

ECONOMIST  
IMPACT

# Feeding the future

How agricultural value chains support inclusive  
and sustainable food systems

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# Foreword

At Lineage, our global team plays a vital role in protecting one of the world's most valuable resources—food—as it moves from where it's produced to where it's consumed. As the world's largest temperature-controlled warehousing and logistics company, our network connects consumers around the globe to safe, quality food.

We are proud to partner with Economist Impact to explore the value that a robust food supply chain brings to society. Moreover, the findings demonstrate how investing in the underlying infrastructure of the food supply chain—including in cold storage, processing and transport—has the potential to boost agricultural productivity, reduce waste and empower communities. Accordingly, this research speaks to the enduring quality of our purpose to transform the food supply chain to eliminate waste and help feed the world.

We believe this report should serve as a call to action. Despite producing enough food to feed everyone, inefficiencies and waste in the system continue to lead to millions facing food insecurity and hunger. There is an opportunity for governments, non-government organisations and private sector partners to collaborate in creating long-term solutions to this age-old challenge. Now is the time to build a global food supply chain that is truly up to the task of feeding the world.

— **Greg Lehmkuhl**, President and CEO, Lineage

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# Introduction

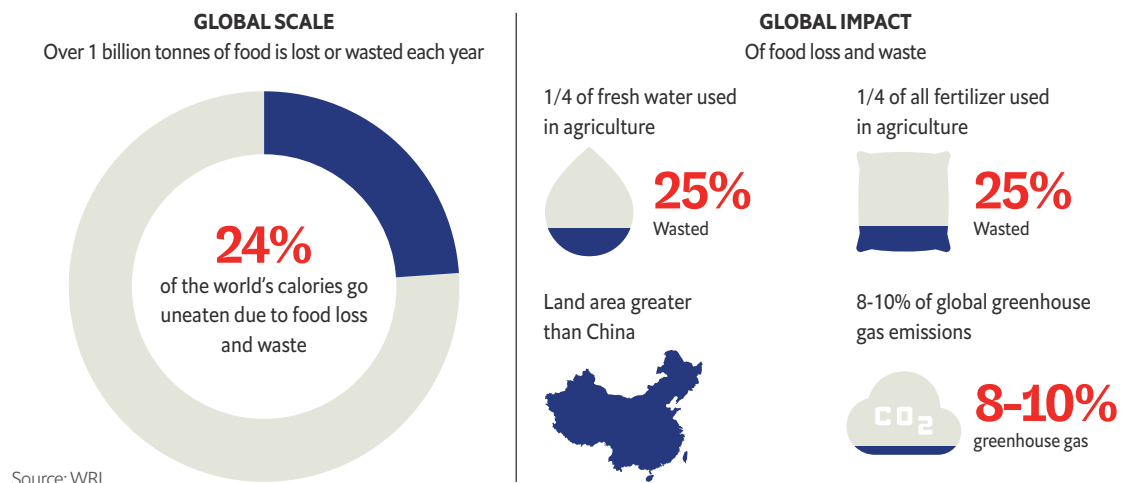
The global food system begins with production and ends with food on our plates, with about 1.3 billion people<sup>1</sup> growing, transporting, processing, storing and selling food, as well as handling food waste. Sustainable and resilient infrastructure ensures each part of this value chain works efficiently, making sure everyone has access to safe, nourishing food.

However, the current global food system needs to be more sustainable and equitable.<sup>2</sup> While enough food is produced to feed the 8 billion people on Earth about 2,200 calories per day,<sup>3</sup> around 733

million people still go hungry,<sup>4</sup> 3.1 billion can't afford a healthy diet (42% of the world's population)<sup>5</sup> and 2.5 billion are overweight or obese.<sup>6</sup>

Adding to these problems, nearly a third of all food is wasted.<sup>7</sup> In developing countries, most of this waste is on farms due to the lack of both storage and processing facilities. As climate change adds pressure to the food system, robust infrastructure is vital, especially in hard-to-reach areas like remote regions or places adversely affected by climate change and low socioeconomic progress.

**FIGURE 1: The scale and impact of food loss and waste**



<sup>1</sup> Metabolic. (n.d.). Global food system: An analysis. <https://www.metabolic.nl/publication/global-food-system-an-analysis/>

<sup>2</sup> Fanzo, J., et. al., (2023). The state of food systems worldwide in the countdown to 2030. *Nature Food*, 4(6), 438-449. <https://doi.org/10.1038/s43016-023-00885-9>

<sup>3</sup> KC, K. B., et. al. (2018). When too much isn't enough: Does current food production meet global nutritional needs? *PLOS ONE*, 13(10), e0205683. <https://doi.org/10.1371/journal.pone.0205683>

<sup>4</sup> Action Against Hunger. (n.d.). World hunger facts & statistics. <https://www.actionagainsthunger.org/the-hunger-crisis/world-hunger-facts/>

<sup>5</sup> Cafiero, C., & Kee, M. (2023, July 12). Over 3.1 billion people could not afford a healthy diet in 2021 - an increase of 134 million since the start of COVID-19. *World Bank Blogs*. <https://blogs.worldbank.org/opendata/over-31-billion-people-could-not-afford-healthy-diet-2021-increase-134-million-start-covid>

<sup>6</sup> World Health Organization. (2023, June 9). Obesity and overweight. <https://www.who.int/news-room/fact-sheets/detail/obesity-and-overweight>

<sup>7</sup> United Nations Environment Programme. (2024). Food Waste Index Report 2024: Key messages. <https://wedocs.unep.org/bitstream/handle/20.500.11822/45275/Food-Waste-Index-2024-key-messages.pdf?sequence=8&isAllowed=y>

### Food infrastructure enables food security and productivity

Infrastructure is a critical component of food systems, enabling and driving food security and agricultural productivity. It impacts how people grow, obtain and consume food, as well as their opportunities to be healthy, educated and financially secure. A robust food system relies on various types of infrastructure—including irrigation systems, processing facilities, warehousing and cold storage, transport networks, and retail stores<sup>8</sup>—that span the entire supply chain. This enables the movement of food from producers to distribution centres in the ‘first mile’ to regional hubs in the ‘middle mile’ and concludes with delivery to consumers in the ‘last mile’.


