Research Paper

Environment and Society Centre

September 2025

How to bolster food security through global early-warning systems

Countering cascading risks with enhanced monitoring and response preparedness

Bhargabi Bharadwaj, Richard King and Mirianna Budimir

CHATHAM HOUSE

Practical ACTION

Chatham House, the Royal Institute of International Affairs, is a world-leading policy institute based in London. Our mission is to help governments and societies build a sustainably secure, prosperous and just world.

Contents

Summary

- The world faces an unprecedented, complex mix of established and emerging risks to food security, as illustrated over the last decade by higher temperature records and recurring episodes of storms, droughts, wildfires, flooding, disease and pest outbreaks. Where these interact with other risk types, such as supply chain disruptions or geopolitical instability, extreme weather and disease can amplify the threats to national food systems and overwhelm siloed response mechanisms. With risks often interconnected through supply chains, financial markets or transboundary climate impacts, threats are increasing in frequency and severity, thereby worsening prospects for food security. These events also imperil the livelihoods of millions and destabilize agri-food systems around the world.
- Early-warning systems are a foundational tool for disaster risk reduction, providing governments, institutions and communities with timely information to prepare and act before risks materialize. These systems monitor, assess and communicate potential outcomes. They are more commonly used to observe natural hazards, both rapid or sudden (e.g. flash floods) and slow-onset (e.g. locust invasion or droughts). While effective in single or dual-hazard scenarios (e.g. responding to natural hazards such as floods, landslides or cyclones), current food security-related early-warning systems are often fragmented – separated by hazard type, institutional ownership and geographic mandate. There is growing, yet little, existing integration of other risk types, such as conflict, disease or dedicated food insecurity warning mechanisms, which could help identify intersectional risks and better understand vulnerabilities.
- This fragmentation limits the ability of these tools to anticipate and respond to the interconnected threats that affect local food systems, such as climate change, pandemics or conflict. Furthermore, early-warning mechanisms often focus on different components of the food system, for example, food availability, and fall short of the coordination needed to address cascading risks (where different risk factors and/or responses can have knock-on effects, sometimes crossing borders and continents) threatening communities, public infrastructure and even social stability more broadly. This paper argues that to effectively support at-risk communities and strengthen food security, early-warning systems must evolve into more comprehensive multi-hazard systems.
- The paper analyses how cascading risks are considered in existing approaches to (1) strengthening risk knowledge; (2) detection, monitoring and forecasting; (3) communication and dissemination; (4) response and preparedness capabilities; and (5) financing early-warning systems and anticipatory action. Our recommendations centre on three areas, with actions required at international, regional, national and subnational levels:

Strengthening the governance of food security early-warning systems and anticipatory action:

- International actors must ensure sustained funding, improve interoperability of data systems, align mandates of existing forecasting initiatives, and elevate the consideration of cascading risks in early-warning and governance structures.
- Regional entities, donors and governments should prioritize investment in and leveraging of existing national or subnational scientific forecasting and monitoring networks to build their multi-risk warning capacities.
- At the national level, there is a need for increased representation of food security and multi-hazard experts in all early warning and disaster response planning. Clear frameworks must define ownership of risks and mechanisms for financing anticipatory responses to address these risks.

Improving the understanding of, and responses to, cascading risks to food systems and the food security of at-risk communities:

- Regional entities should ensure knowledge transfer and capacity-building exchange between regional and national experts. This requires adequate funding and a strong emphasis on community-centred approaches that build local food system resilience.
- Government agencies should integrate real-time monitoring of key drivers of food insecurity to enable timely and informed responses.
- Food security forecasters must collaborate with regional centres and nationally mandated early-warning institutions to ensure coherent, actionable forecasting and monitoring.
- Researchers, civil servants and national civil society should jointly conduct transdisciplinary risk assessments to better understand and prepare for complex, cascading threats to food systems.

