooperatives, aggregators, and retailers. The potential for adaptation also makes it difficult to project the level of training required to promote end user uptake. More complex applications may require more prolonged engagement, while simple SMS services could be introduced more quickly.

Collaborations and partnerships

The key partnership for the success of this innovation is the connection between suppliers and retailers. Both sets of actors would require visibility into each other's stocks and prices, trust in the reliability of this information, and confidence that agreed upon prices will be paid and products delivered in a timely manner. This requires significant buy-in by the end-users, which may need to be supported by upfront engagement during the product development phase. A further consideration is whether financing schemes are required to enable lower-income actors to acquire the necessary technology (e.g. phones or tablets).

Considerations for business models

To increase uptake by end-users, business models for this innovation should account for how the application needs to be adapted to ensure the usability and reliability of information. Applications should translate information into something that is simple and understandable for all parties involved, make it easy to update this information as stocks change, and ensure this information is as transparent as possible to ensure equity.

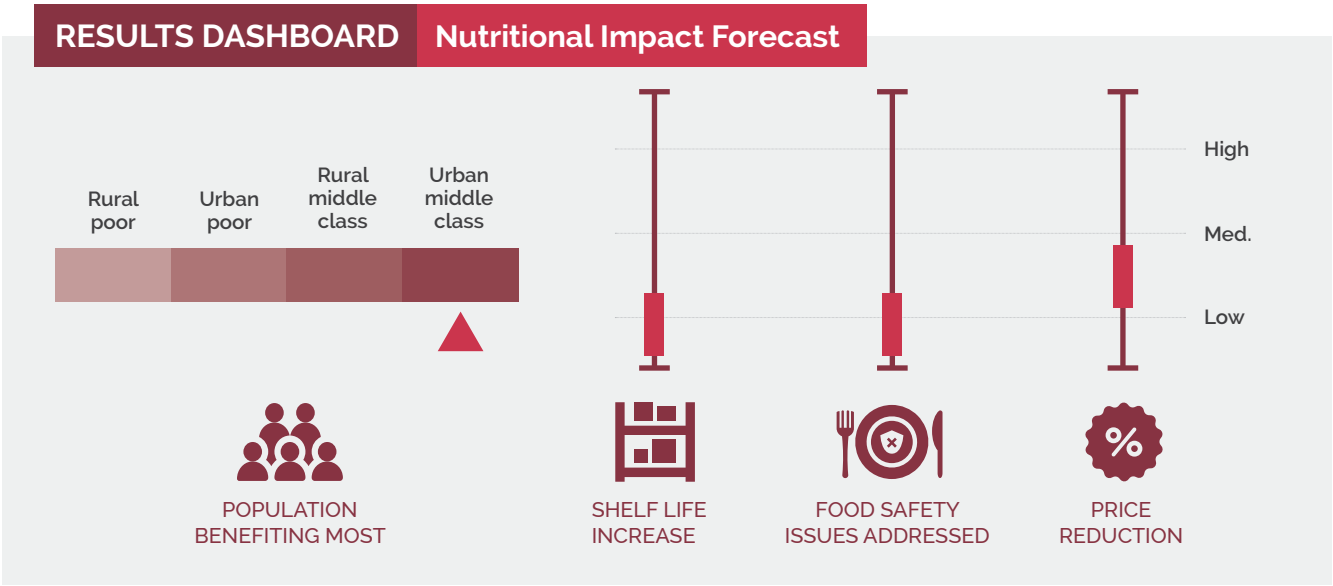


Image: S Njoroge/ ICRISAT

COOPERATIVE PROCESSING AND PACKAGING

INNOVATION SNAPSHOT

Delphi directive	Target nutritious food
Invest in proximate processing	Dairy, pulses, perishables
Link with:	Low-cost solar dryers, On-demand 3PL, Market Brokerage via Mobile Devices

Farmers' cooperatives perform many functions close to the farm gate. They commonly serve as an aggregation point for smallholder-based value chains that require bulking and the standardization of grades. In such cases, cooperatives have developed processing and packaging solutions to manage the supply of perishables. Moving these value addition stages closer to point of production reduces food loss, increases the availability of high quality local foods with improved shelf life, and stabilizes the marketability of local products throughout the seasons.

Processing and packaging also generates additional income for cooperative members, as in the case of Cooperativa Central Gaúcha Ltda, a Brazilian smallholder dairy cooperative. A key question that business models must address is margin of profit versus access. To increase access, cooperatives must aim to maintain the affordability of processed and packaged products at a price point available to a variety of consumers and distribute these products in areas where demand is highest.

NEEDS

Context and Infrastructure

Cooperative processing and packaging would require that cooperatives have access to reliable energy sources, as these technologies are typically energy intensive. Without reliable and affordable energy sources in place cooperatives would have difficulty in managing their supply planning and operations in a sustainable way. Transport infrastructure would also be required for processed and packaged products to reach non-local markets. Depending on the level of infrastructure development this innovation may be suitable for rural villages, rural towns, or peri-urban areas.

End User Considerations

Cooperative processing and packaging could be taken up by a variety of organizations, including existing cooperatives, local entrepreneurs, or even larger companies hoping to expand their supply channels. Depending on the type of processing or packaging service incorporated into the business model, training for cooperative members may be relatively simple or more complex.

Collaborations and partnerships

Farmers are the key actors in any partnership seeking to deploy this innovation, which can only be achieved by demonstrating increased profits. Other partnerships to consider include the role of the government in creating the enabling environment that will incentivize these types of businesses, including investments in needed infrastructure, as well as the development of food safety standards that will promote processed and packaged goods.

Considerations for business models

Business models for cooperative processing and packaging should start by seeking to understand the local demand for these types of goods. Other considerations include branding and product differentiation, and transparency and accountability mechanisms of the business' operations. Finally, to promote environmental sustainability of the business model, attention should be paid to the environmental impact of the business, such as plastic waste, resource efficiency, and the energy source.

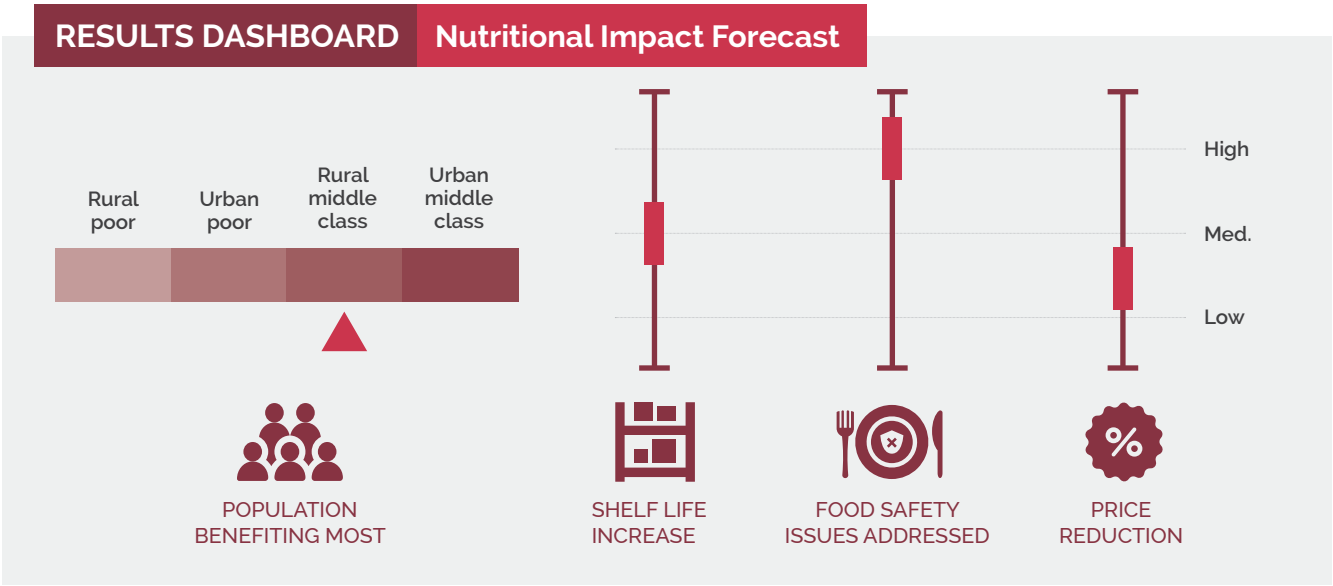


Image: Heather Sullivan/ USAID

LOW-COST SOLAR DRYER

INNOVATION SNAPSHOT

Delphi directive	Target nutritious food
Invest in proximate processing	Fruits and vegetables with a short shelf life and that ripen quickly; pulses, and fish; grains
Link with:	Cooperative processing and packaging

Solar drying offers a simple, cost-efficient method to prevent food spoilage in areas where the ability to distribute products is limited, and cold chain is lacking. Dehydrating fruits and vegetables can remove up to 80% of moisture content, extending shelf life and avoiding contaminants. Dehydrated nutritious food alternatives are high quality and add value for surplus foods that would otherwise be lost during seasonal gluts.