In hard-to-reach areas, there is often a lack of reliable and safe infrastructure. This limits the opportunities that farmers have to process and sell their products, ultimately affecting their livelihoods. Experts highlight that farmers who live in these areas are typically smallholders with low crop yields who struggle to access or afford food. They may lack agricultural workers, food preservation methods, market access, or funds for seeds and supplies. As a result, they may also encounter significant food waste as well as health risks from spoiled food. These challenges extend beyond farmers, with non-farm workers and their families in these areas facing limited job opportunities and low income-earning potential, restricting their ability to buy nutritious food.



**“Communities need a marketplace, and if that doesn’t exist then someone needs to build it. It’s often basic infrastructure that’s needed, such as sheds to protect produce from the sun, bathrooms and lighting so women feel safer,”**

- Emily Chai, head of citrus, Invaio

<sup>8</sup> Morris, S. S. (2023). The case for increased investment in food systems infrastructure in low- and middle-income countries. Global Alliance for Improved Nutrition (GAIN). Discussion Paper #13. <https://www.gainhealth.org/sites/default/files/publications/documents/GAIN-Discussion-Paper-Series-13-The-case-for-increased-investment-in-food-systems-infrastructure-in-low-and-middle-income-countries.pdf>



**“A sustainable food value chain should be climate-positive, enhancing soil health and water quality while building trust among market actors, especially in the global south,”**

- Kindra Halvorson, chief transformation officer, Technoserve

### **Sustainable food value chains: bridging gaps and empowering communities**

Well-designed infrastructure can help people access healthy food and boost their economic and social prospects. But infrastructure alone does not guarantee that communities, including historically marginalised groups such as women or low-income individuals, get the opportunities or resources they need. Public policy is a key enabler to map and monitor impacts throughout the overall food value chain, ensuring the right

interventions to boost economic, social and environmental outcomes. These are important to achieve, as the world needs to invest US\$400bn a year until 2030 to combat hunger and build a sustainable food system.<sup>9</sup>

This report explores the potential impacts of food system infrastructure on people in hard-to-reach areas through a detailed examination of four pathways—economic, nutritional, social and environmental. The following section starts with economic impacts.

<sup>9</sup> IFAD. (2023). Transforming Global Food Systems: \$400 billion needed per year while doing nothing could cost \$12 trillion. <https://www.ifad.org/en/w/news/transforming-global-food-systems-400-billion-needed-per-year-while-doing-nothing-could-cost-12-trillion>

# Unlocking potential income growth and market connectivity through food systems infrastructure

## Boosting incomes: the power of effective food chains

Sustainable infrastructure can transform the lives of smallholder farmers in hard-to-reach areas by increasing their incomes and fostering economic development. Often trapped in subsistence farming, these farmers struggle to access necessary supplies and lack the land, money, education and information needed to produce beyond their family's needs.

Addressing these challenges through improved infrastructure and investments in labour-saving and efficiency-enhancing technologies can significantly boost productivity. With more resources, farmers can sell their crops to consumers and buyers, breaking the cycle of subsistence. For instance, smallholder farmers with access to irrigation can produce up to three times more food than those without, allowing them to cultivate more land and grow diverse cash crops, directly increasing their incomes.<sup>10</sup> Additionally, processing and packaging facilities lead to higher-value produce sales and create off-farm job

opportunities<sup>11</sup> in areas like transport, maintenance and quality control. Storage and drying facilities help reduce post-harvest losses and waste, ensuring farmers have more to sell.

Improving roads, for the most part, helps farmers earn higher incomes and cuts transport costs.<sup>12</sup> But infrastructure investments alone are insufficient to guarantee these outcomes. A nuanced policy approach is also required, one that complements infrastructure investments with measures that promote market and crop diversity, engage local communities, and monitor outcomes to sustainably improve farmers' incomes.

Collaboration among governments, non-government organisations (NGOs) and business is crucial for providing the training, technology and resources that help farmers become better at producing, processing and marketing. Partnerships, such as community-based village savings and loans associations in Ghana and the Ivory Coast, have proven effective in helping members save money and access small loans to start businesses and diversify their incomes.<sup>13</sup>

<sup>10</sup> Maru H, Hailelassie A, Zeleke T. Impacts of small-scale irrigation on farmers' livelihood: Evidence from the drought prone areas of upper Awash sub-basin, Ethiopia. *Heliyon*. 2023 May 16;9(5):e16354. doi: 10.1016/j.heliyon.2023.e16354.

