Task Force 6
Accelerating SDGs: Exploring New Pathways to the 2030 Agenda

GREENING COLD CHAIN INFRASTRUCTURE TO DEVELOP GLOBAL FOOD CORRIDORS: ACCELERATING THE ACHIEVEMENT OF THE 2030 AGENDA

July 2023

Vibha Dhawan, Director General, The Energy Resources Institute

Zerin Osho, Director-India Program, Institute for Governance & Sustainable Development

Durwood Zaelke, President, Institute for Governance & Sustainable Development

Ana Maria Kleymeyer, International Law and Policy Expert

Amelia Murphy, Research Associate, Institute for Governance & Sustainable Development)

वसुधैव कुटुम्बकम्

ONE EARTH • ONE FAMILY • ONE FUTURE

Abstract

Each year, one-third of the total food for human consumption is either lost or wasted even as millions worldwide experience food insecurity.[1] Similarly, over 25 percent of vaccines are wasted each year while millions die from vaccine-preventable illnesses[2] Sustainable cold chain infrastructure can significantly reduce post-harvest food loss and vaccine wastage, and deliver social and climate benefits. However, acknowledging the need for cold storage alone does not ensure food security or access to vaccines, and must be supported by policies and resources, including technologies.[3] Cooperation among G20 countries on cold chains can help coordinate the policies and resources necessary to advance food security, public health, and climate change mitigation.

The Challenge

1

At the beginning of 2022, approximately 828 million people (nearly 10 percent of the global population) were affected by hunger,[4] and 2.3 billion people suffered moderate to severe food insecurity.[5] As the global population grows to a projected 9.8 billion in 2050 and incomes grow across the developing world, overall food demand is projected to increase by more than 50 percent.[6] To feed a global population of this size, about 593 million hectares of land (twice the size of India) would be required.[7] Agriculture already uses almost half of the world's vegetated land, and agriculture and related land-use change generate one-quarter of annual greenhouse gas (GHG) emissions.[8]

While the world grapples with the challenges of feeding a growing global population, one-third or 1.3 billion tons of food produced for human consumption is wasted or lost each year,[9] accounting for up to 10 percent of the total anthropogenic climate emissions from 2010–2016.[10] Lack of adequate cold chains is responsible for 9 percent of lost production of perishable foods in developed countries and more than 17 percent of the same in developing countries.[11] The total cost of food waste is US$936 billion per annum and could reach US$1.5 trillion by 2030.[12]

Most vaccines need to be transported and stored at temperatures between 2-8°C at all times, and this is particularly challenging in hotter temperatures and last-mile deliveries.[13] Vaccine wastage due to inadequate cold storage results in a cost of US$34.1 billion per year.[14] An estimated 20 percent of targeted health facilities in countries supported by Gavi, the Vaccine Alliance, still lack cold chain. Where there is cold chain equipment, 20 percent is broken and 50 percent is poor-performing or of the older generation.[15] These failings become more serious during a pandemic, where significant proportions of, or the entire, population needs to be immunised.

The ability to effectively and efficiently feed the global population and protect global public health in an escalating climate crisis (increasing hot temperatures and heat extremes)[16] depends on a robust sustainable cold chain. Sustainable cold chains protect food and health security and provide

multiple co-benefits, including jobs and a healthy workforce, income streams, economic development, reduction of energy consumption, and mitigation of, as well as adaptation to, the climate crisis. Developing an integrated and sustainable cold chain infrastructure across G20 nations and trading partners can help reduce post-harvest food losses, provide safe vaccine storage that reduces vaccine wastage, and help accelerate the adoption of the Paris Climate Agreement while attaining the broader goals of the 2030 development agenda.

Greening cold chains presents a significant climate mitigation opportunity

The food cold chain is responsible for around 4 percent of the total GHG emissions, including emissions from cold chain technologies and from food loss and waste due to lack of refrigeration.[17] Post-harvest food loss and waste is also one of the largest contributors to methane emissions, a super climate pollutant that is about 81 times more potent than carbon dioxide over a 20-year period,[18] and is responsible for nearly 45 percent of current net warming.[19] Food and green waste comprise 44 percent of the total global waste,[20] resulting in about 20 percent of total anthropogenic methane emissions[21] and 50 percent of total emissions from the entire food system.[22]

Four percent of post-harvest transit, storage, and retail processes in developing countries is the result of food waste.[23] In India, for example, only 4 percent of fresh produce is covered by cold chain facilities, as compared to 70 percent in the UK.[24] The National Centre for Clean Cold-Chain Development India estimates that there is a gap of 3.28 million tons between required and available cold storage.[25]

Reducing post-harvest food loss through the introduction of cooling along the agriculture value chain presents an opportunity to advance methane mitigation, which is the best and fastest strategy to avoid crashing through the 1.5 Paris Agreement guardrail.[26] Pursuing all methane mitigation measures this decade can avoid nearly 0.3°C of warming by the 2040s and slow down warming by 30 percent; it is the only known way to slow near-term warming.[27]

While it is important to develop robust and sustainable cold chains, it is also necessary to ensure that the cold chains minimise climate emissions. Emissions from the food cold chain are set to rise significantly as new cooling-related infrastructure comes online in developing countries.[28] Improved cold chain infrastructure can mitigate 19-21 $GtCO_2e$ by 2050 while improving food security and increasing farmer incomes.[29] When paired with the decreasing costs of renewable energy, reducing food loss and waste through technically-viable and publicly-supported sustainable cold chain management is a no-regret option.[30]

The Intergovernmental Panel on Climate Change (IPCC) has confirmed that reaching zero GHG emissions requires "deep reductions" in carbon dioxide and methane.[31] Developing sustainable, solar-powered, energy-efficient, and Kigali Amendment-compliant cold chains supports the circular economy and is critical for climate and food security.