Available low-cost solar dryers include Feed the Future's "improved" solar dryer, the International Rice Research Institute's solar bubble dryer, and Science for Society's solar conduction dryer. In India, Vaibhav Tidke and Shital Somani are producing a low-cost solar conduction dryer that can help farmers store up to three tons of food a year. This is incredibly consequential for consumers, especially if stakeholders align to distribute dehydrated foods where they are needed most.

NEEDS

Context and Infrastructure

Low-cost solar dryers would be effective in a variety of geographies, including rural and peri-urban areas, due to the lack of reliance on energy infrastructure. However, transport infrastructure capable of connecting the dried products to markets would be required.

End User Considerations

Low-cost solar dryers could be targeted to a range of end-users, including smallholder farmers looking for increased income generation opportunities, cooperatives, and SME agribusinesses. Uptake by these various actors would require some sort of training to introduce them to the technology and how to apply it.

Collaborations and partnerships

The key partnership consideration for low-cost solar dryers relates to the financing capable of promoting uptake, as the technology requires upfront investments by farmers or businesses. This could potentially be facilitated through micro-financing options or partnerships with local civil society organizations. Finally, though solutions are relatively low-tech, repair and maintenance may require specialist support.

Considerations for business models

Business models for low-cost solar dryers need to consider the downstream distribution channel for products. Without demand for dried foods the preservation of goods through drying would create an oversupply that would quickly decrease the benefits of its application. If the distribution channels are more formalized market settings than dried products will need to adhere to food safety regulations and standards which may require for further monitoring and controlled processes to be established.

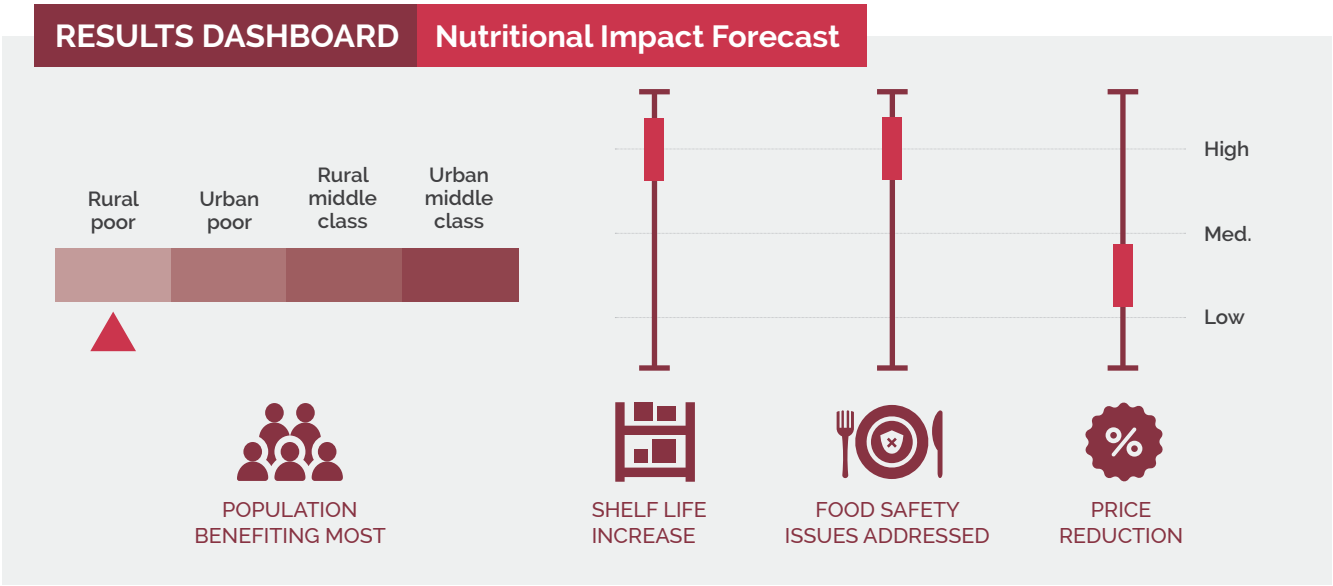


Image: InspiraFarms

MODULAR FACTORIES

INNOVATION SNAPSHOT

Delphi directive	Target nutritious food
Invest in proximate processing	Processed food such as canned fruits and vegetables; dairy, vegetables, and fruits; cereals and pulses; livestock
Link with:	Cooperative processing and packaging

Modular factories are functional buildings such as cold storage containers and food processing plants that can be easily assembled and continually expanded from prefabricated components. The factories are cost-effective and can be modified in size when needed or in accordance with seasonal harvest patterns. Modular factories enable cooling and processing activities close to the farm gate, reduce post-harvest loss, and extend the shelf life of perishable products.

UK-based InspiraFarms has already commercialized several modular factory models to provide agribusinesses and farmers in Central and East Africa with on-farm storage and pre-cooling services. More recently, Nestlé invested in modular factories to industrialize processes like mixing dry goods. Paired with decentralized distribution services in rural and remote areas, these modular factories can enable more nutritious food of higher quality to reach consumers in need.

NEEDS

Context and Infrastructure

Market brokerage via mobile devices would require a minimum level of ICT infrastructure to be deployed effectively, but solutions such as those offered as examples may be adapted to differential levels of infrastructure development. In some countries a mobile application that uses 3G or 4G networks may be appropriate, while in others an SMS based service could be deployed. Depending on the level of infrastructure development, our panel believes this innovation would be suitable in rural and peri-urban areas as a means of connecting businesses to markets.

End User Considerations

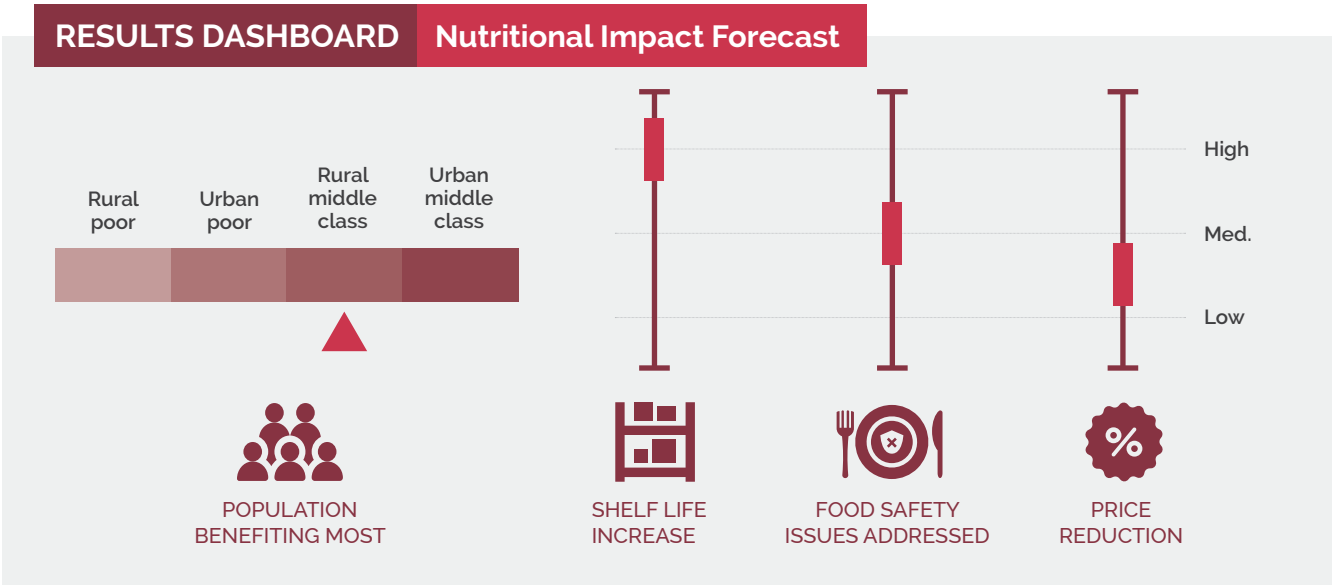
Market brokerage via mobile devices would primarily be suitable for businesses and organizations already in operation in the agriculture sector. Depending on how the technology is adapted to the local context there is potential for uptake by a farmers cooperatives, aggregators, and retailers. The potential for adaptation also makes it difficult to project the level of training required to promote end user uptake. More complex applications may require more prolonged engagement, while simple SMS services could be introduced more quickly.

Collaborations and partnerships

The key partnership for the success of this innovation is the connection between suppliers and retailers. Both sets of actors would require visibility into each other's stocks and prices, trust in the reliability of this information, and confidence that agreed upon prices will be paid and products delivered in a timely manner. This requires significant buy-in by the end-users, which may need to be supported by upfront engagement during the product development phase. A further consideration is whether financing schemes are required to enable lower-income actors to acquire the necessary technology (e.g. phones or tablets).

Considerations for business models

To increase uptake by end-users, business models for this innovation should account for how the application needs to be adapted to ensure the usability and reliability of information. Applications should translate information into something that is simple and understandable for all parties involved, make it easy to update this information as stocks change, and ensure this information is as transparent as possible to ensure equity.