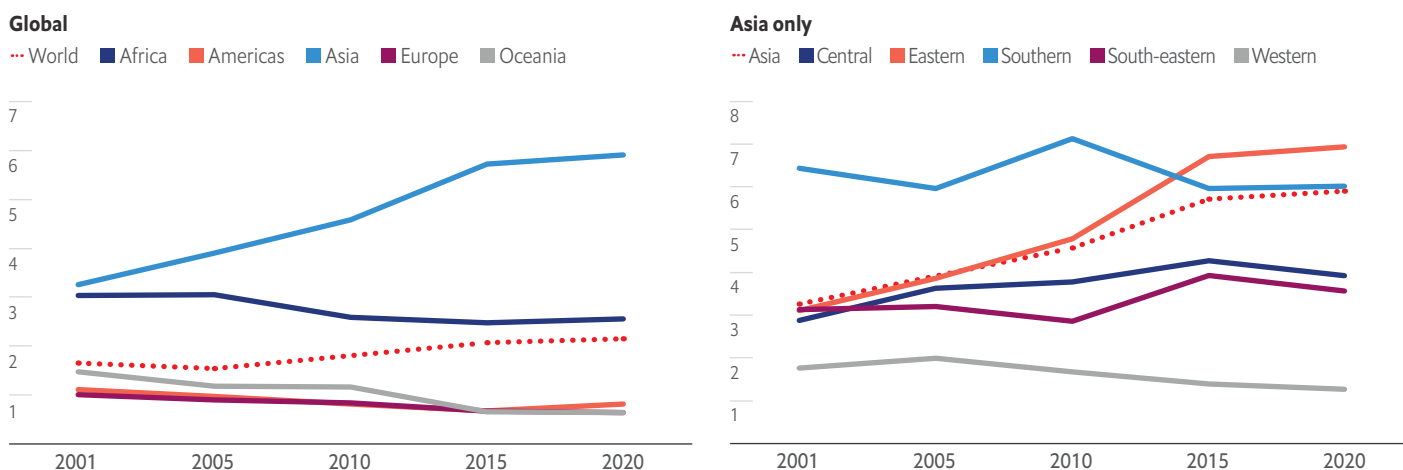
<sup>11</sup> Bryan, E., & Garner, E. (2022). Understanding the pathways to women's empowerment in Northern Ghana and the relationship with small-scale irrigation. *Agriculture and Human Values*, 39(1), 375-393. <https://doi.org/10.1007/s10460-021-10291-1>

<sup>12</sup> Inoni, O. E. (2009). Effects of road infrastructure on agricultural output and income of rural households in Delta State, Nigeria. *Agricultura Tropica et Subtropica*, 42(2), 90-97.

<sup>13</sup> Amoak, D., Braimah, J. A., Agyemang-Duah, W., Osei Kye, N., Anfaara, F. W., Sano, Y., & Antabe, R. (2024). The Impact of Village Savings and Loan Associations as a Financial and Climate Resilience Strategy for Mitigating Food Insecurity in Northern Ghana. *Risks*, 12(4), 58. <https://doi.org/10.3390/risks12040058>

**FIGURE 2: Share of agriculture in government expenditures by region (%) (2001-2020)**

Public investment in agriculture, particularly in low-income countries, should increase in order to achieve the much-needed economic benefits



Source: FAO (2021)

### Bridging the gap: infrastructure connects farmers to markets

While effective food chains boost productivity in hard-to-reach areas, their full potential is unlocked only when robust infrastructure connects farmers to markets. If farmers can triple their yield but there is no one to sell their food to, or nowhere to safely store it before it's sold, it will go to waste, giving them little incentive to increase productivity.

Both public and private sector involvement are crucial for overcoming these logistical inefficiencies.<sup>14</sup> To compete in industrial value chains in modern food systems, decision-makers need to help smallholder farmers counter the significant fixed costs, structural barriers and power imbalances they face.

Storage, for example, allows farmers to time their sales and access distant markets, while all-weather roads improve local market access,<sup>15</sup> allowing them to choose

between multiple traders.<sup>16</sup> Making sure farmers have information on prices and demand can guide them on what to grow and when to sell at these markets.


In addition to physical infrastructure, soft infrastructure—such as telecommunications, extension services and financial services—enhances information flows. Farmer co-operatives and producer groups can improve connections to formal markets, enabling collective bargaining for better prices and securing finance. For example, coffee co-operatives in Honduras help farmers use the latest information and technology solutions to secure better prices and access international coffee auctions. Furthermore, mobile phone and digital platforms strengthen bargaining power, linking producers with traders. These technologies also assist farmers in meeting quality control and market standards for higher-value markets, including those related to sustainability and climate change.

<sup>14</sup> United Nations Department of Economic and Social Affairs. (2021). Frontier technology issues: Frontier technologies for smallholder farmers: Addressing information asymmetries and deficiencies. <https://www.un.org/development/desa/dpad/publication/frontier-technology-issues-frontier-technologies-for-smallholder-farmers-addressing-information-asymmetries-and-deficiencies/>

<sup>15</sup> Jouanjean, M. A. (2013). Targeting infrastructure development to foster agricultural trade and market integration in developing countries: an analytical review. Overseas Development Institute. <https://odi.cdn.ngo/media/documents/8557.pdf>

<sup>16</sup> Food and Agriculture Organization of the United Nations. (2003). The role of agriculture in the development of least-developed countries and their integration into the world economy. <https://www.fao.org/4/Y6831E/Y6831E-04.htm>



A photograph of a man wearing a hat and a light-colored shirt, leaning over a large pile of cocoa beans in a field. The background shows lush green foliage, likely a cocoa plantation. The lighting is warm, suggesting late afternoon or early morning.