Strengthening anticipatory action plans at subnational and national levels:

- International actors must support subnational and national planning through sustainable financing strategies, looking beyond aid, to build complementarities with blended climate finance.
- Regional entities must co-develop indicators based on community and technical food system early-warning knowledge, as well as design communication tools for complex risks.
- At the national level, governments and civil society must develop integrated tools and frameworks with the support of international organizations to monitor evolving risk cascades and ensure this information is used alongside forecasting to complement communication and preparedness plans.
- Finally, at the subnational level, authorities and emergency preparedness actors must develop ways of understanding how communities face impacts, identify where funding gaps are most hindering response and how communities can be better integrated into early-warning and early-action mechanisms.

Glossary

Agri-food systems: All the interconnected activities and actors involved in getting food from field to fork. This encompasses everything from agricultural production and processing, to distribution, consumption and waste management.

Build funding: Investments that directly set up or strengthen the operation of anticipatory action frameworks, e.g. to improve risk data and early-warning processes.

Cascading risk: Refers to the knock-on impact of a hazard in one location that triggers a sequence of secondary events, across borders and sectors, and impacts and spreads through interconnected systems.

Disasters: The direct or indirect results of hazards that negatively impact a population or systems; serious events, often involving loss of life, injury, or severe disruption, that often require external assistance to mitigate or recover from the impact.

Disaster risk reduction: Preventing new, and reducing existing, disaster risk and managing residual risk, all of which contribute to strengthening resilience and therefore to the achievement of sustainable development.

Early-warning systems: An integrated system of hazard monitoring, forecasting and prediction, disaster risk assessment, communication and preparedness activities, systems and processes that enable individuals, communities, governments, businesses and others to take timely action to reduce disaster risks in advance of hazardous events.

Exposure: The people, activities and assets that may be affected by a physical hazard, such as numbers of people living on floodplains or the location and timing of crop production.

Fuel funding: Funds released to implement pre-planned interventions in the event of a disaster or shock.

Hazard: Any potential threat or event that can cause harm. Can include slow-onset (e.g. droughts) or rapid-onset (e.g. flash floods) events and can be both natural and man-made phenomena.

Multi-hazard early-warning systems: Systems that address several hazards and/or impacts of similar or different type in contexts where hazardous events may occur alone, simultaneously, cascadingly or cumulatively over time, and which take into account the potential interrelated effects.

Risk: The interaction of *hazards*, *exposure* to the hazard(s) and *vulnerability* to the hazard(s).

Risk value chain: The interconnected, end-to-end process of producing a warning and the subsequent actions taken to reduce risk.

Triggering hazard: An initial hazard event that initiates a risk cascade.

Threshold conditions: A predetermined, typically quantitative, criterion that, when met, is used to initiate actions. For example, forecast temperatures of over 40°C can trigger the opening of cooling centres.

Undernourishment: The condition of a person that is not able to acquire enough food to meet the daily minimum dietary energy requirements, over a period of one year.

Vulnerability: The propensity of what is exposed to hazard to suffer harm or loss. More difficult to quantify than hazard or exposure. It includes the ability and capacity to adapt to impact.

01 Introduction

As natural disasters and climate change increasingly threaten global food security, the humanitarian system is struggling to cope. Existing early-warning systems are ill equipped for the complex, cascading effects of these crises, leaving communities unprepared and at greater risk.

Sustainable Development Goal 2, which aims to end hunger, achieve food security and improve nutrition by 2030 remains a distant global ambition. According to the latest available figures, one in 12 people faced hunger in 2024.[1] This figure has declined only slightly since 2021, having increased significantly during the COVID-19 pandemic. The global prevalence of food insecurity (the state of not having regular access to food) is also only gradually declining since the pandemic, with 28 per cent of the world population – 2.3 billion people – moderately or severely food insecure in 2024.[2]