MOBILE PRE-COOLING AND PACKHOUSES

INNOVATION SNAPSHOT

Delphi directive	Target nutritious food
Invest in proximate processing	All perishables such as dairy, meats, fruits, and vegetables
Link with:	Cooperative processing and packaging

Pre-cooling and packhouses typically contain adaptive refrigeration systems that adjust to the needs of specific crop varieties, extending the holding life of perishable foods. Mobile pre-cooling and packhouse units provide farmers access to pre-cooling technologies when cold storage is not immediately available. This reduces food waste, extends shelf life, preserves nutritional quality, and reduces microbial food safety risks. Increased product availability across markets can also stabilize demand, providing farmers with incentive to increase production.

In India, Promethean Power Systems has successfully rolled out mobile chilling systems for dairy producers, and Pick 'N Serve enables farmers to pre-cool bananas on site before transporting them to reefer storage containers. As the units are more widely adopted, they will spur SMEs in urban and rural areas alike to invest in high quality storage, sorting, packing, and distribution facilities. This potential for a domino effect calls for stakeholders to develop a replicable framework for scaling this innovation

NEEDS

Context and Infrastructure

Mobile pre-cooling and packhouses would require well developed transportation infrastructure in order to reach the rural areas targeted by this innovation. Energy infrastructure in the form of fueling stations would also be required, however, there is potential that solar installations could be used to power service provision on-site. This innovation would primarily target rural areas.

End User Considerations

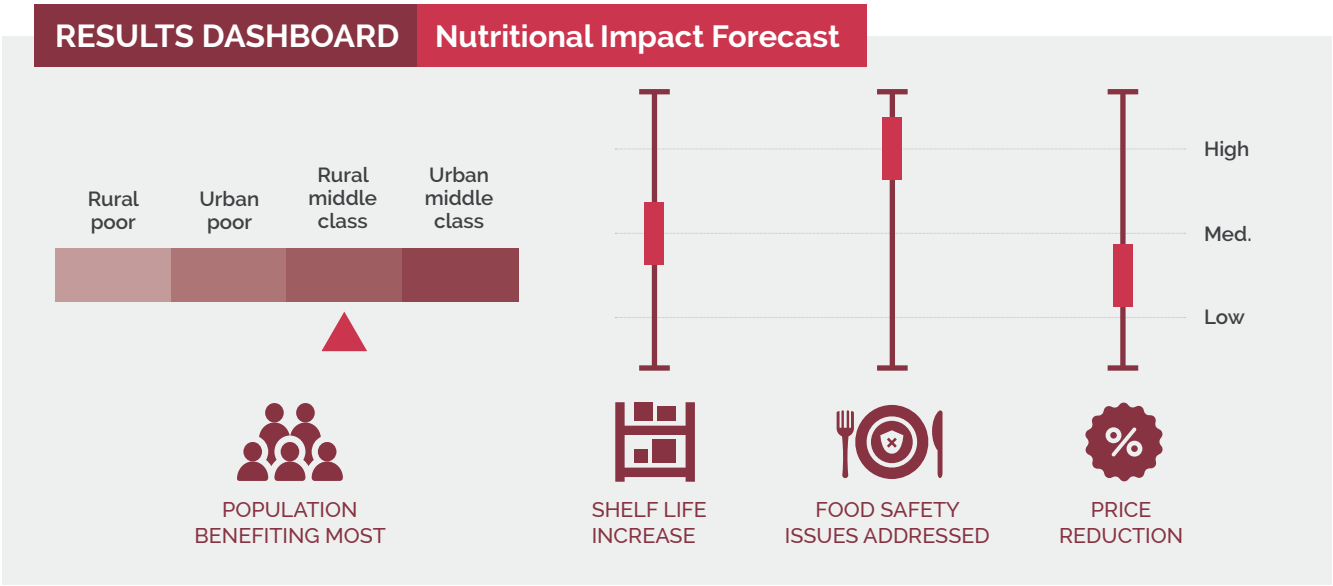
Mobile pre-cooling and packhouses could be targeted to a variety of end-users. Entrepreneurs, cooperatives, and SMEs are envisioned as the primary service providers, while farmers above the poverty line are envisioned as the service users who would pay businesses for accessing the service. For service providers, there would be some level of training required to understand the operation of the equipment, while service users might require a simple explanation.

Collaborations and partnerships

The key partnership for this innovation is the link to downstream, temperature controlled, distribution channels. This innovation focuses on bringing services closer to farmers to fill the gap in access to cooling and packing services at the first-mile services. Without agreements further along the supply chain this would simply delay the degradation of farmers' products, but not actually ensure that more supply is reaching markets.

Considerations for business models

In addition to the downstream distribution channels, business models for this innovation should consider the cost-effectiveness of technology decisions. While certain energy solutions like solar might require more upfront investments, they may provide cost-savings in the long-run due to reduced operating costs. Adequate training for staff is also necessary to ensure proper handling of foods.



ON-DEMAND 3rd PARTY LOGISTICS

INNOVATION SNAPSHOT

Delphi directive	Target nutritious food
Tackle traceability for transparency	Perishable foods such as meat, fishery products, dairy, fruit, and vegetables; Cereals and pulses
Link with:	Small-scale refrigerated transport, Modular factories, Mobile pre-cooling and packhouses

On-demand 3rd Party Logistics (3PL) utilizes mobile technology to provide for the fair, transparent, and efficient movement of food between areas where it is grown and areas where it is consumed. By connecting fragmented land holdings across supply chains, on-demand 3PL covers logistics gaps and offsets transport costs while also creating jobs. This system can easily move seasonal oversupply into markets with greater demand, thereby increasing access to nutritious foods in those markets.

A number of companies have cropped up in recent years to help bridge the gap between producers and consumers. Kenya-based Twiga Foods uses a web-based platform to source quality produce from rural producers and deliver to urban food vendors. Arguppa in Colombia uses mobile apps, SMS, or calls, while India-based CroFarm also presents farmers with guidance on market demand via mobile app. In order to scale this innovation to address broad food systems challenges, stakeholders can take on communal logistics challenges over micro-logistics. A high-level sorting of the food system will create valuable infrastructure availing more improved access to nutritious foods to more people.

NEEDS

Context and Infrastructure

On-demand 3PL would rely on a combination of transport and ICT infrastructure to be effective as a value chain solution. Depending on the level of transport infrastructure development, it could be targeted to rural, urban, and peri-urban areas. ICT required would vary depending on the application developed, ranging from SMS-based solutions to mobile applications that use 3G(+) networks.

End User Considerations

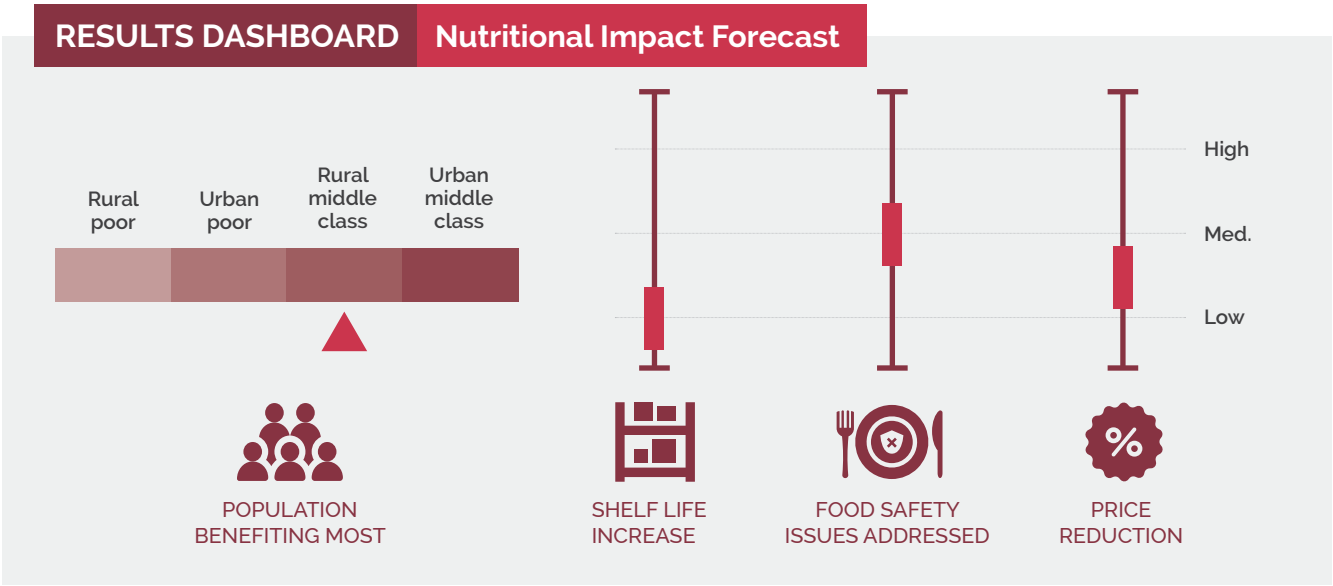
On-demand 3PL could be targeted to a variety of end-users. Entrepreneurs and SMEs are envisioned as the primary service providers, while there are a variety of potential service users, including farmers, cooperatives, aggregators, and other agribusinesses. To provide this service would require a significant level of expertise in logistics and supply chain management, but for service users uptake can be facilitated through short demonstrations.