**“Companies need to put in place robust systems in their supply chains. But to make an impact and improve conditions in the rural areas where cocoa is grown, these systems need to be connected to broader governments and industry initiatives. We also need clear policies in place and [to] collaborate with implementing partners that can actively work with and through those government systems to ensure collective and co-ordinated actions,”**

- Olivier Zwolsman, responsible sourcing manager cocoa, Ferrero

### **Case study: Honduras Coffee Chain (2020-23)**

In 2020 three coffee co-operatives and their partners teamed up under the Coffee Chain project to help 800 small family farmers in Honduras earn more money by using blockchain technology for digital recordkeeping. Using this technology, the farmers were able to get information on the quality and price of coffee and go directly to buyers through international coffee auctions.

Over three years, the project educated 643 farmers on this technology and registered 904 farmers on the platform. They also trained 96 workers from the co-operatives, including 48 women, on how to use blockchain. Additionally, 904 coffee producers became associated with co-operatives that adopted the new blockchain technology to provide transparency in the coffee chain.

Despite its small size, this project provides important lessons that can be applied to larger-scale projects. It highlights the importance of stakeholder collaboration and showcases that when farmers use new technologies and work together with the private sector and governments, they can sell their produce for better prices in bigger markets.

# Safeguarding nutrition and food safety in the global food system

## Building better diets: infrastructure bolsters safe and nutritious food

In hard-to-reach areas, limited infrastructure is closely linked to poverty, the primary cause of malnourishment.<sup>17</sup> Financial constraints often force people to rely on cheap, high-energy staple foods instead of more nutritious options.<sup>18</sup> This creates a cycle where malnutrition reduces physical and mental abilities, leading to lower productivity and making them more susceptible to poverty.<sup>19</sup>

As markets develop and infrastructure improves, communities can better store and safely sell

food requiring temperature-control, increasing access to more affordable nutritional options. Warehousing and cold chains preserve perishable goods and prevent spoilage, keeping fresh food safe, while transport networks move food from farms to consumers, offering more diverse foods to local communities. For example, in Honduras, refrigerated trucks transport bananas, cocoa, cacao and sugar from rural farms, preventing spoilage and ensuring these foods reach consumers. Such infrastructure is crucial for ensuring the year-round availability of fruits and vegetables, especially in areas with limited access to fresh produce.<sup>20</sup>

**“Farmers have to be healthy and food secure themselves to be able to farm well,”**

- Julie Greene, chief sustainability officer, Olam Agri



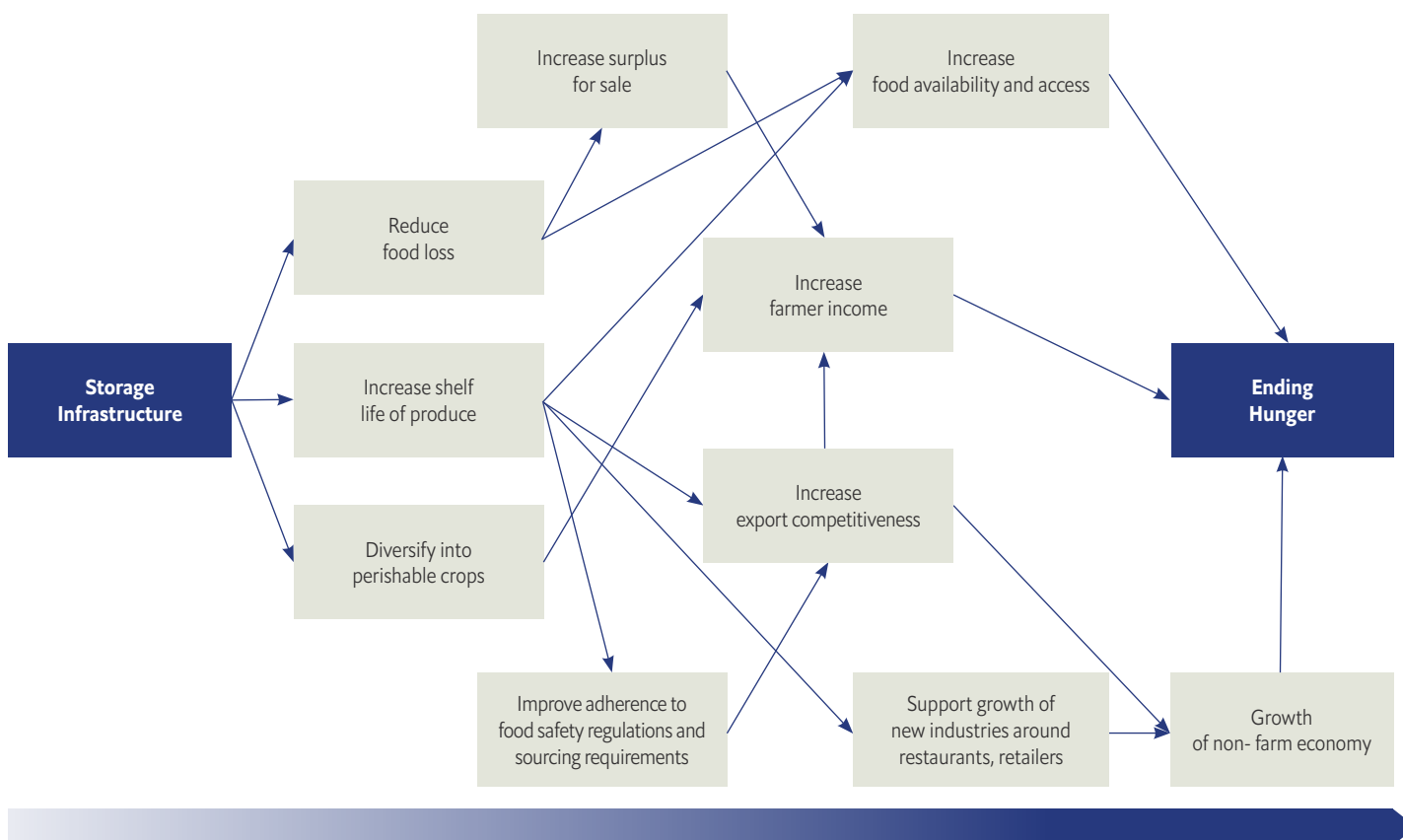
<sup>17</sup> Tanumihardjo, S. A., et. al. (2007). Poverty, Obesity, and Malnutrition: An International Perspective Recognizing the Paradox. *Journal of the Academy of Nutrition and Dietetics*, 107:1966-1972. DOI: 10.1016/j.jada.2007.08.007