Sustainable cold chains positively impact economics and the quality of food while improving public health

Sustainable cold chains can improve access to affordable, nutritious, and safe food while minimising both environmental and climate impacts and providing optimal returns to farmers and others in the cold chain, including but not limited to, equipment operators, service providers, and consumers.

The proportion of costs shared by stakeholders in the produce supply chain, from farmers to retailers, is skewed towards the retailer. Typically, the price at which the produce is sold to the retailer is 120 percent more than the price the farmer receives.[32] Policies that directly reduce post-harvest food losses by increasing cold chain efficiency, market connectivity, and sustainability can improve farmers' incomes and ensure climate and food security.

Reducing losses through minimising post-harvest food loss and waste also increases farmers' incomes. In

developing countries, food loss was estimated to reduce incomes by at least 15 percent for 470 million smallholders, farmers, and downstream value chain actors.[33] More efficient cold chain management and expanded market connectivity can enable farmers to optimise the production value of their goods.[34]

According to the World Bank, in India alone, annual food losses cost the economy US$13 billion in losses.[35] In contrast, the market potential and investment opportunity in the country's cold chain and refrigeration sector will be US$29 billion by 2038. Meanwhile, investments in the cold chain sector can potentially create 1.7 million jobs.[36]

Cold chains also play a crucial role in delivering safe and quality foods to end consumers by extending the holding life of perishable products. By ensuring a robust food supply chain that extends the reach of nutrition to underserved regions, the cold chain helps reduce malnutrition and the health, social, and economic consequences of unhealthy diets.[37]

Cold chains are also able to ensure food security by reducing food price inflation. Refrigerated storage and cold chains overcome seasonal food supply shortfalls and dampen price fluctuations. This is of particular importance in communities at high risk of poverty and hunger, where 40-50 percent of incremental income is spent on food.[38]

G20 countries would benefit from a coordinated and integrated approach to greening cold chains that advances food security, public health, and can help countries reach net zero and sustainable developmental goals by 2030.

The G20's Role

2

Given that the G20 includes the world's top food producers[39] and exporters,[40] it is strategically positioned to optimise the benefits of sustainable cold chain management globally.

The G20 can contribute to slowing the near-term rate of warming and improving food security and global health by coordinating food cold chain policies among member countries. Recognising this, in 2015 at the G20 Leaders' Summit in Antalya, Turkey, the G20 emphasised the need to prioritise reduction of food loss and waste.[41] The G20 agriculture ministers, in their communique, highlighted several initiatives on sustainable cooling that led to reduced food loss and waste.[42] These initiatives could serve as building blocks for coordinated action on sustainable cold chain management (see Table 1).

In addition to the collective action taken at the international level, some G20 countries are already developing sustainable cold chain initiatives. For example, India is working to reduce or avoid GHG emissions in the retail sector through sustainable cooling technologies that use renewable energy.[43] France is also leading implementation of solar-powered cold rooms in two Senegalese ports, where access to cold storage will serve to reduce food loss and improve income for fishers.[44]

The G20 should call on international and national initiatives to mobilise resources and expertise towards coordinated action on sustainable cold chain development.

Recommendations to the G20

3

Food security, climate change, health, energy, and sustainable development have been major priority issues for the G20 in recent years. Numerous declarations and initiatives call for, *inter alia*, national and cooperative action in these areas, recognising the importance of capping global temperature increase at 1.5 ,[45],[46] taking fast action on methane reductions,[47] and scaling up measures to enhance energy efficiency.[48] G20 leaders have also worked to reduce the negative impacts of agricultural production to ecosystems,[49] address land degradation, and transform the role of cities in accelerating climate solutions to slow the rate of global warming, build resilience, and enable the transition towards clean and sustainable energy.[50] Table 2 lists elements in prior G20 agreements that lay the foundation for immediate action to strengthen sustainable cold chains and food corridors.

Direct financing in line with the Food and Agricultural Organization (FAO) Technical Platform on Food Loss and Waste and the Committee on World Food Security's Principles for Responsible Agricultural Investment

The G20 should explicitly commit to build upon previous agreements that support food security and climate objectives by collectively directing financial resources in line with the recommendations of the FAO Technical Platform on Food Loss and Waste and the Committee on World Food Security's Principles for Responsible Agricultural Investment.

Following the leadership of the G20 through the Action Plan on Food Security and Sustainable Food Systems, FAO and the International Food Policy Research Institute established the Technical Platform on Food Loss and Waste in 2015 to facilitate information-sharing and discussions on optimising food systems to reduce food loss and waste.[51]

The Global Agriculture and Food Security Program (GAFSP), which supports the implementation of the Committee on World Food Security's Principles for Responsible Agricultural Investment, was launched by the G20 in 2010. Since then, GAFSP has accumulated US$2 billion in financing.[52] G20 governments can commit to continuing support for GAFSP to

encourage the implementation of the Principles for Responsible Agricultural Investment and to expand the development of a sustainable cold chain network.

The Committee on World Food Security published the Principles for Responsible Investment in Agriculture and Food Systems (CFS-RAI) in 2018 and recognised that responsible investment in agriculture and food systems contributes to food security by increasing sustainable production and productivity of food, reducing food loss and waste, and enhancing food utilisation through access to energy and technology. [53] Through leveraging successful investment platforms such as the GAFSP, G20 countries can accelerate implementation of the CFS-RAI, improve cold chain infrastructure and energy supply, and support capacity-building for actors in the cold chain, particularly in developing countries.