Collaborations and partnerships

A business seeking to capitalize on the opportunity presented by on-demand 3PL would need to develop trust with actors on both ends of the supply chains, including suppliers and retailers. Working with civil society stakeholders that have knowledge of distributed farming networks could be one opportunity to bridge the gap on the supply side to ensure more consistent supply channels. Alternatively, innovators could focus on developing relationships with aggregators. On the retail end, relationships will need to be developed with the target retailers, which can vary from super markets to smaller food vendors, through outreach.

Considerations for business models

The most important consideration for this innovation is understanding the geographic extent that an on-demand 3PL provider can be profitable matchmaking the supply from rural area producers to demand from offtakers in a specific urban area. To be able to serve larger geographic areas would require establishing offtaker relationships with retailers in a variety of locations.



NEAR-FARM MOBILE PROCESSING

INNOVATION SNAPSHOT

Delphi directive	Target nutritious food
Invest in proximate processing	Perishables such as fresh vegetables, fruits, meat and dairy; Small scale livestock production; Cereals and pulses

Near-farm mobile processing units offer fee-based value addition services in areas where processing technologies are limited or unavailable. These technologies can be moved from one farm to the next as needed. For producers, the result is a high-quality value-added product, such as jellies, pickles, juices, flours, and frozen fruits and vegetables, which can be sold in either local or distance markets. The reduced perishability from such processing increases consumer access to nutritious foods.

In Uganda, UK-based processing company Alvan Blanch is piloting a mobile juicing plant specific to low-resource contexts. The truck comes fully-equipped with a generator, water treatment cylinder and a fruit-processing unit to preserve the pulp. Similarly, DADTCO Philafrica uses mobile processing technologies to manufacture cassava-based products, which are widely consumed though not part of a planetary health diet. In order to increase the availability of these processed foods, stakeholders should align to decentralize distribution, allowing the products to reach rural and low-income consumers.

NEEDS

Context and Infrastructure

Near-farm mobile processing would rely heavily on local transport infrastructure to provide adequate services to farmers, as units need to be able to reach producers at the first-mile. In addition, units would require likely require diesel fuel unless technologies reliant on alternative fuel sources, like biofuels, can be developed. Both are important considerations for this innovation, which is best suited for deployment in rural areas.

End User Considerations

Near-farm mobile processing would best be provided by SMEs or cooperatives, with farmers accessing processing as a paid service for value-addition. SMEs or cooperatives providing this service would require some sort of training in the operation of the processing equipment, as well as food handling practices, to ensure high quality and safe outputs. The panel estimates that 15 – 50% of end users could be reached in a five year time frame.

Collaborations and partnerships

Collaboration is most needed at the local level to connect a few processors to many farmers, particularly during times of seasonal harvests when the service is most needed. Another important partnership consideration is the role of government in promoting the food safety of processed products. Organizations interested in supporting near-farm mobile processing can explore ways to bridge financing gaps for stakeholders interested in taking up this innovation, particularly as it relates to upfront capital requirements and long-term operating costs.

Considerations for business models

Business models for near-farm mobile processing need to take into account how to profitably provide services when demand from farmers is highest (e.g. during times of harvest) while having leaner operations during other parts of the year. Diversifying the type of crops processed could help. There is also a need to explore ways to maximize value-addition for farmers to enhance demand for near-farm mobile processing services.

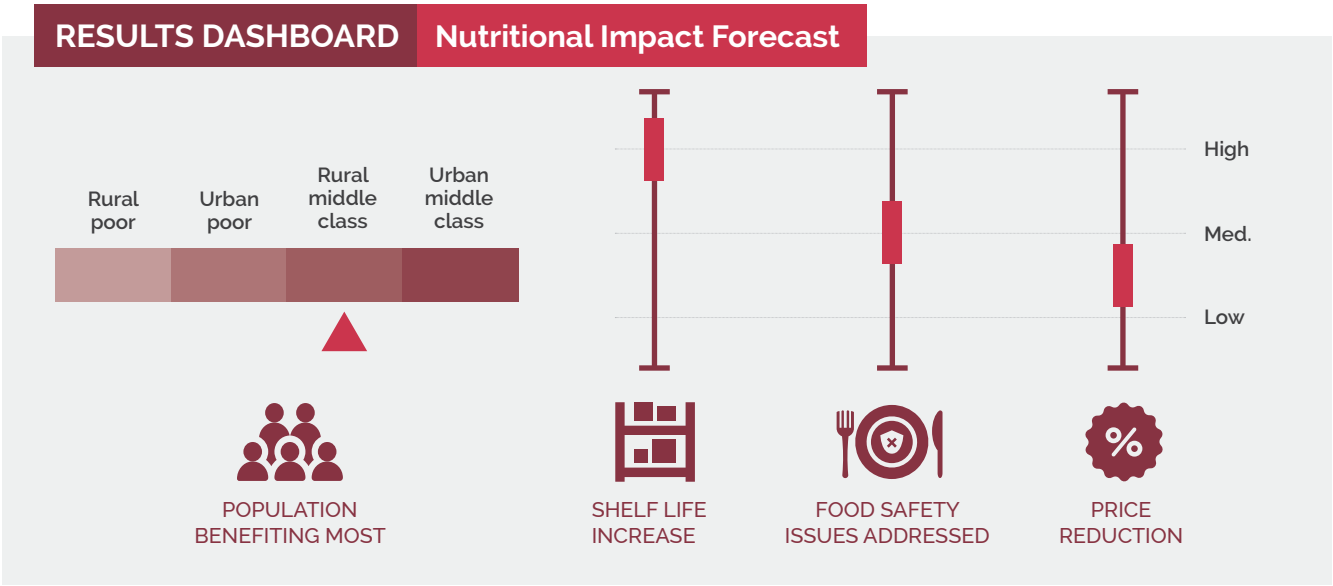


Image: ColdHubs

SMALL-SCALE COOLING BOXES

INNOVATION SNAPSHOT

Delphi directive	Target nutritious food
Keep it cool	Dairy products, meat, fruits, and vegetables; all perishables
Link with:	Small-scale refrigerated transport, On-demand 3PL

Low cost and efficient cooling boxes combine the technology of a traditional refrigerator, evaporative cooling, and solar cooling. They provide an option for remote producers and consumers needing access to cold chain. Cold chain access is a key leverage point in order to improve food safety and access to food and decrease food loss.

In Kenya, FreshBox has pioneered a cooling technology able to extend the shelf life of fruits and vegetables to over 21 days. It has the ability to be powered by solar energy and can be rented on a crate per day basis. Similarly, ColdHubs provides on- or near-farm solar-powered cold storage through a subscription model. Tessol, the fastest growing cold chain product company in India, even offers customizable last-mile distribution cooling boxes. While last-mile distribution may be relevant to a small sector of the population, it has potential to improve the lives of the poorest and fill a niche.

NEEDS

Context and Infrastructure

Small-scale cooling boxes use solar powered refrigeration to cool produce in lieu of access to traditional cold chain, and thus do not require energy infrastructure to operate. This makes them adaptable to a variety of contexts, including rural, peri-urban, and urban areas.

End User Considerations

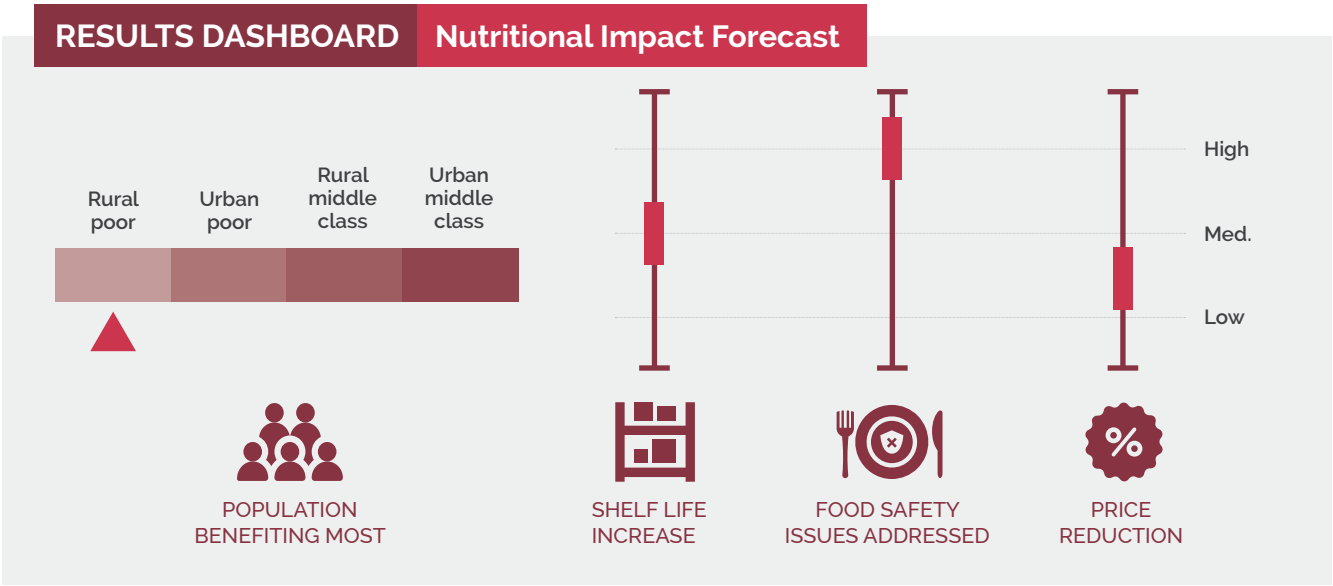
Small-scale cooling boxes could be suitable for end users at the first- or last-mile. Depending where and how they are deployed they offer a range of benefits for a variety of end users, including individuals at all income levels. In addition, the potential for simple designs and operation offers room for significant uptake over the next five years, estimated as high as 50%.