<sup>18</sup> Ibid.

<sup>19</sup> Siddiqui, F., Salam, R. A., Lassi, Z. S., & Das, J. K. (2020). The Intertwined Relationship Between Malnutrition and Poverty. *Frontiers in Public Health*, 8, 453. <https://doi.org/10.3389/fpubh.2020.00453>

<sup>20</sup> Sibhatu, K. T., Krishna, V. V., & Qaim, M. (2015). Production diversity and dietary diversity in smallholder farm households. *Proceedings of the National Academy of Sciences*, 112(34), 10657-10662. <https://doi.org/10.1073/pnas.1510982112>

FIGURE 3: Pathways from better storage infrastructure to safer food



Source: IISD

While improved infrastructure can facilitate healthier diets by reducing spoilage and improving the overall lifespan of food products, availability alone doesn't guarantee affordable or regular access to nutritious food.<sup>21</sup> Policymakers and stakeholders can improve nutritional outcomes by breaking the cycle of poverty and malnutrition through targeted interventions. Nutrition-sensitive value chains that prioritise nutrition alongside economic goals show promise.<sup>22</sup> Policymakers can address consumer awareness and nutrition gaps through subsidies

and grants that promote the cultivation and safe movement of nutrient-rich crops like orange-fleshed sweet potatoes and biofortified crops.

It is also important to create demand for healthy foods through education and implementing regulations that help guide consumers to better dietary choices. Because the need to safeguard food is greater in areas lacking adequate healthcare services,<sup>23,24</sup> education on proper food handling and storage practices further enhances food safety.

<sup>21</sup> Davis, B., Lipper, L., & Winters, P. (2022). Do not transform food systems on the backs of the rural poor. *Food Security*, 14(3), 729-740. <https://doi.org/10.1007/s12571-021-01214-3>

<sup>22</sup> Hawkes, C., & Ruel, M. T. (2011). Value Chains for Nutrition. 2020 Conference Paper 4. International Food Policy Research Institute (IFPRI). <http://assets.fsnforum.fao.org/s3-eu-west-1.amazonaws.com/public/discussions/contributions/Value-Chains-for-Nutrition.pdf>

<sup>23</sup> Jasper, C., Le, T.-T., & Bartram, J. (2012). Water and Sanitation in Schools: A Systematic Review of the Health and Educational Outcomes. *International Journal of Environmental Research and Public Health*, 9(8), 2772-2787. <https://doi.org/10.3390/ijerph9082772>

<sup>24</sup> Evans, M. V., et al. (2023). Geographic barriers to care persist at the community healthcare level: Evidence from rural Madagascar. *PLOS Global Public Health*, 3(3), e0001033. <https://doi.org/10.1371/journal.pgph.0001033>

**“Undiversified consumption patterns tend to limit the products that are produced. For example, maize is widely produced, but there are other crops that can grow very well, for example, cassava, millet, sorghum and others, but our consumption patterns are not that diversified,”**

- Rhoda Mofya, nutrition and food systems co-ordinator, Food and Agriculture Organization



Technology, too, can address challenges in food supply chains to enhance access to safe nutritional food. Real-time monitoring technologies, like Internet of Things (IoT) devices, can reduce contamination risks during cold transport and storage.<sup>25</sup> IoT sensors, artificial intelligence and data analytics can offer predictive insights on where food is needed, while automation and blockchain enhance traceability in the temperature-controlled supply chain, ensuring food products meet market demands effectively and safely.

Moving nutritious food effectively along the supply chain, including into and out of cold storage facilities, requires proper management, roads and reliable power sources.<sup>26</sup> Government involvement is often necessary to co-ordinate the development of such large-scale infrastructure projects. In regions lacking access to reliable power, localised energy grids, especially those powered by renewable energy, can keep food safe during storage and transport.<sup>27</sup>

<sup>25</sup> Xu, Y., Sun, Y., Zhang, Y., & Jiang, Y. (2023). Overview of Food Preservation and Traceability Technology in the Smart Cold Chain System. *Foods*, 12(15), 3067. <https://doi.org/10.3390/foods12153067>

<sup>26</sup> Aulakh, J., Regmi, A., Fulton, J. R., & Alexander, C. E. (2013). Estimating Post-Harvest Food Losses: Developing a Consistent Global Estimation Framework. 2013 Annual Meeting, August 4-6, 2013, Washington, D.C. 150363, Agricultural and Applied Economics Association.