Encourage and support the adoption of national action plans in line with the recommendations of the FAO Technical Platform on Food Loss and Waste, and the G20 Action Plan on Food Price Volatility and Agriculture

The G20 can further encourage and support member countries to adopt integrated national and regional cold chain policies, in line with the recommendations of the FAO Technical Platform on Food Loss and Waste[54] and G20 Action Plan on Food Price Volatility and Agriculture.[55] Countries should be supported with financing, capacity-building, and access to information in the Agricultural Market Information System (AMIS), developed by the 2011 G20 Action Plan on Food Price Volatility and Agriculture.[56]

To address climate change and food security and strengthen international policy coordination and to enhance confidence in international markets and respond to food crises more efficiently, the G20 established the AMIS platform. AMIS can be further strengthened by integrating considerations of the near-term climate emergency, and drawing explicit linkages between cold chain management, energy efficiency, food loss and waste, and methane mitigation.

Some G20 governments are already working with the Technical Platform on Food Loss and Waste to implement national and regional policies and

plans, such as Argentina's National Plan for the Reduction of Food Loss and Waste 2030,[57] the United States Food Loss and Waste 2030 Champions,[58] and the European Citizens' Panel on Food Waste.[59] With the guidance of the Technical Platform, G20 governments can ensure that the benefits of their investments in sustainable cold chains are maximised. Such plans can be strengthened by recognising the work already undertaken under the Kigali Amendment of the Montreal Protocol and its implementing bodies, and by coordinating integrated cooling strategies for the food sector.

Conclusion

4

Through financing platforms, technical support, and encouraging national action plans, the G20 can build upon the initiatives in Table 1, and coordinate collective action to green cold chains. Stronger coordination on cold chains can mitigate the near-term climate and food security impacts of post-harvest food losses due to the compounded contribution of energy, agriculture, transportation, and building sectors. It can also support capacity-building and innovation in cold chain sectors and advance a just transition to renewable energy sources through high-efficiency, renewable-powered cold chain infrastructure.

Attribution: Vibha Dhawan et al., "Greening Cold Chain Infrastructure to Develop Global Food Corridors: Accelerating the Achievement of the 2030 Agenda," *T20 Policy Brief*, July 2023.

Annex:

Table 1: Summary of Initiatives from the G20 Agriculture Ministers Communique (2015)

Initiative	Status	Description
FAO Technical Platform on Food Loss and Waste	Ongoing	Following the leadership of the G20 through the Action Plan on Food Security and Sustainable Food Systems, FAO, and the International Food Policy Research Institute established the Technical Platform on Food Loss and Waste in 2015 to facilitate information-sharing and discussions on optimising food systems to reduce food loss and waste.[60] The Technical Platform supports several projects, including implementation of Argentina's National Plan for the Reduction of Food Loss and Waste 2030,[61] the United States Food Loss and Waste 2030 Champions,[62] and the European Citizens' Panel on Food Waste.[63] The Technical Platform has generated several reports, including regional overviews on the state of food security and nutrition in Asia and the Pacific,[64] and Europe and Central Asia,[65] which highlight the importance of cooling to avoid food waste.
CFS-RAI	Ongoing	The Committee on World Food Security is an international and intergovernmental platform that aims to eliminate hunger and malnutrition through policy convergence/coherence globally.[66] Its programme of work for 2020–2023 includes improving the understanding of agroecological and innovative approaches in addressing food system challenges, ensuring food security, and addressing other problems, like climate change and biodiversity.[67] The CFS produced the CFS-RAI and policy recommendations on Food Losses and Waste in the Context of Sustainable Food Systems. RAI Principle 1 recognises that responsible investment in agriculture and food systems contributes to food security by increasing sustainable production and productivity of food, reducing food loss and waste, and enhancing food utilisation through access to energy and technology.[68] The CFS' policy recommendations on food loss and waste include investing in infrastructure like storage and processing facilities, reliable energy supply, and transport, and supporting smallholder farmers access to knowledge, markets, financial services, and logistics. The CFS also recommends that states and subnational authorities improve coordination of policies, strategies, and actions to reduce food loss and waste by optimising policies and resources and seeking solutions to reduce waste that ends up in landfills.[69] In 2021, G20 agriculture ministers affirmed the role of CFS-RAI in engaging with smallholder farmers and supporting innovative technologies.[70]

Initiative	Status	Description
GAFSP	Ongoing Latest Project: 28 March 2023	The GAFSP, a multilateral financing platform launched by the G20 in 2010, supports projects to build sustainable agriculture and food systems in developing countries. Since then, GAFSP has pooled US$2 billion in financing.[71] The GASFP has supported several projects, including one in Bangladesh to install a 700-litre milk refrigeration plant to ensure that rural farmers can get their milk to the market.[72] Its latest project, implemented by the International Fund for Agricultural Development in Lao People's Democratic Republic, seeks to improve market access for Lao's agricultural producers.[73]
G20 Action Plan on Food Price Volatility and Agriculture	Ongoing Upcoming Scheduled Publications: • 6 April 2023 • 4 May 2023 • 1 June 2023 • 6 July 2023 • 7 September 2023 • 5 October 2023 • 2 November 2023 • 7 December 2023	In the Action Plan on Food Price Volatility and Agriculture, the G20 committed to, among other things, improving agricultural production and productivity to meet the growing demand for agricultural commodities and to strengthen international policy coordination to enhance confidence in international markets and respond to food crises more efficiently.[74] To that end, the G20 established the AMIS, which brings together principal agricultural traders, assesses food supplies, and provides a platform to coordinate policy action.[75] The AMIS regularly publishes the Market Monitor on major developments in international commodity markets.[76] At the G20 Summit in Bali in 2022, G20 leaders committed to further strengthening the AMIS as a tool to enhance food security and transparency in global food markets.[77] The G20 Presidency, at the G20 Joint Finance and Agriculture Ministers' Meeting in October 2022, agreed to ask the FAO and the World Bank to share the results of their exercise on mapping food insecurity to build on several initiatives, including AMIS.[78]
G20 Action Plan on Food Security and Sustainable Food Systems (Antalya Leaders' Summit)	Ongoing	In adopting the action plan, the G20 recognised that improving food security and sustainable food systems should be a global priority. The G20 committed to prioritising prevention, recovery, and redistribution of safe and nutritious otherwise wasted food, as well as taking action to advance the objectives of the G20 Food Security and Nutrition Framework. Further, the G20 welcomed the decision to establish the Technical Platform on Food Loss and Waste.[79]