Collaborations and partnerships

Partnerships to promote small-scale cooling boxes can focus on connecting farmers, or groups of farmers, with equipment suppliers. A key partnership consideration is the availability of mechanics to repair the technology, which may require engaging with local repair businesses or universities if the technology is not simple enough for the owner to fix.

Considerations for business models

Business models for this innovation will need to understand the willingness to pay of end-users, and how those users would meet that price. For instance, a pay-as-you go subscription model has been used in some instances, while more standard sales models suppliers would benefit from developing financing schemes, potentially in coordination with local microfinance institutions or banks.



SMALL-SCALE REFRIGERATED TRANSPORT

INNOVATION SNAPSHOT

Delphi directive	Target nutritious food
Keep it cool	Small scale livestock supply, fish, fruit, and vegetables
Link with:	Small-scale cooling boxes, On-demand 3PL

Refrigerated transport is a critical link in food supply chains. Small-scale refrigerated transport continues cold chain until delivery to the sales point. By maintaining the temperature integrity of the products being transported, it reduces food loss and increases the quality and shelf life of nutritious foods reaching the remote locations.

In several cities across India, ColdEX offers a door-to-door frozen and refrigerated transport service with a load size ranging from 500 kg to 4000 kg. A fresh take on this concept is the Fruit-Cycle, a tricycle powered by biogas, which has a carrying capacity of 300 kg. Stakeholders endeavoring to distribute goods both close to production and far from production in remote, high-demand but low-supply areas must ensure that the price of goods is affordable for low income populations.

NEEDS

Context and Infrastructure

Small-scale refrigerated transport is adapted to contexts with limited transport infrastructure, including rural, peri-urban, and urban areas. However, access to fuel sources is still required to operate the vehicles, be that traditional sources or alternatives, like biofuel. Another important contextual consideration is whether local cold storage is available as an offtaker for the transporters goods.

End User Considerations

Small-scale refrigerated transport is a technology ripe for a variety of entrepreneurs to provide as a service, including individual service providers and SMEs. The most significant end-user consideration is the ability to maintain and repair vehicles and cooling chambers, which may require access to specialists like mechanics.

Collaborations and partnerships

Collaboration and partnerships to promote this innovation would need to focus on connecting a service provider using small-scale refrigerated transport with actors up and down the value chain, including farmers, packhouses, and markets. As a facilitative unit within the value chain, business relationships with suppliers and offtakers alike are critical. Another partnership consideration is whether this innovation is compliant with local food handling regulations. If not, the government would need to be engaged to create more flexible policies.

Considerations for business models

Business models for this innovation would benefit from developing clear understanding of the supply and demand needs in the local area. This may require engaging with a logistics company to improve understanding of this topic, and support more efficient distribution of small-scale refrigerated transport units.

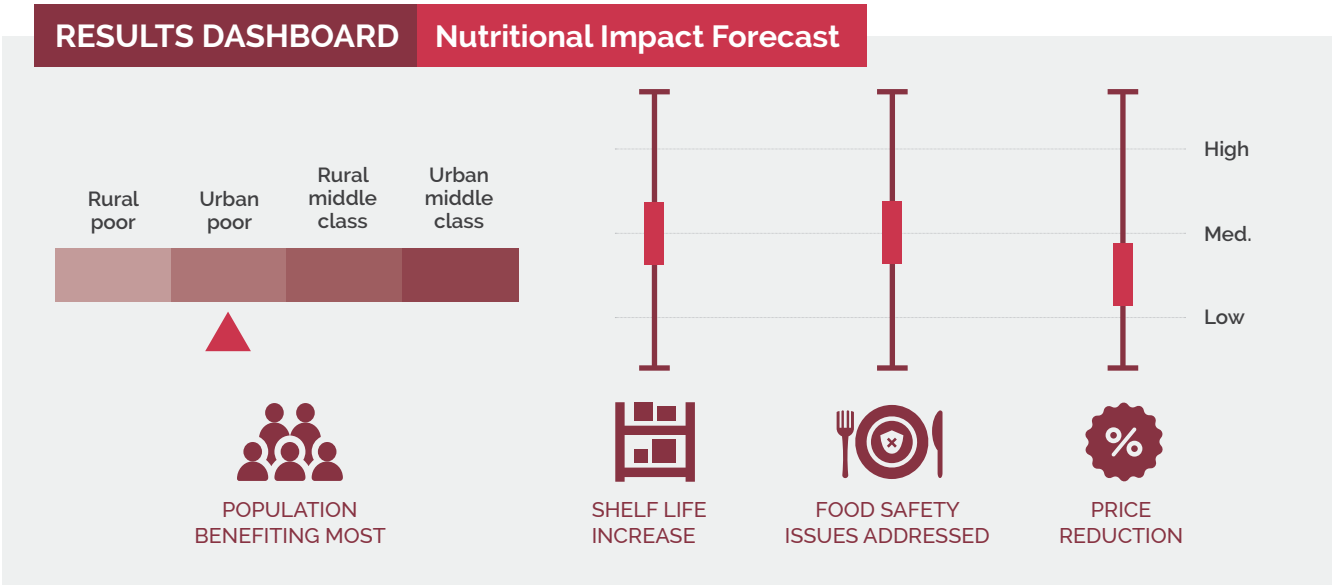


Image: Stanley Kimunge

SOLAR COOLING

INNOVATION SNAPSHOT

Delphi directive	Target nutritious food
Keep it cool	All perishables including dairy, animal proteins, vegetables, fruits, and raw spices
Link with:	SMobile pre-cooling and packhouses, Cooperative processing and packaging, Market brokerage via mobile devices, and Small-scale refrigerated transport

Solar cooling is used across cold chain to reduce the perishability of foods. Cooling extends shelf life and maintains quality and nutritional value for longer, ultimately expanding consumer access to nutritious foods. The technologies may utilize different principles from photovoltaic conversion to convective heat transfer.

Solar cooling has enabled milk to be stored cooled while awaiting collection at the farm gate. A step beyond reducing loss, the Kenya-produced Maziwa Plus cooler also includes a milk PH test kit, an automatic weighing scale, and a customized dairy cooperative management system. Kenyan Kibumbu Dairy Farmers Association owns one such solar cooling plant and sends two-thirds of its supply to the capital for processing. To counter the expense of these solar cooling plants, modular factory options may also be explored in conjunction with linkage to quality assurance instruments.

NEEDS

Context and Infrastructure

Solar cooling would require very little infrastructure to be used effectively, other than transport networks that would allow for the product to be distributed to target users. This makes it applicable in a variety of contexts, including rural, peri-urban, and urban areas.