<sup>27</sup> Amjad, W., Munir, A., Akram, F., Parmar, A., Precoppe, M., Asghar, F., & Mahmood, F. (2023). Decentralized solar-powered cooling systems for fresh fruit and vegetables to reduce post-harvest losses in developing regions: a review. *Clean Energy*, 7(3), 635-653. <https://doi.org/10.1093/ce/zkado15>

# Cultivating greater social equity through the food value chain

## Fostering gender equity in agriculture

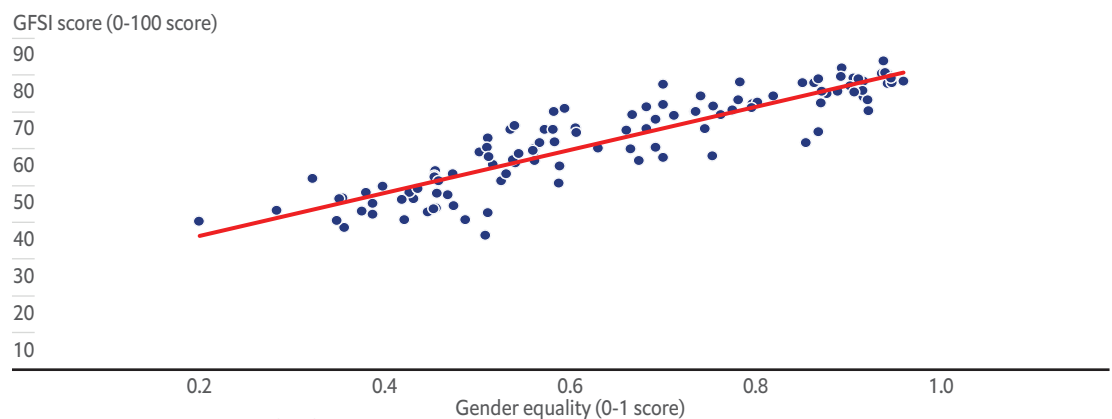
For women, more efficient food value chains create new opportunities. However, this can sometimes be accompanied by potential barriers, highlighting the need for initiatives that address specific needs.<sup>28</sup> Women often face inequities in accessing land, education, technology and finance, which can lead to lower productivity and increased vulnerability to market and climate shocks.<sup>29</sup>

Mapping and monitoring gender-sensitive agri-food value chains can help identify barriers and create

policies to enhance access to markets, information and resources.<sup>30</sup> With better transport, women spend less time on household tasks and can more easily access schools, jobs, healthcare and other resources.<sup>31</sup> Additionally, this boosts women's participation in both the informal and formal labour markets.

Ensuring gender equality as a key focus area in policymaking is essential. Simply starting a business or increasing income doesn't guarantee empowerment, just as ensuring market access does not produce gender equality. Studies show that even small efforts to promote gender equality can create a ripple effect of greater economic and social development.<sup>32</sup>

**FIGURE 4: Gender equality and food security**  
Food security increases with improvements in gender equality



Source: Global Food Security Index (GFSI) 2022

- <sup>28</sup> Quisumbing, A., et al., for Market Inclusion Study Team. (2021). Women's empowerment and gender equality in agricultural value chains: Evidence from four countries in Asia and Africa. *Agriculture and Human Values*, 38(4), 967-986. <https://doi.org/10.1007/s10460-021-10230-0>
- <sup>29</sup> International Labour Organization. (n.d.). Women in infrastructure works: Boosting gender equality and rural development! <https://www.ilo.org/publications/women-infrastructure-works-boosting-gender-equality-and-rural-development>
- <sup>30</sup> Food and Agriculture Organization of the United Nations. (2022). Developing gender-sensitive value chains: Guidelines for practitioners. <https://www.folur.org/sites/default/files/2022-03/FAO-Guidelines-Gender-Sensitive-VCs.pdf>
- <sup>31</sup> Gupta, G et al., (2018). PROTOCOL: The effects of road infrastructure, and transport and logistics services interventions on women's participation in informal and formal labour markets in low- and middle-income countries: a systematic review;14(1):1-57. doi: 10.1002/CL2.200.
- <sup>32</sup> Grow Asia. (n.d.). Integrating Gender Inclusion into Agricultural Value Chains. <https://www.growasia.org/post/integrating-gender-inclusion-into-agricultural-value-chains>

### Case study: Majang Forest livelihoods project, Ethiopia (2015-20)

In 2015 TechnoServe, MELCA and Swedish agency Sida collaborated in Ethiopia's Majang Zone to create sustainable jobs while protecting one of the most biodiverse forest areas in East Africa. They restored 11 maize mills and created co-operatives, connecting farmers with buyers and governments. These co-operatives helped farmers get funding to grow non-timber products, like coffee and black pepper, and assisted with market access.

Over five years this project resulted in 10,000 people, half of them women, reporting a 240% increase in coffee income because of higher yields and prices. They were able to eat more and varied foods. Moreover, there was a 26% drop in families saying they didn't have enough food to eat. Women in the community saved 3,300 hours each week—as using the mills meant they did not have to hand grind the maize—which also allowed their children to attend school because they didn't need to help.