In addition to deep-seated structural issues such as poverty and inequality, food security is increasingly under threat from disasters – both slow- and rapid-onset – that are resulting in unprecedented levels of agricultural damage and losses across the world. The UN Food and Agriculture Organization (FAO) estimates that the value of crop and livestock production lost due to disasters equates to more than 5 per cent of global agricultural GDP every year.[3] Disasters – including the impacts of natural hazards, which may be exacerbated by climate change, pandemics, epidemics and armed conflict – affect food security by disrupting the functioning and sustainability of agricultural production, as well as by threatening the livelihoods of millions of people reliant on agri-food systems.[4] While the first-order risks from such hazards to communities' food security are important, societies are increasingly exposed and vulnerable to other complex, compound and cascading

1 FAO, IFAD, UNICEF, WFP and WHO (2025), *The State of Food Security and Nutrition in the World 2025: Addressing high food price inflation for food security and nutrition*, Rome: FAO, IFAD, UNICEF, WFP and WHO, https://doi.org/10.4060/cd6008en.
2 Ibid.
3 Food and Agriculture Organization of the United Nations (2023), *The Impact of Disasters on Agriculture and Food Security 2023: Avoiding and reducing losses through investment in resilience*, Rome: Food and Agriculture Organization of the United Nations, https://doi.org/10.4060/cc7900en.
4 Ibid.

effects on global, regional, national and local food systems, such as food price inflation and disruptions to food availability when logistics infrastructure is harmed by conflict or extreme weather events. These impacts on people's food security are transmitted through system components such as globalized physical supply chains and commodity markets. Impacts on food security can also, in turn, lead to political protests, destabilization, conflict and other forms of societal breakdown; such factors contributed, albeit unevenly and alongside other causal factors, to the 2011 Arab Spring.[5]

The early-warning approach accounts for a fraction of the spending required on disaster response and recovery, and it can contribute towards addressing underlying drivers and providing proactive interventions to prevent predictable hazards from becoming humanitarian emergencies.

The humanitarian system is unable to cope with the trend of these increasing impacts on people's lives and livelihoods (both in terms of food security and other effects).[6] Consequently, the sector is shifting to strengthen anticipatory action by increasingly using early-warning systems to prepare for and reduce risks in advance of hazards occurring. These range from systems that provide vital hours of warning to at-risk populations in advance of a tsunami to those that alert humanitarians of unfolding famine risk over the course of many months. This early-warning approach accounts for a fraction of the spending required on disaster response and recovery, and it can contribute towards addressing underlying drivers and providing proactive interventions to prevent predictable hazards from becoming humanitarian emergencies. Such investments should be funded through broader disaster risk management funding rather than drawing from dedicated operational anticipatory action resources. However, there are gaps in current early-warning systems, meaning that people at risk do not receive sufficiently complete information in appropriate ways to be able to take early action in advance of impending, complex crises.

Recent reductions in official development assistance commitments and disbursements by many donors have made the outlook even more challenging. Most notably for food security, the US-funded and administered Famine Early Warning Systems Network (FEWS NET), which has been a leading famine-monitoring system providing long-term risk assessment since its establishment in 1985, was shut down in January 2025 by the Department of Government Efficiency, under President Donald Trump's second administration. At the time of writing, FEWS NET is now partially back online but is facing an uncertain future.

---

5 Soffiantini, G. (2020), 'Food insecurity and political instability during the Arab Spring', *Global Food Security*, 26, https://doi.org/10.1016/j.gfs.2020.100400.
6 Chawla, N. and Smith, G. (2024), 'The global humanitarian system needs to adapt to the worsening climate crisis', *Humanitarian Practice Network*, https://odihpn.org/publication/the-global-humanitarian-system-needs-to-adapt-to-the-worsening-climate-crisis.

One of the reasons that actionable information is not comprehensive is that current early-warning systems are highly fragmented and siloed by risk types, owners and geographies. They are often focused on responding to specific natural hazards, such as floods, landslides or cyclones, and there is little integration with other types of risk-response mechanisms (such as those relating to conflict, disease or food insecurity).