Initiative	Status	Description
G20 Food Security and Nutrition Framework	Ongoing	The G20 Food Security and Nutrition Framework aims to increase responsible investment in food systems, increase incomes and employment in the food sector, and boost productivity sustainably to expand food supplies. In the Framework Implementation Plan, the Development Working Group on Food Security and Nutrition recognised that food losses result from technical constraints, like gaps in cooling infrastructure.[80]The Framework further recognises that investment in production, storage, transport, and logistics can expand markets and enable countries to deliver food to inaccessible areas, contributing to national food policies.[81]
Meeting of Agricultural Chief Scientists (MACS)	Ongoing	The MACs is comprised of governmental bodies responsible for agricultural research and advice in G20 states. Based on the themes identified by the G20 Presidency, MAC participants inform each other of the relevant ongoing activities in their respective states and identify relevant issues for joint action in the future.[82] In 2015, the MACs launched the Collaboration Initiative on Food Loss and Waste, which supports activities to reduce food loss and waste, including establishing research platforms, raising awareness, and conducting capacity building in G20 members.[83] In 2022, it entered into a project cooperation with Canada to study the impacts of road conditions and altitudes on the quality of food along cold chains.[84] At the G20 Summit in Italy in 2021, MAC issued a communique recognising the role of agricultural solutions in mitigating climate change.[85]
Platforms for Agricultural Risk Management (PARM)	Ongoing	The PARM was created in 2013 to provide technical support for least developed countries and lower middle-income countries to integrate agricultural risk management (ARM) into policies and investments and build resilience in the agriculture sector.[86] PARM sets up facilities across priority regions to facilitate generation and exchange of knowledge in ARM. PARM is currently focused on capacity-building in Sub-Saharan Africa.[87]

Initiative	Status	Description
Tropical Agriculture Platform (TAP)	Ongoing through cooperation with the European Union (EU): Developing capacities in agricultural innovation systems: scaling up the Tropical Agriculture Platform (TAP) Framework (TAP-AIS Project)	The TAP is a facilitation mechanism that aims to improve efficiency and effectiveness of capacity development programmes and knowledge sharing in the tropics and the sub-tropics. The second TAP action plan (2018–2021) aimed to strengthen agricultural innovation capacities by increasing country recognition that agricultural innovation is important in their national strategic plans and by encouraging investments in priority areas.[88] Through the support of the EU, the TAP continues to do its work under the Developing capacities agricultural innovation systems: scaling up the TAP-AIS project. TAP-AIS works in Pakistan, Cambodia, Colombia, Rwanda, and other developing countries.[89]
Voluntary Guidelines on the Responsible Governance of Tenure of Land, Fisheries and Forests in the Context of National Food Security (VGGT)	Completed; Revised in May 2022	The VGGT aims to improve tenure governance, recognising that the eradication of hunger and poverty, and the sustainable use of the environment depends on the access of communities to land, fisheries, and forests. The Guidelines impose on states the responsibility to ensure that tenure rights are respected under national laws and that national laws on tenure rights are aligned with a country's international obligations. Further, the Guidelines recommend that states establish frameworks to promote and uphold responsible governance of tenure of land, fisheries, and forests.[90]
Global Initiative for Food Loss and Waste Reduction (SaveFood)	Ongoing	In May 2011, political and business experts, and members of civil society signed the declaration to save food, committing to finding solutions to avoid food losses along supply chains, creating the Save Food Initiative. The Save Food Initiative initially aimed to reduce food loss and waste in industrialised countries through awareness-raising, collaboration, and policy development.[91] Since then, the Save Food Initiative has published guidance documents to minimise food loss, including a report on how access to energy can influence food losses that was published in 2016. The report recognises that providing cooling and refrigeration is an important tool to reduce post-harvest losses, particularly in tropical and sub-tropical regions.[92] The Initiative also supports projects in developing countries, like a regional technical cooperation project in Afghanistan, Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan, and Sri Lanka to reduce post-harvest losses in horticultural chains. The project pilots good post-harvest management practice to improve quality and reduce losses in prioritised traditional fruit and vegetable supply chains.[93]

Table 2: G20 agreements and initiatives that support sustainable cold chain action