### Feeding knowledge: the link between food systems and education

The connection between education, childhood nutrition, health and productivity is clear: hunger and a lack of nutritious food prevent children from attending school and learning effectively. Infrastructure that provides access to drinking water,<sup>33</sup> healthy food and safe roads increases school attendance,<sup>34</sup> with higher education leading to better health and nutrition.<sup>35,36</sup>

Investing and improving access to food processing infrastructure and co-operatives not only enhances education, but also raises incomes, particularly for women.<sup>37,38</sup> As families gain more resources, children can spend more time in school rather than helping at home or on farms. While the

number of farmers may decrease with increased education, a more educated workforce can specialise in higher-value crops or labour-saving technologies, driving economic growth.<sup>39</sup>

As food systems transform, education about healthy diets becomes crucial, particularly as mass-produced foods can lead to nutrient deficiencies and obesity. School meal programmes<sup>40</sup> across Africa connect local farmers with schools, giving children nutritious meals that encourage enrolment and retention, while supporting farmers. Additionally, community gardens in Africa serve as valuable educational tools, teaching both adults and children about growing food and healthy eating, with research showing that gardening and cooking helps students learn about nutrition.<sup>41</sup>

<sup>33</sup> Jasper, C., Le, T. T., & Bartram, J. (2012). Water and sanitation in schools: A systematic review of the health and educational outcomes. *International Journal of Environmental Research and Public Health*, 9(8), 2772-2787. <https://doi.org/10.3390/ijerph9082772>

<sup>34</sup> Gayen, J., & Sarkar, D. (2021). Assessment of Social Infrastructure Due to Growth and Development in Roads: A Case Study. *Asian Review of Social Sciences*, 10(1), 52-56.

<sup>35</sup> Alderman, H., Behrman, J. R., & Puetz, C. (2017). Big Numbers about Small Children: Estimating the Economic Benefits of Addressing Undernutrition. *The World Bank Research Observer*, 32(1), 107-125. <https://www.ncbi.nlm.nih.gov/books/NBK525244/>

<sup>36</sup> Lundborg, P., Rooth, D. O., & Alex-Petersen, J. (2022). Long-Term Effects of Childhood Nutrition: Evidence from a School Lunch Reform. *The Review of Economic Studies*, 89(2), 876-908. <https://doi.org/10.1093/restud/rdab028>

<sup>37</sup> Adlam, H. (n.d.). Supporting Female Farming Cooperatives: The Smart Choice for the African Development Bank. *Journal of Public & International Affairs*, Princeton University. <https://jpia.princeton.edu/news/supporting-female-farming-cooperatives-smart-choice-african-development-bank>

<sup>38</sup> Chan, M. K. (2010). Improving opportunities for women in smallholder-based supply chains: Business case and practical guidance for international food companies. Bill & Melinda Gates Foundation. <https://docs.gatesfoundation.org/documents/gender>

<sup>39</sup> de Brauw, A., Mueller, V., & Lee, H. L. (2014). The Role of Rural-Urban Migration in the Structural Transformation of Sub-Saharan Africa. *World Development*, 63, 33-42. <https://doi.org/10.1016/j.worlddev.2013.10.013>

<sup>40</sup> Wineman, A., et. al., (2022). School Meal Programs in Africa: Regional Results From the 2019 Global Survey of School Meal Programs. *Frontiers in Public Health*, 10, 846076. <https://doi.org/10.3389/fpubh.2022.846076>

<sup>41</sup> International Fund for Agricultural Development. (2019, April 12). Community gardens in the Gambia: One solution, many benefits. <https://www.ifad.org/en/web/latest/-/story/community-gardens-in-the-gambia-one-solution-many-benefits>

# Protecting ecosystems through climate-resilient infrastructure

## Building resilience in a changing climate

Sustainable infrastructure that supports the resilience of food systems is crucial for addressing climate change. Food systems are major contributors to emissions, responsible for 75% of deforestation and the largest source of non-carbon greenhouse gases.<sup>42</sup> Resilient infrastructure helps farmers cope with climate challenges like floods

and heatwaves, which threaten crops and price stability. It also addresses ongoing issues such as rising temperatures that affect crop suitability and productivity. For instance, cocoa may need to be grown at different altitudes due to changing climate conditions.

Adapting to these escalating challenges requires that farmers, local groups and governments balance agricultural needs with ecosystem health

**"It's easy for a think-tank to say, 'farmers should do this'. The difficulty lies in defining what 'this' is in detail and making sure that it works with a farmer's day-to-day life without leaving them worse off. That level of context-appropriate detail is often what's missing in climate-smart policies, and it means that initiatives fail,"**

- Emily Chai, head of citrus, Invaio



<sup>42</sup> International Energy Agency. (2021). Methane and climate change – Methane Tracker 2021. <https://www.iea.org/reports/methane-tracker-2021/methane-and-climate-change>

and sustainable practices.<sup>43</sup> Part of the solution is working out just how vulnerable different parts of the food chain are.<sup>44</sup> It is clear that farmers are very sensitive to climate change, and rural communities in underdeveloped nations face greater food loss and climate shocks due to a lack of cold-storage facilities.<sup>45</sup> The cold chain can protect harvests from spoilage and extreme weather, ensuring food is kept safely and innovations like the use of solar power, alternative fuels and smart warehousing can make that part of the agricultural value chain more resilient.