In 2021, the UN Food Systems Summit Scientific Group highlighted the growing role for science in developing a common language for addressing food-related risks, allowing multiple knowledge systems to converge around the shared goals of better understanding emerging risks and uncertainties, and developing improved means of preparing for and managing them.[7] It recognized the increasing frequency and magnitude of impact from extreme weather events, and the additional volatility and uncertainty related to market and inflationary shocks, widespread disease outbreaks, as well as political or governance disruptions among others.

Existing food security early-warning systems, even those taking a multi-hazard approach, focus on different components of the global food system (such as agricultural production or market prices). They fall short of the level of coordination needed given the complexity of the cascading risks[8] that threaten communities, assets, public infrastructure and nation states more broadly.[9] Accounting for these interrelated effects is essential when seeking to bolster food security through disaster risk management approaches.

While specific early-warning systems for food security exist, they were not designed to respond to the increasingly interconnected hazards and risks for which they are now used. Instead, each of these systems has traditionally been focused on one or two hazards due to complexities and differences in data, expertise and institutional mandates. While monitoring of multiple hazards is increasingly integrated into early-warning systems for food security, greater attention needs to be paid to transboundary risk transmission, whereby connections such as trade or financial flows propagate risks from one area of the world to another, exposing individuals and communities to potentially unforeseen risks.

In an increasingly complex risk landscape, this paper explores early warning and food security communities of practice and assesses the challenges in, and opportunities for, integrating cascading risks to global food systems into existing early-warning systems – with an aim to strengthen approaches to disaster-risk reduction. It considers specific communities in Bangladesh and Senegal, two of the world's most climate-vulnerable countries, as well as global institutions and governance approaches. After providing a conceptual evaluation of early-warning systems and early actions in response to cascading risks to food security (Chapter 2), our analysis in Chapter 3 is organized to reflect four crucial components (often referred to as pillars) of multi-hazard early-warning systems: risk knowledge; detection, monitoring and forecasting risks; disseminating and

---

7 Von Braun, J., Afsana, K., Fresco, L. and Hassan, M. (eds) (2023), *Science and Innovations for Food Systems Transformation and Summit Actions*, Springer.
8 Where different risk factors and/or responses can have knock-on effects, sometimes crossing borders and continents.
9 Inter-Agency Standing Committee (undated), 'Grand Bargain Caucus on Scaling Up Anticipatory Action – Outcome Document Commitments', https://interagencystandingcommittee.org/sites/default/files/2024-02/Caucus_AA%20Problem%20definition%20and%20strategy_final%20version.pdf.

communicating warnings; and addressing preparedness and response capabilities. Financing challenges are considered in Chapter 4, and recommendations in Chapter 5 aim to improve global early warning and anticipatory actions and reduce the impacts of hazards on local food systems and all aspects of food security.

The insights are based on joint work by Chatham House and Practical Action.[10] Our analysis included global and regional semi-structured interviews with mid- and senior-level experts who are working in and on food security and early-warnings systems across UN and humanitarian agencies, academia and think-tanks. It is further supplemented by Practical Action's work with Bangladeshi and Senegalese communities. Key findings were tested in a virtual workshop in February 2025.

10 Practical Action is an international development organization working to empower people in poverty to change their world. It is a leading voice on early-warning systems and is involved in several global networks on early-warning initiatives. Practical Action (2025), 'Improving early warnings of cascading risks to food security in Senegal', Policy Brief, https://practicalaction.org/knowledge-centre/resources/improving-early-warnings-of-cascading-risks-to-food-security-in-senegal/#:~:text=The%20brief%20highlights%20the%20urgent,safeguard%20food%20security%20in%20Senegal.

02
Food security risks and early-warning systems

Communities facing threats to food security often encounter intersecting and cascading risks that do not occur in isolation. To be effective, food security early-warning systems must go beyond single-hazard analysis and integrate these risks, vulnerabilities and socio-economic dimensions.