G20 Declaration	Key Elements
G20 Agriculture Ministerial Istanbul Communiqué (2015)[94]	• Emphasise the need to prioritise reduction of food loss and waste • Recognise that food losses result from technical constraints, including gaps in cooling infrastructure • Urge the UN Food and Agriculture Organization and the International Food Policy Research Institute to establish an information-sharing platform to reduce food loss and waste
G20 Energy Ministerial Meeting Beijing Communiqué (2016)[95]	• Recognise that energy efficiency is a long-term goal that brings multiple co-benefits • Adopt a cooperative approach in achieving energy efficiency
G20 Energy Efficiency Leading Programme (2016)[96]	• Take the lead in energy efficiency by improving energy efficiency in the G20 through cooperation and support, particularly in the cooling sector
G20 Global Land Initiative (2020)[97]	• Promote sustainable land management through, among other things, sustainable agricultural practices, to maintain and enhance ecosystem functionality
G20 Platform on SDG Localization and Intermediary Cities (2021)[98]	• Promote greater common understanding on the role of cities and rural-urban linkages in sustainable and inclusive post-Covid-19 recovery and climate action • Provide a collaborative space to build consensus on localising SDG implementation and to strengthen city-to-city partnerships and rural-urban linkages
G20 Rome Leaders' Declaration (2021)[99]	• Recognise the urgency of capping global temperature increases at 1.5 • Enhance efforts towards sustainable consumption and production, employing circular economy approaches, and supporting local climate action • Acknowledge that methane mitigation can be one of the fastest, most cost-effective ways to limit climate impacts
G20 Matera Declaration (2021)[100]	• Promote circularity in food systems to adapt to and mitigate climate change, improve global food trade, and reduce waste and biodiversity loss, including through improved storage to reduce post-harvest food loss and waste
G20 Bali Leaders' Declaration (2022)[101]	• Cooperate to sustainably produce and distribute food, ensure that food systems contribute to climate change adaptation and mitigation, including through accelerating efforts to reduce food loss and waste. • Rapidly scale up clean power generation, including renewable energy.

Endnotes

1. Food and Agriculture Organisation, Global food losses and food waste – Extent, Causes and Prevention, 2011, Rome, https://www.fao.org/3/mb060e/mb060e.pdf.
2. Sustainable Energy for All, Cooling for All: The role of cold chain in delivering a COVID-19 vaccine, Briefing Note, Sustainable Energy for All, Vienna, 2020, https://www.seforall.org/system/files/2020-11/Medical-Cold-Chains-Briefing-Note-SEforALL.pdf.
3. "Net Zero Cold Chains for Food", Carbon Trust, last modified September 2020, https://www.carbontrust.com/our-work-and-impact/guides-reports-and-tools/net-zero-cold-chains-for-food.
4. Food and Agriculture Organization, International Fund for Agricultural Development, United Nations Children's Emergency Fund, World Food Programme, and World Health Organisation, The State of Food Security and Nutrition in the World 2022: Repurposing food and agricultural policies to make healthy diets more affordable, 2022, Rome, https://doi.org/10.4060/cc0639en.
5. "UN report: Pandemic year marked by spike in world hunger", World Health Organization, last modified July 12, 2021, https://www.who.int/news/item/12-07-2021-un-report-pandemic-year-marked-by-spike-in-world-hunger.
6. World Resources Institute, Creating a Sustainable Food Future: A Menu of Solutions to Feed Nearly 1- Billion People by 2050, July 2019, https://research.wri.org/sites/default/files/2019-07/WRR_Food_Full_Report_0.pdf.
7. World Resources Institute, Creating a Sustainable Food Future: A Menu of Solutions to Feed Nearly 1- Billion People by 2050.
8. World Resources Institute, Creating a Sustainable Food Future: A Menu of Solutions to Feed Nearly 1- Billion People by 2050.
9. Food and Agriculture Organisation, Global food losses and food waste – Extent, Causes and Prevention.
10. Cheikh Mbow et al., "Food Security" in *Climate Change and Land: An IPCC Special Report on Climate Change, Desertification, Land Degradation, Sustainable Land Management, Food Security, and Greenhouse Gas Fluxes in Terrestrial Ecosystems: Summary for Policymakers,* eds. P.R. Shukla (Geneva: Cambridge University Press, 2019), 437-550, https://www.ipcc.ch/site/assets/uploads/2019/11/08_Chapter-5.pdf.
11. International Institute of Refrigeration, The Role of Refrigeration in Worldwide Nutrition, Paris, IIF-IIR, 2020, 10, http://dx.doi.org/10.18462/iir.INfood06.03.2020.
12. Toby Peters and Leyla Sayin, "The Cold Economy," *Asian Development Bank*, no. 1326 (June 2022): 1–22, 3, https://www.adb.org/publications/the-cold-economy.
13. World Health Organization (WHO) and United Nations Children's Fund (UNICEF), Solar direct-drive vaccine refrigerators and freezers, WHO and UNICEF, 2017, https://apps.who.int/iris/bitstream/handle/10665/254715/WHO-IVB-17.01-eng.pdf;sequence=1.