End User Considerations

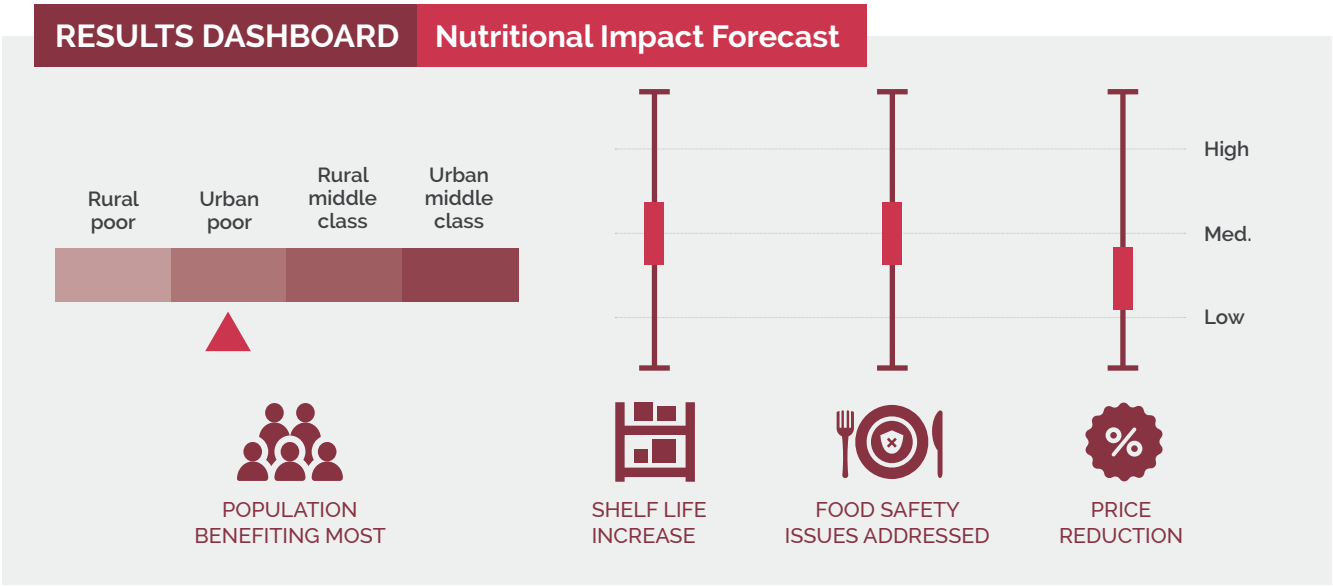
Solar cooling is relatively simple to use and would require very little explanation. Depending on how it is deployed it could end uses could include on-farm by farmers, in last-mile settings like markets, and throughout the value chain where products are stored. Depending on the target group, Delphi experts project that diffusion would likely range from 15-50% over the next five years.

Collaborations and partnerships

Collaboration and partnerships to maximize the benefits of solar cooling for farmers could focus on developing downstream relationships to link with other cold chain services, while partnerships in a market setting should focus on linking with upstream cold chain services. Without this, cooling benefits would be limited. Other partnership considerations could explore the facilitative role the government or financing institutions can play to enhance uptake, such as through tax incentives or financing models for operating costs.

Considerations for business models

Business model exploration for this innovation should start by understanding the payoff period of the investment in solar cooling, as costs will be concentrated, and benefits distributed over time. This is needed to understand which markets to target, as not all markets will bear near-term price increases for perishables that may be required to support the use of this innovation.



The Delphi Directives

The innovations profiled represent opportunities to begin to reorient food systems toward sustainable balance. As a group, the innovations strengthen local food systems to more effectively manage and distribute nutritious foods from the first mile to the last.

The Delphi Panel prioritized innovations that share a central tenet: context-appropriate innovations that reduce inefficiencies and waste can do more to make local markets work in the near term than exceedingly radical or disruptive innovations might.

The innovation opportunities deemed most promising by the Delphi Panel combat inefficiency and focus on specific changes at select leverage points along traditional value chains. We refer to these priorities as the Delphi Directives.

They are:

1. **Start with native, nutritious foods.** Production, processing and consumption of sustainable local foods reduces long-term reliance on imports and can yield planetary and human health benefits.

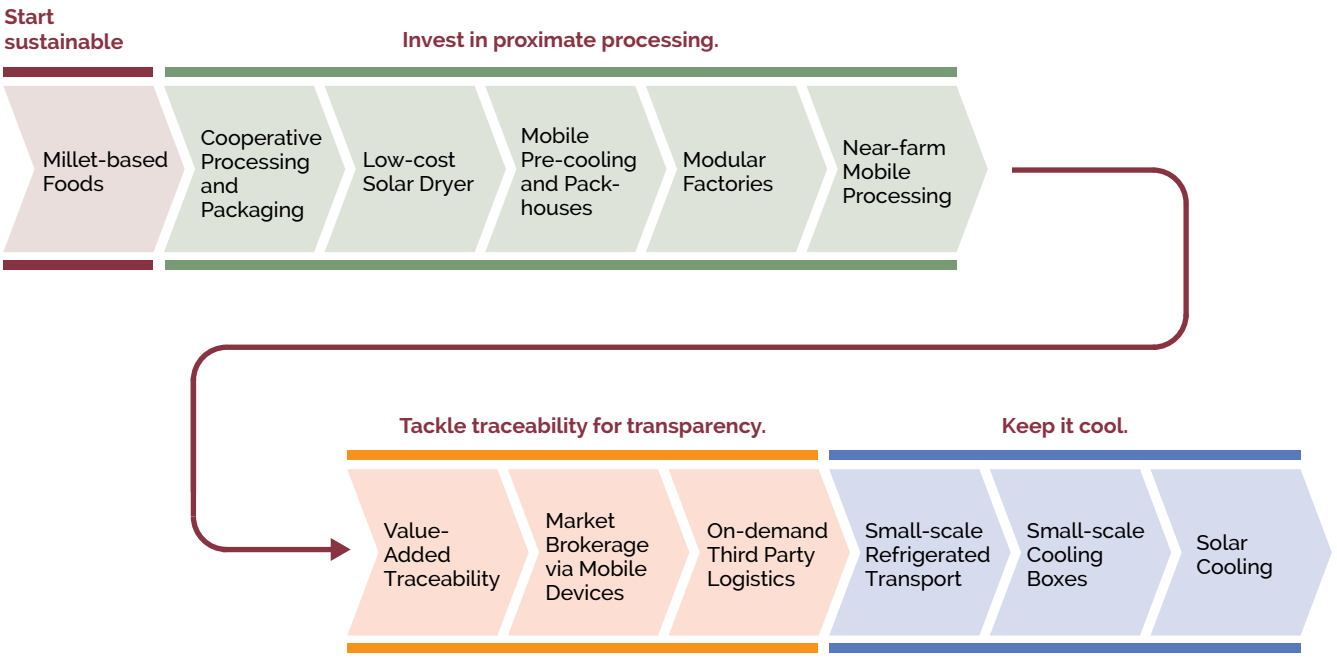
2. **Invest in proximate processing.** Processing and value addition closer to the point of production reduces postharvest loss, ensures nutrient retention, and increases the volume of nutritious foods on the market.

3. **Tackle traceability for transparency.** Efficient and transparent distribution enables access to wider markets, stabilizing demand and reducing price volatility, while ensuring food safety.

4. **Keep it cool.** Cold storage options at the last mile extend the life of nutritious food and make more nutrients available to vulnerable rural populations such as mothers, children and adolescent girls.

The Delphi Directives incorporate the top 12 innovation opportunities profiled in this report and provide a blueprint for maximizing investment impact at systemic leverage points where innovation can advance nutrition, as illustrated in Figure 4.

Figure 5: Delphi Directives and Innovation Opportunities



FROM INNOVATION TO IMPACT

While the Delphi Directives provide a blueprint for using innovation to increase access to nutritious foods, capitalizing on these opportunities will require several shifts to take place. Below we highlight four of these shifts and offer questions for consideration for stakeholders, from development actors and civil society to governments and the private sector.

The first shift, highlighted by our partners and Panelists, is the need to enhance the level of collaboration among diverse sets of stakeholders. Actors up and down the value chain lack a line of sight on the next steps in the chain, and thus miss out on opportunities to collaborate. Lack of coordination between government, civil society organizations, and development organizations further contributes to these systemic collaboration constraints. We believe the question development and civil society organizations should consider is: **How might we work with actors across the food system to promote collaboration?**

The second shift that needs to take place is where resources are being directed. If the problem of food loss and waste is truly as large of an economic opportunity as research suggest, then one would expect businesses to capitalize on it. However, it is possible that risk and uncertain returns are deterring capital from flowing toward potential market solutions. We believe the question finance institutions – both private sector and international financing bodies like multilateral development banks – should consider is: **How might we create innovative modalities to finance food system change?**

Another shift that needs to take place is related to policy and regulation. This research, as well as our 2018 report "Putting Business to Work,"[25] highlighted a multitude of opportunities for government to enhance food systems, either through direct intervention or by the removal of barriers. We believe the question governments should consider is: **How might we make it easier for businesses to bring more nutritious foods to market?**

The final shift that we should work toward is something for all of us to consider. The long-term systemic transformation needed for our food systems to reorient toward people and planet will not take place unless we demand it and express it in how we spend our dollars, euros, pesos, renminbi, rupees, schillings, and yen. We believe the question we should all consider is: **How might we demand foods that sustain human and planetary health and disrupt unsustainable dietary trends?**

[25] Hansen, A. R., Keenan, C., Sidhu, G. K. (2018). Putting Business to Work: Policy Interventions for a Nutritious Food System. Postharvest Loss Alliance for Nutrition.

CONCLUSION

Innovation is urgently needed to bring our food systems into balance with the dual goals of human well-being and environmental sustainability. We believe our Short List offers twelve opportunities for high impact investments that can support this journey. Our Panel prioritized this Short List because they are adaptable to different contexts, affordable for target users, easy to use, and poised to scale.