Supporting farmers in this transition is crucial, as they often face food insecurity and may be hesitant to adopt new practices. Research shows that immediate benefits can motivate change. Financial incentives, regulations and support from governments and NGOs can promote climate-smart practices<sup>46</sup> such as rainwater harvesting, drought- and heat-resistant seeds, and maintaining soil health.<sup>47</sup>

Infrastructure development plays a vital role, with roads crucial for connecting communities and storage and processing key for reducing food losses. However, infrastructure needs to be well-designed, constructed and operated. Otherwise, it can quickly deteriorate, leading to higher costs and inefficiencies.

Another key aspect of successful climate adaptation is working with local ecosystems to support the long-term viability of agricultural production. Incorporating indigenous knowledge and considering both human and biodiversity needs<sup>48</sup> align with the UN Sustainable Development Goals on hunger, nutrition and protecting the environment.

<sup>43</sup> Tchoukouang, R. D., Mabah, G. L. T., Tabe-Ojong, M. P., & Balgah, R. A. (2024). Assessing the vulnerability of food supply chains to climate change-induced disruptions. *Science of The Total Environment*, 905, 168150. <https://doi.org/10.1016/j.scitotenv.2024.168150>

<sup>44</sup> Ibid.

<sup>45</sup> Amjad, W., Munir, A., Akram, F., Parmar, A., Precoppe, M., Asghar, F., & Mahmood, F. (2023). Decentralized solar-powered cooling systems for fresh fruit and vegetables to reduce post-harvest losses in developing regions: a review. *Clean Energy*, 7(3), 635-653. <https://doi.org/10.1093/ce/zkad015>

<sup>46</sup> United Nations Development Programme. (n.d.). Strengthening the resilience of small farmers through Climate Smart Agriculture techniques in the Tahoua Region of Niger. *Climate Change Adaptation*. Retrieved September 4, 2024, from <https://www.adaptation-undp.org/projects/strengthening-resilience-small-farmers-through-climate-smart-agriculture-techniques-tahoua>

<sup>47</sup> Mabaso, A., Mupambwa, H. A., & Munyati, C. (2023). Climate-smart agricultural practices among rural farmers in Masvingo district of Zimbabwe: perspectives on the mitigation strategies to drought and water scarcity for improved crop production. *Frontiers in Sustainable Food Systems*, 7, 1298908. <https://doi.org/10.3389/fsufs.2023.1298908>

<sup>48</sup> Zellmer, A. J., & Goto, B. S. (2022). Urban wildlife corridors: Building bridges for wildlife and people. *Frontiers in Sustainable Cities*, 4, 954089. <https://doi.org/10.3389/frsc.2022.954089>



# Conclusion

Robust infrastructure is a driver and enabler of sustainable food systems in hard-to-reach areas. An inclusive system benefits everyone—farmers, the private sector and governments alike—by providing essential opportunities to not only combat hunger and malnutrition, but also to educate and grow the economy. Better roads, cold storage solutions and transport networks provide access to markets, facilitate the delivery of nutritious foods, combat food waste and malnutrition, and promote healthier diets in underserved communities.

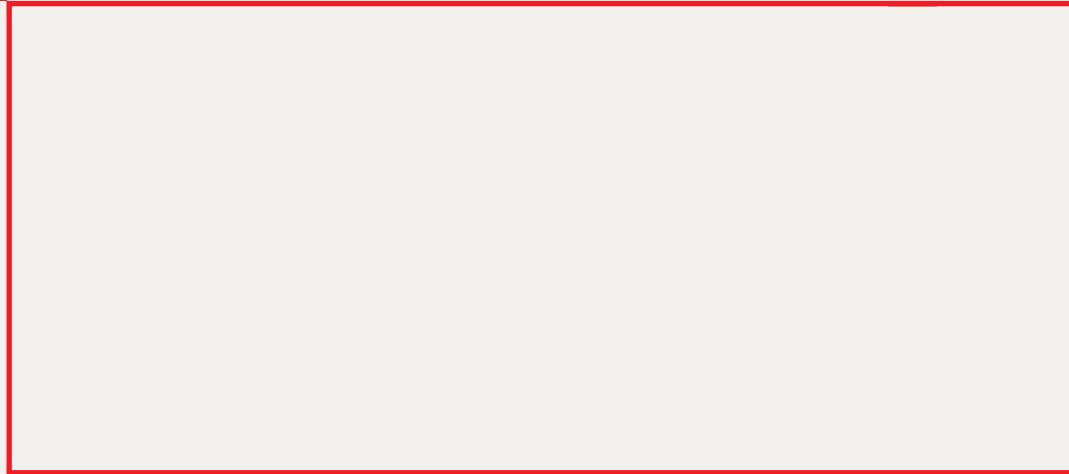
Resilient food infrastructure empowers vulnerable communities, and especially women, by increasing market access and decision-making roles. It also improves children's school attendance and education. Effective food systems encourage collaboration between farmers, local groups and governments, creating a resilient framework that addresses the challenges posed by climate change while ensuring sustainable practices that protect food security.

Integrated policies that bring together diverse stakeholders, while prioritising the needs of the smallholder farmer, will also maximise the benefits of food infrastructure. By mapping and monitoring food value chains, decision-makers can assess their impacts on outcomes such as gender equality, education, nutrition and economic development, identifying both the gaps and opportunities.

Ultimately, investing in roads, storage facilities and processing plants creates a ripple effect, as small changes can lead to significant benefits for communities in building a sustainable, effective and collaborative food value chain for a more food-secure future.

While every effort has been taken to verify the accuracy of this information, Economist Impact cannot accept any responsibility or liability for reliance by any person on this report or any of the information, opinions or conclusions set out in this report.

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