Evaluating food security early-warning systems requires a clear understanding of the factors affecting food-system resilience and how cascading risks impact food security outcomes. This chapter explores the current landscape of early-warning systems, highlighting their often-siloed nature and assessing progress towards more integrated, multi-hazard approaches. By mapping transmission dynamics of risks and response archetypes as well as critical stakeholders and institutional partners, the analysis provides a holistic framing for considering the adequacy of early-warning systems to anticipate the cascading risks to food security.

Food security and resilient food systems

At the core of food systems are the activities and actors involved in the production, supply and consumption of food through multiple interacting value chains. But rather than considering these elements in isolation, it is important to examine these activities in a systemic context, focusing on their interactions with each other, and the broader drivers of the socio-economic, political and environmental landscapes in which they occur. With this in mind, it is clear that food security can only be sustained when indirect and systemic risks are effectively managed together

with more direct risks to agricultural production and specific communities' access to food. Food security – 'when all people, at all times, have physical, economic and social access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life'[11] – is commonly distilled into four components:

- **Availability:** achieved when there is a reliable supply of food of sufficient quantity and quality (from production, stocks, trade and food aid). Disrupted weather patterns hampering agricultural production, inadequate food reserves and trade dislocations all make food less available.
- **Access:** achieved when there are adequate resources to obtain appropriate food (dependant on affordability, purchasing power, equitable distribution and market access). Rising food prices (e.g. from production shocks or trade dislocations), social inequalities and poor or hazard-impacted infrastructure all worsen food accessibility.
- **Utilization:** ensured when food is nutritious and can be metabolized and used by the body (dependant on food safety, quality, preparation and sanitation). Climate-induced health and sanitation issues such as vector-borne diseases, lack of climate-controlled food storage and erosive coping strategies that impair future resilience can all compromise the ability to utilize nutritious food.
- **Stability over time:** achieved when there is permanent and durable availability, access and utilization. Fluctuating incomes and harvests and disrupted supply chains make food systems less stable.

When food security is threatened, it can disrupt social cohesion and stability. In 2007–08, rapidly rising staple food prices triggered a wave of so-called 'food riots' around the world, as (mainly) urban populations experiencing rapid increases in the cost of living protested at both the failures of governments to stabilize prices and the withdrawal of consumer subsidies. In some cases, these protests contributed to broader political instability such as during the 'Arab Spring'.[12]

Cascading and compound risks

Cascading and compound risks develop from the interactions between direct hazards, such as extreme weather events, and the actions or inactions in response. These interactions and responses may, in turn, have potential knock-on impacts for different segments of society or socio-economic or political systems, which may be far removed – geographically or by sector – from the location of the initial

11 Committee on World Food Security (2009), *Reform of the Committee on World Food Security – Final Version*, Thirty-fifth Session, Rome, http://www.fao.org/tempref/docrep/fao/meeting/018/k7197e.pdf.
12 Scott-Villiers, P., Chisholm, N., Wanjiku Kelbert, A. and Hossain, N. (2016), *Precarious Lives: Food, Work and Care After the Global Food Crisis*, Institute of Development Studies and Oxfam, https://www.ids.ac.uk/publications/precarious-lives-food-work-and-care-after-the-global-food-crisis.

hazard.[13] These novel interactions and confluences of risks and responses can lead to further, sometimes systemic, risks to other peoples and to the supply networks on which those people depend.

The complexity and global connectivity of food systems today, coupled with the non-linear ways in which they interact with other human and natural systems, creates significant potential for localized risks to affect nutrition outcomes for people and societies in distant locations. For example, in 2007–08 and 2012, after a build-up of structural weaknesses in the food system, a series of relatively localized droughts in global breadbasket regions (particularly Australia in 2006, and the US Midwest and the Black Sea region in 2012) precipitated two global food crises.[14]