14. Sustainable Energy for All, Cooling for All: The role of cold chain in delivering a COVID-19 vaccine
15. Tara Azimi, Lauren Franzel, and Nina Probst, “Seizing market shaping opportunities for vaccine cold chain equipment,” *Vaccine* 35, no. 17 (April 2017): 2260–64, https://doi.org/10.1016/j.vaccine.2016.12.073.
16. Intergovernmental Panel on Climate Change (IPCC), Climate Change 2021: The Physical Science Basis: Summary for Policymakers, Working Group I Contribution to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change, Geneva, IPCC, 2022, https://www.ipcc.ch/report/ar6/wg1/downloads/report/IPCC_AR6_WGI_SPM_final.pdf.
17. United Nations Environment Programme (UNEP) and Food and Agriculture Organization (FAO), Sustainable Food Cold Chains: Opportunities, Challenges and the Way Forward, UNEP and FAO, 2022, 13, https://doi.org/10.4060/cc0923en.
18. Piers Forster et al., “The Earth’s Energy Budget, Climate Feedbacks, and Climate Sensitivity”, in *Climate Change 2021: The Physical Science Basis, Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change,* ed. Masson-Delmotte et al (Cambridge: Cambridge University Press, 2021), 923-1054, https://www.ipcc.ch/report/ar6/wg1/downloads/report/IPCC_AR6_WGI_Chapter07.pdf.
19. United Nations Environment Programme (UNEP) and Climate & Clean Air Coalition (CCAC), Global Methane Assessment: 2030 Baseline Report, Why Act Now: A New Era for Accelerated Implementation, Kenya, UNEP and CCAC, 2022, https://www.ccacoalition.org/en/resources/global-methane-assessment-2030-baseline-report.
20. Silpa Kaza, Lisa Yao, Perinaz Bhada-Tata, and Frank Van Woerden, *What a Waste 2.0: A Global Snapshot of Solid Waste Management to 2050* (Washington, DC: World Bank, 2018), 29, https://doi.org/10.1596/978-1-4648-1329-0.
21. United Nations Environment Programme (UNEP) and Climate & Clean Air Coalition (CCAC), Global Methane Assessment: Benefits and Costs of Mitigating Methane Emissions, UNEP and CCAC, 2019, https://www.ccacoalition.org/projects/global-methane-assessment-benefits-and-costs-mitigating-methane-emissions.
22. Jingyu Zhu et al.,“Cradle-to-Grave Emissions from Food Loss and Waste Represent Half of Total Greenhouse Gas Emissions from Food Systems.” *Nature Food 4*, (March 2023): 247-256, https://doi.org/10.1038/s43016-023-00710-3.
23. MPEnsystems et al., Promoting Clean and Energy Efficient Cold-Chain in India, MPEnsystems, Shakti Sustainable Energy Foundation and University of Birmingham, 2019, 23, https://shaktifoundation.in/wp-content/uploads/2019/04/Cold-Chains-in-India-Report-Final-Web.pdf.
24. MPEnsystems et al., Promoting Clean and Energy Efficient Cold-Chain in India.
25. MPEnsystems et al., Promoting Clean and Energy Efficient Cold-Chain in India.

26. UNEP and CCAC, Global Methane Assessment: Benefits and Costs of Mitigating Methane Emissions.
27. Ilissa B Ocko, "Global Methane Assessment: Benefits and Costs of Mitigating Methane Emissions*", Environmental Research Letters* 16, (May 2021): 1, http://iopscience.iop.org/article/10.1088/1748-9326/abf9c8.
28. UNEP and FAO, Sustainable Food Cold Chains: Opportunities, Challenges and the Way Forward.
29. Gabrielle Dreyfus et al., *Assessment of Climate and Development Benefits of Efficient and Climate-Friendly Cooling* (UNEP and CCAC, 2020), 20–21, https://www.ccacoalition.org/en/resources/assessment-climate-and-development-benefits-efficient-and-climate-friendly-cooling.
30. Hoesung Lee et al., "Synthesis Report of the IPCC Sixth Assessment Report (AR6): Summary for Policymakers," in *Climate Change 2023: Synthesis Report. Contribution of Working Groups I, II and III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change,* eds. Hoesung Lee et al. (Geneva: IPCC, 2023), 11, https://report.ipcc.ch/ar6syr/pdf/IPCC_AR6_SYR_SPM.pdf.
31. Hoesung Lee et al., "Synthesis Report of the IPCC Sixth Assessment Report (AR6): Summary for Policymakers," 11.
32. MPEnsystems et al., Promoting Clean and Energy Efficient Cold-Chain in India.
33. Carbon Trust, Net Zero Cold Chains for Food.
34. MPEnsystems et al., Promoting Clean and Energy Efficient Cold-Chain in India.
35. World Bank, Climate Investment Opportunities in India's Cooling Sector, Washington DC, World Bank Group, 2022, 15, https://documents.worldbank.org/en/publication/documents-reports/documentdetail/099920011222212474/p15743300f4cc10380b9f6051f8e7ed1147
36. World Bank, Climate Investment Opportunities in India's Cooling Sector.
37. Carbon Trust, Net Zero Cold Chains for Food.
38. Carbon Trust, Net Zero Cold Chains for Food.
39. Food and Agriculture Organization, World Food and Agriculture: Statistical Yearbook 2021, Rome, FAO, 2021, https://www.fao.org/3/cb4477en/cb4477en.pdf
40. "Food Products Exports by country in US Thousand 2020", World Integrated Trade Solution, World Bank, 2020, https://wits.worldbank.org/CountryProfile/en/Country/WLD/Year/LTST/TradeFlow/Export/Partner/by-country/Product/16-24_FoodProd.
41. "G20 Leaders' Communique," G20, Turkey, 2015, https://www.g20.org/content/dam/gtwenty/about_g20/pdf_leaders_declaration/2015-G20-antalya-leaders-summit-communique.pdf.
42. "G20 Agriculture Ministers Meeting Final Communique," G20, Turkey, 2015, https://www.g20.org/content/dam/gtwenty/about_g20/previous_summit_documents/2015/Communique-G20-Agriculture-Ministers-Meeting-Istanbul.pdf