Each of these innovations would provide benefits by supporting improvements in local market systems. Together, they would promote increased access to safe, nutritious foods that are available to consumers for longer periods of time. Ultimately policy, consumer preference, and business models will drive whether or not these foods are affordable, but by bringing more food to market there are opportunities to bring prices down by increasing the level of supply in the system. While these innovations largely represent incremental improvements, if well adapted to local contexts, they could drive significant changes in food systems, improving human well-being and environmental sustainability.

The current wave of food systems innovation marks an important opportunity for businesses and investors. Agri-tech is a USD 7.8 trillion industry.[26] Much of this investment is backing high-tech solutions that could change food on a fundamental level. For instance, a number of companies are already exploring processes for lab-grown meat, which could help to satiate consumer demand for animal products without the environmental costs of the livestock industry. Other organizations are exploring the ability of blockchain to provide solutions for end-to-end supply chain transparency, which is only one of the potential uses in the food system. 3D printing of food could beam gourmet recipes right to the kitchen counter, so long as heavily processed food is available to serve as the "ink." Data-driven vertical farming could bring the source of production closer to home for the world's increasingly urban population, in turn, reducing the need for complex global value chains. And CRISPR offers a litany of potential applications for altering crops on a genetic level, such as to increase their resilience to drought, or prolong their shelf life.

Ultimately, our Panel thought fundamental food-changing solutions like these were unlikely to take root in emerging markets in the next five years, and thus they prioritized other innovations. Investors seem to agree, as the majority of agri-tech investment is being made in developed markets, not emerging ones. The good news is that the financing gap in emerging markets creates an opportunity for investors looking for robust food system solutions adapted to local contexts.

The twelve innovations highlighted in this report are viable technologies, processes, and business models that can promote incremental change in the locales where it is needed most. If we capitalize on the opportunity presented by these innovations, we can begin the necessary shifts in our approach to food systems and start to bring food, people, and planet into balance.

[26] AgFunder. (2017). *AgFunder Agrifood Tech Investing Report: Year in Review.*

ANNEX: RESEARCH PROCESS

Innovation is often envisioned as a disruptive technology or business model that reorients convention. Innovations - concepts, technologies, and new adaptations of current solutions - can also usher in incremental positive change. These viable innovations integrate into existing processes and norms to create large-scale sustainable balance.

In 2018, GKI and its partner GAIN set out to understand which innovations have the most potential to advance specific outcomes – namely, accessibility affordability, food safety, and shelf life – in emerging economies in the next five years. GKI led a panel of 29 world-class experts at the intersection of agriculture, business, food systems, investment, and nutrition through a collaborative, virtual research process based on the Delphi technique. Over the course of four months, from December 2018 – March 2019, the Delphi Panel scrutinized an initial list of 68 prospective innovations and their respective value propositions to balance food systems to better access to nutritious foods where it is needed most. Many innovations on this initial roster surfaced at GKI's foresight and strategy development workshop on food systems innovation in Washington, DC in October 2018. More innovations emerged during our first engagement with experts in the Delphi process for a total of 87 innovations.

The Delphi Panel answered questions about each innovation's market opportunity, comparative advantage, critical risks, systemic enablers and barriers, time to scale, need for additional R&D, and dozens more important considerations. This process relied on the power of collective intelligence to illuminate which innovations have the highest potential to improve access to nutritious food in our target time frame and context. The experts collectively added to, revised, and prioritized the list of innovations, ultimately narrowing it to approximately 25 innovations.

From here, GKI applied a planetary health systems lens to assess which of these innovations demonstrate evidence of promoting the much-discussed planetary diets proposed in the 2018 EAT-Lancet Report. Essentially, we coded qualitative responses provided by the Delphi experts during our research process based on the following criteria:

- Demonstrated impact or demand in emerging economy contexts
- Improves food choice and dietary diversity for the most vulnerable consumers
- Improves food system sustainability
  - Reduces loss and waste
  - Shortens supply chains
  - Reduces yield gaps

In total, twelve innovation opportunities emerged, presenting immediate opportunities for technical development, support, and in some cases, investment.

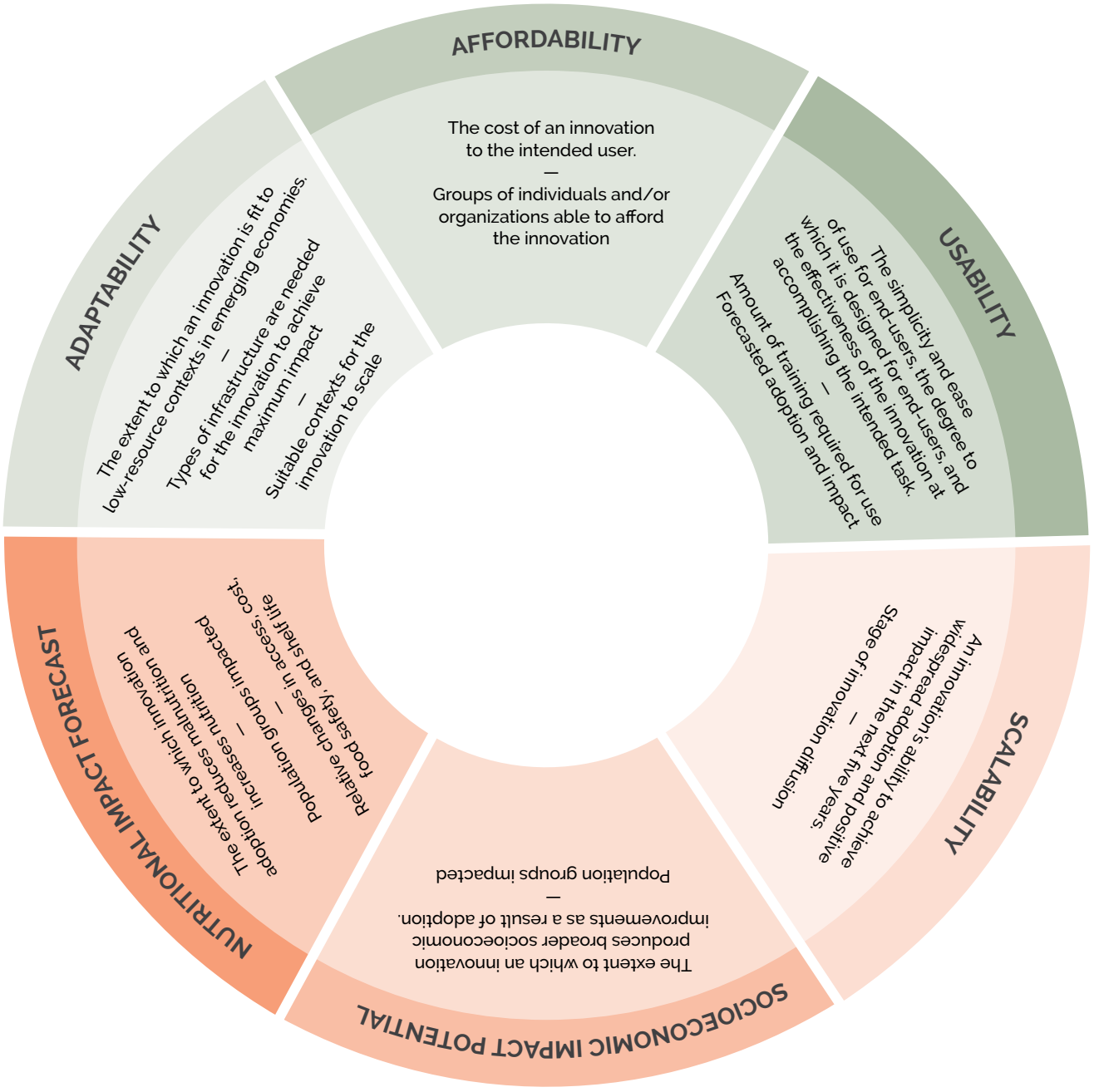
Evaluating the Short List

To generate a set of criteria most pertinent to evaluating the potential of an innovation to certain outcomes, prior to investment or deployment, we asked the Delphi Panel to identify criteria that they use, either implicitly or explicitly, to evaluate innovations. The result was a bountiful 100 recommended metrics for evaluation. The experts posed questions such as:

- Is the innovation easy to use and manage?
- What are the costs and benefits of deployment?
- Is the innovation associated with a sustainable business model?
- Can the innovation be deployed and scale to achieve impact in five years?
- What types of partnerships and support does the innovation require to scale?
- Does the innovation respect local values and cultural practices around food?