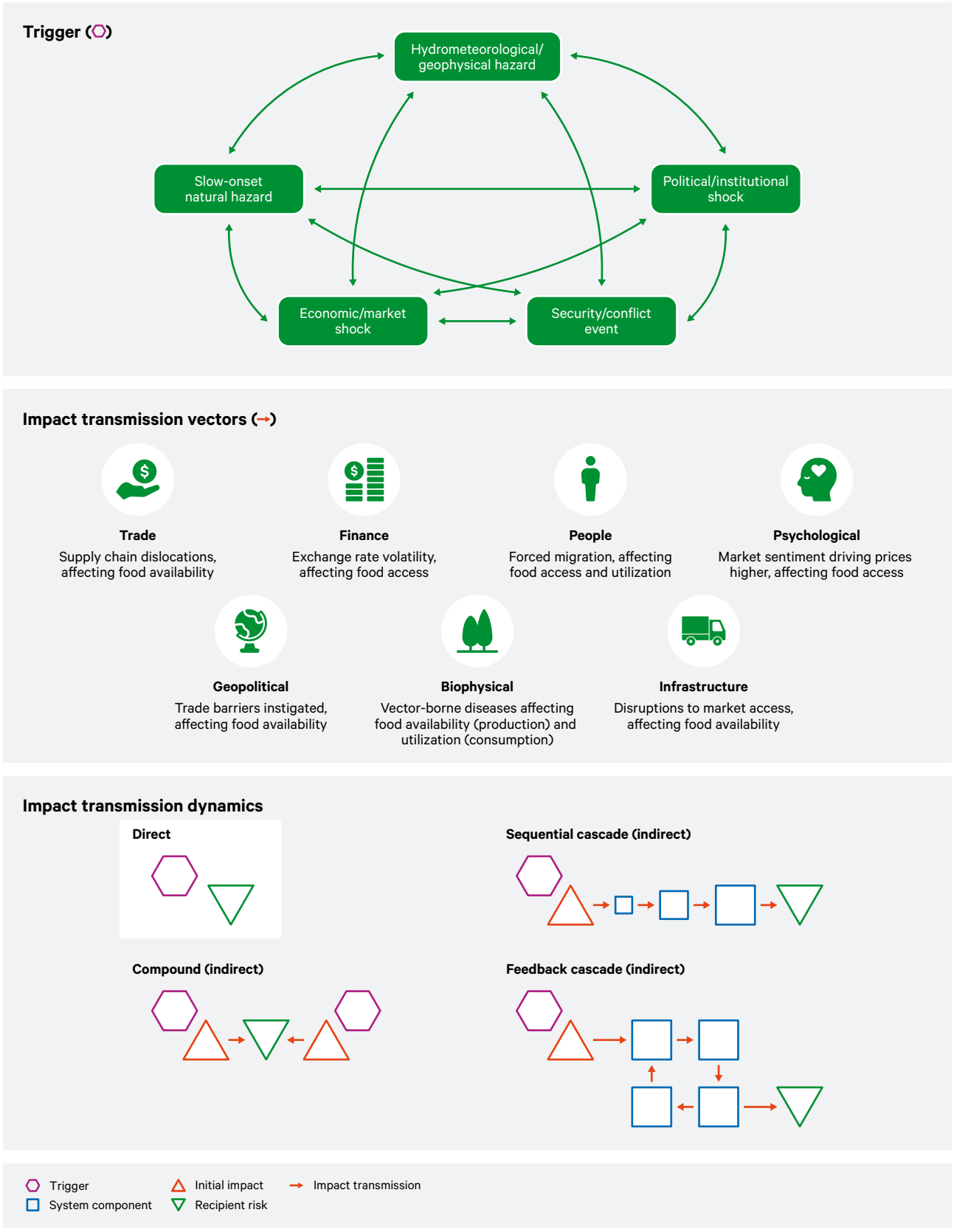
The complexity and global connectivity of food systems today, coupled with the non-linear ways in which they interact with other human and natural systems, creates significant potential for localized risks to affect nutrition outcomes for people and societies in distant locations.