43. UNEP and FAO, Sustainable Food Cold Chains: Opportunities, Challenges and the Way Forward.
44. Climate & Clean Air Coalition, Cool Coalition, and French Ministry of Ecological Transition, France Leadership on Efficient, Climate-Friendly Cooling, Carbon Trust, Cool Coalition, 2021, 5, https://coolcoalition.org/france-leadership-on-efficient-climate-friendly-cooling/.
45. "Rome Leader's Declaration," G20, Italy, October 30-31, 2021, 8, https://www.gpfi.org/sites/gpfi/files/7_G20%20Rome%20Leaders%27%20Declaration.pdf.
46. "Chair's Summary and Outcome Document," G20, India, March 1-2, 2023, 4, https://www.g20.org/content/dam/gtwenty/gtwenty_new/document/FMM_OUTCOME_DOC.pdf.
47. "Joint G20 Energy-Climate Ministerial Communiqué," G20, Italy, July 23, 2021, 6, http://www.g20.utoronto.ca/2021/2021_G20-Energy-Climate-joint-Ministerial-Communique.pdf.
48. "Bali Leader's Declaration," G20, Indonesia, November 15-16, 2022, 4, https://www.bundesregierung.de/resource/blob/997532/2143366/2d83f07f195e98a12f1f7659daceea285/2022-11-16-g20-declaration-data.pdf?download=1.
49. United Nations Convention to Combat Desertification (UNCCD), "G20 Initiative for Food Security and Africa," UNCCD, www.unccd.int/our-work/G20Initiative#:~:text=The%20ambition%20of%20this%20Global,50%20per%20cent%20by%202040.
50. Organization for Economic Cooperation and Development, G20 Platform on SDGs Localisation and Intermediary Cities (G20 PLIC), OECD, November 23, 2021, https://www.oecd.org/dev/G20-PLIC-Launch-Agenda.pdf.
51. "Technical Platform on the Measurement and Reduction of Food Loss and Waste", Food and Agriculture Organisation, https://www.fao.org/platform-food-loss-waste/background/en.
52. "Who We Are," Global Agriculture & Food Security Program, last modified July 26, 2023, https://www.gafspfund.org/about.
53. Committee on World Food Security, Principles for Responsible Investment in Agriculture and Food Systems, Committee on World Food Security, 2018, 11-16, https://www.fao.org/3/au866e/au866e.pdf.
54. Food and Agriculture Organization, "Technical Platform on the Measurement and Reduction of Food Loss and Waste".
55. "Ministerial Declaration: Action Plan on Food Price Volatility and Agriculture," G20, France, June 23, 2011, https://www.oecd.org/g20/topics/agriculture-food-security/2011-06-23_-_Action_Plan_-_VFinale.pdf.
56. "Market Monitor," Agricultural Market Information System, last modified April 4, 2023, https://www.amis-outlook.org/amis-monitoring/monthly-report/en/.
57. "Technical Platform on the Measurement and Reduction of Food Loss and Waste: LEG – Support for the strengthening of the National Plan for the Reduction of Food Losses and Waste in Argentina (National Law 27,454)," Food and Agriculture Organization, https://www.fao.org/platform-food-loss-waste/in-action/projects/project-detail/apoyo-al-fortalecimiento-

del-plan-nacional-de-reducci%C3%B3n-de-p%C3%A9rdidas-y-desperdicio-de-alimentos-en-argentina-(ley-nacional-27.454)/en.

58. "Technical Platform on the Measurement and Reduction of Food Loss and Waste: LEG - United States Food Loss and Waste 2030 Champions," Food and Agriculture Organization, https://www.fao.org/platform-food-loss-waste/in-action/projects/project-detail/leg---united-states-food-loss-and-waste-2030-champions/en.
59. "Technical Platform on the Measurement and Reduction of Food Loss and Waste: New phase of citizens' engagement: European Citizens' Panel on Food Waste," Food and Agriculture Organization, https://www.fao.org/platform-food-loss-waste/in-action/projects/project-detail/new-phase-of-citizens-engagement-european-citizens-panel-on-food-waste/en.
60. Food and Agriculture Organization, "Technical Platform on the Measurement and Reduction of Food Loss and Waste".
61. Food and Agriculture Organization, "Technical Platform on the Measurement and Reduction of Food Loss and Waste: LEG – Support for the strengthening of the National Plan for the Reduction of Food Losses and Waste in Argentina".
62. Food and Agriculture Organization, "Technical Platform on the Measurement and Reduction of Food Loss and Waste: LEG - United States Food Loss and Waste 2030 Champions."
63. Food and Agriculture Organization, "Technical Platform on the Measurement and Reduction of Food Loss and Waste: New phase of citizens' engagement: European Citizens' Panel on Food Waste."
64. FAO, UNICEF, WFP, and WHO, Asia, and the Pacific – Regional Overview of Food Security and Nutrition 2022: Urban food security and nutrition, 2022, Bangkok, Food and Agriculture Organization of the United Nations, https://doi.org/10.4060/cc3990en.
65. FAO, UNICEF, WFP, and WHO, Europe and Central Asia – Regional Overview of Food Security and Nutrition, 2022, Budapest, Food and Agriculture Organization of the United Nations, 2023, https://doi.org/10.4060/cc4196en.
66. Committee on World Food Security, Forty-sixth Session: Making a Difference in Food Security and Nutrition, August 2019, Rome, CFS, 2–3, https://www.fao.org/3/na703en/na703en.pdf.
67. Committee on World Food Security, Forty-sixth Session: Making a Difference in Food Security and Nutrition.
68. Committee on World Food Security, Principles for Responsible Investment in Agriculture and Food Systems.
69. Committee of World Food Security, Food Losses and Waste in the Context of Sustainable Food Systems: Policy Recommendations, 2014, CFS, https://www.fao.org/3/av037e/av037e.pdf.
70. "G20 Agriculture Ministers' Meeting," G20, September 17-18, 2021), 2, http://www.g20.utoronto.ca/2021/G20-Agriculture-Ministers-Communique-Final.pdf.