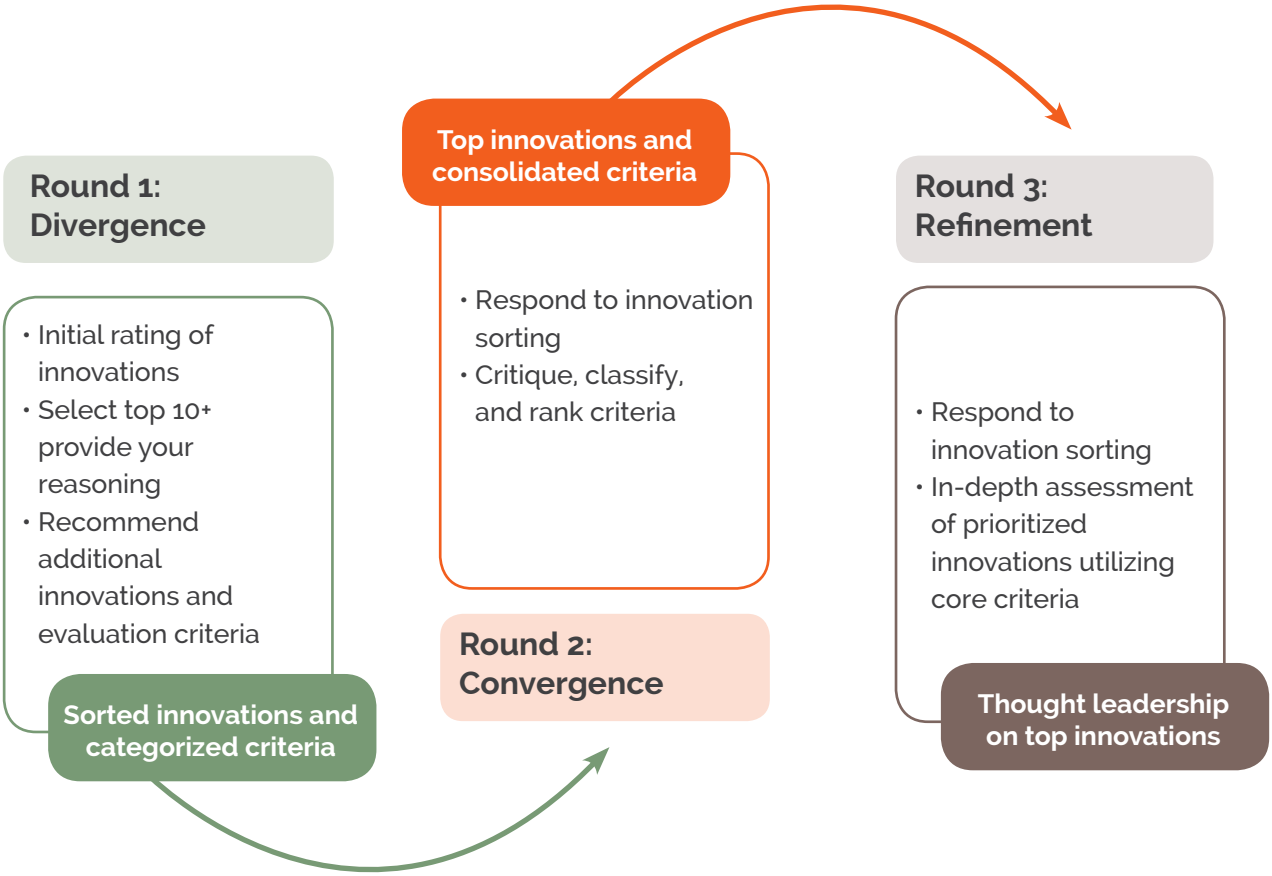
First, we coded these criteria into categories, to which the experts agreed or disagreed. Second, we asked our experts to use their initial recommendations to build a suite of criteria that could serve as an innovation assessment tool to describe and evaluate the potential of an innovation before it elicits investment. Figure A1 captures the six evaluation criteria, their shared meaning, and how they were applied in the context of this study.

Figure A1. Criteria Definitions and Application for Evaluation



Zooming out from the criteria, Figure A2 represents the inputs and outputs of two parallel Delphi processes – one to select innovations and one to select evaluation criteria. Through three rounds of engagement, the experts provided deep insight on the innovations and distinct values guiding criteria selection. Over the course of this process, the questions quickly slid from uncomfortably ambiguous to rather exhaustive. This is one of the greatest benefits of our methodology, aside from harnessing collective wisdom from all corners of the globe at once.

Figure A2. Overview of Innovation and Criteria Selection Processes



Once the experts completed a deep dive into each selected innovation, evaluating the selected innovations using the criteria above, we compared data across the portfolio of innovations. Below, we summarize key data in two tables. Table A1 displays information related to how an innovation might scale, as related to context, infrastructure, user friendliness, and partnership needs. Presenting the opposite side of this coin, Table A2 presents data in which the experts were asked to imagine the next five years in a world where the innovations have been provided with all needed support. This set of data forecasts to what extent each innovation might scale and its impact potential.

The data in these sets aggregate individual expert responses per question, per innovation. Each data point reports a greater than 50% expert consensus on a given need or potential outcome. The last column of each table represents a comparison of data across the innovations and provides information on similarities and distinctions across the portfolio.

Table A1. Analysis of Innovation Needs to Scale-up

		Cooperative Processing and Packaging	Low-cost Solar Dryer	Market Brokerage via Mobile Devices	Millet-based Foods	Mobile Pre-cooling and Packhouses	Modular Factories	Near-farm Mobile Processing	On-demand Third Party Logistics	Small-scale Cooling Boxes	Small-scale Refrigerated Transport	Solar Cooling	Value-Added Traceability	TOTAL
Adaptability – Necessary or Useful Infrastructure Needs	Transport	x	x			x	x	x	x		x			7
	ICT			x					x				x	3
	Energy	x	x			x	x					x		5
Adaptability – Most Appropriate Local Contexts	Rural villages	x	x	x	x	x	x	x	x	x	x	x	x	12
	Rural towns	x	x	x	x	x	x	x	x	x	x	x	x	12
	Peri-urban areas	x	x	x	x	x	x	x	x	x	x	x	x	12
	Urban areas								x				x	2
Affordability – Assets of Intended End Users	Individuals earning < $1.90/day		x		x					x				3
	Individuals earning $1.90-$10/day		x		x	x	x	x	x	x	x	x		9
	Individuals earning > $10/day	x			x	x	x		x	x	x	x		8
	Small enterprises	x	x	x	x	x	x	x	x	x	x	x	x	12
	Medium enterprises	x	x	x		x	x	x	x		x	x	x	10
	Large enterprises	x		x									x	3
Usability – Necessary or Useful End User Training	Requires no training			x										1
	Requires simple explanation/ demonstration	x		x	x	x			x	x	x	x		8
	Requires a detailed explanation or short training		x					x	x			x		4
	Requires prolonged training/engagement	x		x		x	x						x	5
	Not usable for non-specialists													0
Usability – Necessary or Useful Collaborations	Local-level	x	x	x	x	x	x	x	x	x	x	x	x	12
	External non-specialist		x				x							2
	External specialist	x	x	x			x	x	x	x	x	x	x	10

Table A2. Analysis of Innovation Potential

		Cooperative Packaging	Low-cost Solar Dryer	Market Brokerage via Mobile Devices	Millet-based Foods	Mobile Pre-cooling and Packhouses	Modular Factories	Near-farm Mobile Processing	On-demand Third Party Logistics	Small-scale Cooling Boxes	Small-scale Refrigerated Transport	Solar Cooling	Value-Added Traceability	TOTAL
Scalability - Expected diffusion in 5 years	Early Adopters (0-15% diffusion)				x		x							2
	Early Majority (15-50%)	x	x	x	x	x		x	x	x	x	x	x	11
	Late Majority (50-85%)												x	1
	Laggards (85-100%)													0
Socioeconomic Impact – Populations Forecasted to Benefit Most	Smallholder farmers	x	x	x	x	x	x	x	x	x	x	x	x	12
	Women		x			x		x		x	x	x	x	7
	Youth					x		x			x	x	x	5
	Rural residents	x	x		x	x	x	x	x	x	x	x	x	11
	Urban residents						x				x	x		3
	Cooperatives	x	x	x	x	x	x				x	x	x	9
	SMEs	x		x		x	x	x	x	x	x	x	x	10
	Supply chain actors			x		x	x	x			x	x	x	7
Nutritional Impact – Populations Forecasted to Benefit Most	Rural poor	x	x		x	x	x	x		x	x	x	x	10
	Urban poor	x	x	x	x	x	x	x		x	x	x	x	11
	Rural middle class	x	x	x	x	x	x	x	x	x	x	x	x	12
	Urban middle class	x	x	x		x	x	x	x	x	x	x	x	11
Nutritional Impact –Forecasted Change in Affordability	0-50% reduction in price	x	x	x	x	x	x	x	x	x	x	x	x	12
	50-100% reduction in price												x	1
	1-2x reduction in price													0
	> 2x reduction in price													0
Nutritional Impact – Forecasted Change in Shelf Life	None			x	x									2
	1-5 days	x				x	x		x	x				5
	5-30 days	x	x			x	x	x		x	x	x	x	9
	30+ days		x				x	x						3
Nutritional Impact – Forecasted Scope of Food Safety Issues Addressed	None			x	x									2
	<5%												x	1
	5-10%	x		x				x	x		x			5
	10-50%	x	x			x		x	x	x	x	x		8
	50-100%	x	x			x				x			x	5