More recently, in 2021, the *Ever Given* container ship ran aground in the Suez Canal, blocking the vital maritime passage for six days, disrupting an estimated $9.6 billion of trade per day. As around 15 per cent of global grain trade passes through the Suez Canal, had the interruption lasted longer, the impacts on many countries' food security could have been much worse – both for those with directly affected import orders and more generally, as disruptions are reflected in international market prices.[15] Similarly, Russia's invasion of Ukraine disrupted both the availability and affordability of food, with historically high prices affecting some of the world's poorest and most food-insecure countries in 2022.[16]

---

13 Carter, T. R. et al. (2021), 'A conceptual framework for cross-border impacts of climate change', Global Environmental Change, 69, 102307, https://doi.org/10.1016/j.gloenvcha.2021.102307; Hochrainer-Stigler, S. et al. (2023), 'Toward a framework for systemic multi-hazard and multi-risk assessment and management', *iScience*, 26(5), https://doi.org/10.1016/j.isci.2023.106736.
14 King, R. (2015), 'Anomaly or Augury? Global Food Prices Since 2007', *IDS Bulletin*, 46(6), pp. 20–32, http://doi.org/10.1111/1759-5436.12183.
15 King, R. (2022), *Exploring the cascading impacts from climate shocks to chokepoints in global food trade*, CASCADES, https://www.cascades.eu/publication/exploring-the-cascading-impacts-from-climate-shocks-to-chokepoints-in-global-food-trade.
16 Diao, X., Dorosh, P. and Thurlow, J. (2022), *Impacts of the Ukraine and Global Crisis on Food Systems and Poverty and Policy Responses: Bangladesh Case Study*, presentation at the Bangladesh Institute of Development Studies, International Food Policy Research Institute, https://bids.org.bd/public/bids-org/uploads/events/Dr.%20Paul%20Dorosh.pdf.

Figure 1. Typologies of cascading and compound risks



Source: Adapted from Carter, T. R. et al. (2021), 'A conceptual framework for cross-border impacts of climate change', *Global Environmental Change*, 69, 102307, https://doi.org/10.1016/j.gloenvcha.2021.102307.

Figure 1 provides a conceptual overview of triggering hazards that can initiate a risk cascade, the vectors that can transmit the ensuing impacts to other places, peoples and sectors of society, and the pathways through which risks may subsequently amplify, attenuate or mutate.

A local food system may be thought of as one where production, processing, distribution and consumption all occur in a broadly contiguous region. For direct risks to local food systems and food security (such as extreme weather events affecting local production), the nature and proximity of the hazard will fundamentally determine the type of response required. For indirect and cascading risks (such as weather or conflict affecting international supply chain continuity), this is less clearly the case; the risk to communities may be best reduced through resilience-building measures in the communities ultimately affected, or by interrupting upstream exposures and vulnerabilities to secondary, tertiary or later-order risks. However, anticipatory action and resilience-building strategies are mostly confined within tightly defined sectoral contexts or specific geographical regions that often overlook transmission of impacts across sectors and borders and are not typically part of systemic and cross-scale solutions to build resilience more holistically.[17] Therefore, understanding and anticipating the transmission pathways of potential risk cascades, and the best ways and locations for responding to these, can inform planning and decision-making to better support both local and systemic food system resilience.

Early-warning systems

Warning systems are a key component of disaster risk reduction. They coordinate various stakeholders and provide communities with timely information, allowing them to prepare for and mitigate the impacts of hazard events (such as geophysical or hydrometeorological shocks or the outbreak of conflict).[18] Warning systems monitor, assess and communicate risks to support resilience and sustainable development. However, as mentioned, they frequently have a narrow focus. This results in pervasive difficulties in developing knowledge of and monitoring indirect, cascading risks; in establishing cohesive institutional ownership of recurring risks; and in adequate financing for systemically focused early-warning systems.