71. Global Agriculture & Food Security Program, “Who We Are”.
72. “One dairy cooperative is growing with funds from the Global Agriculture and Food Security Program (GAFSP),” Global Agriculture & Food Security Program, last modified May 1, 2020, https://www.gafspfund.org/news/cow-customer-women-farmers-bangladesh-organize-themselves.
73. “New IFAD- and GAFSP-funded project to scale up successful approaches to increasing food and nutrition security and increase small-scale farmers,’ incomes in Lao PDR,” Global Agriculture & Food Security Program, last modified March 28, 2023, https://www.gafspfund.org/news/new-ifad-and-gafsp-funded-project-scale-successful-approaches-increasing-food-and-nutrition.
74. G20, “Ministerial Declaration: Action Plan on Food Price Volatility and Agriculture,”
75. Agricultural Market Information System, “Market Monitor.”
76. Agricultural Market Information System, “Market Monitor.”
77. G20, “Bali Leader’s Declaration.”
78. “G20 Presidency Chair’s Summary: The G20 Joint Finance and Agriculture Ministers’ Meeting,” G20, Washington DC, October 11, 2022**,** http://www.g20.utoronto.ca/2022/Chair-Summary_G20-JFAMM_11-Oct-2022.pdf.
79. “G20 Action Plan on Food Security and Sustainable Food Systems,” G20, Turkey, 2015, https://www.mofa.go.jp/files/000111212.pdf.
80. G20, Implementation Plan of the G20 Food Security and Nutrition Framework, G20 Development Working Group Food Security and Nutrition, 2015, http://g20.org.tr/wp-content/uploads/2015/11/Implementation-Plan-of-the-G20-Food-Security-and-Nutrition-Framework.pdf.
81. G20, G20 Food Security and Nutrition Framework, G20 Development Working Group on Food Security and Nutrition, 2021, https://dwgg20.org/app/uploads/2021/09/g20-food-security-and-nutrition-framework.pdf.
82. “Mandate & Functioning,” G20, https://www.macs-g20.org/about-macs/mandate-functioning.
83. Thunen, Collaboration Initiative Food Loss and Waste launched at MACS-G20 2022 update on activities, Braunschweig, 2022, https://www.macs-g20.org/fileadmin/macs/Activities/2022_FLW_WS/2022_MACS_G20_FLW_annual_report_2022.pdf.
84. Thunen, Collaboration Initiative Food Loss and Waste launched at MACS-G20 2022 update on activities.
85. “10th Meeting of Agricultural Chief Scientists (MACS): Communiqué,” G20, Italy, 2021, https://www.macs-g20.org/fileadmin/macs/Annual_Meetings/2021_Italy/Documents/Communique.pdf.
86. “Who We Are,” Platform for Agricultural Risk Management, https://www.p4arm.org/who-we-are/.
87. Platform for Agricultural Risk Management, “Where We Work.”

88. Tropical Agriculture Platform (TAP), TAP Action Plan 2018-2021, TAP, September 11, 2018, https://tapipedia.org/sites/default/files/tap_action_plan_2018_2021_11sept2018.pdf.
89. Food and Agriculture Organization, Developing capacities agricultural innovation systems: scaling up the Tropical Agriculture Platform Framework: The TAP-AIS project, FAO, 2019, https://www.fao.org/3/cb3762en/cb3762en.pdf.
90. Food and Agriculture Organization and Committee on World Food Security, Voluntary Guidelines on the Responsible Governance of Tenure of Land, Fisheries and Forests in the Context of National Food Security, 2022, Rome, https://www.fao.org/3/i2801e/i2801e.pdf.
91. "SAVE FOOD: Global Initiative on Food Loss and Waste Reduction," Food and Agriculture Organization, https://www.fao.org/save-food/background/en/.
92. Food and Agriculture Organization, How Access To Energy Can Influence Food Losses: A Brief Overview, Rome, FAO, 2016, https://www.fao.org/3/i6626e/i6626e.pdf.
93. Food and Agriculture Organization, "SAVE FOOD: Global Initiative on Food Loss and Waste Reduction."
94. G20 Turkey, "G20 Leaders' Communique: Antalya Summit.
95. "G20 Energy Ministerial Meeting: Beijing Communiqué," G20, China, June 29, 2016, http://www.g20.utoronto.ca/2016/160629-energy.pdf.
96. G20, G20 Energy Efficiency Leading Programme G20 Energy Efficiency Leading Programme, G20, China, 2016, https://www.ccacoalition.org/en/resources/g20-2016-g20-energy-efficiency-leading-programme.
97. "Global Land Initiative, G20 Global Land Initiative," United Nations Convention to Combat Desertification, https://www.unccd.int/our-work/G20-Initiative.
98. "Territorial Development and SDGs Localisation," G20, Italy, 2021, https://www.esteri.it/mae/resource/doc/2021/11/territorial_development_and_sdgs_localisation.pdf.
99. G20, Rome, "G20 Rome Leader's Declaration".
100. "Matera Declaration on Food Security, Nutrition, and Food Systems: A Call to Action in the Time of the COVID-19 Pandemic and Beyond," G20, Italy, 2021, http://www.g20.utoronto.ca/2021/Matera-Declaration.pdf.
101. G20, "Bali Leader's Declaration."

वसुधैव कुटुम्बकम्

ONE EARTH • ONE FAMILY • ONE FUTURE