There is increasing global recognition of the importance – and the shortcomings – of early-warning systems. The Sendai Framework for Disaster Risk Reduction (adopted by the UN in 2015) set out a substantial increase in availability and access to multi-hazard early-warning systems, disaster risk information and assessments to people by 2030. During the 27th UNFCCC Conference of the Parties (COP27) in 2022, the UN secretary-general launched the Early Warnings for All (EW4All) Initiative.[19] This set an ambitious target to ensure that everyone on Earth is protected by multi-hazard early-warning systems within five years. One year after launch

---

17 Talebian, S. et al. (2025), 'A conceptual framework for responding to cross-border climate change impacts', *Environmental Science & Policy*, 163, https://doi.org/10.1016/j.envsci.2024.103949.
18 Rokhideh, M., Fearnley, C. and Budimir, M. (2025), 'Multi-Hazard Early Warning Systems in the Sendai Framework for Disaster Risk Reduction: Achievements, Gaps, and Future Directions', *International Journal of Disaster Risk Science*, 16, pp. 103–116, https://doi.org/10.1007/s13753-025-00622-9.
19 United Nations (2025), 'Early Warnings for All', https://www.un.org/en/climatechange/early-warnings-for-all.

the number of countries reporting the existence of multi-hazard early-warning systems stood at 101 (double the number in 2015), but significant gaps in coverage and efficacy remained.[20] The initiative supports countries in building and operating effective and inclusive multi-hazard early-warning systems by focusing and organizing efforts and financing around four 'pillars', each led by a different UN agency or, in the case of Pillar 4, the International Federation of Red Cross and Red Crescent Societies: Pillar 1 focuses on disaster risk knowledge; Pillar 2 on detection, observations, monitoring, analysis and forecasting of hazards; Pillar 3 on warning dissemination and communication; and Pillar 4 on preparedness and response capabilities (Figure 2).

Figure 2. The four pillars of the UN's Early Warnings for All initiative

Source: World Meteorological Organization (2022), 'Early Warnings for All initiative gains momentum', press release, https://wmo.int/news/media-centre/early-warnings-all-initiative-gains-momentum.

Early-warning alerts exist to enable anticipatory action to be taken before risks materialize. Anticipatory action is defined as 'acting ahead of a predicted hazardous event to prevent or reduce impacts on lives and livelihoods and humanitarian needs before they fully unfold'.[21] This approach is most effective when activities, along with triggers or decision-making protocols, are already established, enabling timely decisions that ensure the rapid release of pre-arranged funding. Acting early reduces the need for coping strategies that have the potential to negatively affect long-term resilience by affected peoples and allows stakeholders to reach more people effectively, providing long-term benefits and cost savings.

20 United Nations Office for Disaster Risk Reduction and World Meteorological Organization (2023), 'Global Status of Multi-Hazard Early Warning Systems', https://www.undrr.org/reports/global-status-MHEWS-2023.
21 Inter-Agency Standing Committee (2024), 'Grand Bargain Caucus on Scaling Up Anticipatory Action', Inter-Agency Standing Committee, https://interagencystandingcommittee.org/sites/default/files/2024-12/GB%20AA%20-%20Final%20Caucus%20Outcome%20Document%20-%20New.pdf.

Such actions can, and should, complement long-term investments in disaster risk reduction and resilience-building by being included in, and aligned with, broader disaster risk management portfolios and social protection programmes.[22]

Acting early reduces the need for coping strategies that have the potential to negatively affect long-term resilience by affected peoples and allows stakeholders to reach more people effectively, providing long-term benefits and cost savings.

Determining how early to respond depends on the nature of risks and how well the occurrence and incidence of hazards and impacts can be anticipated. Current efforts by the World Food Programme (WFP) and other early-warning information producers are often focused on making technological advancements that can reliably forecast the triggering hazard event.[23] Translating existing early-warning systems, which tend to monitor single or dual-hazard events, into more comprehensive multi-hazard early-warning systems is a complex task.[24] These systems must address several hazards of similar or different natures occurring alone, simultaneously, in cascades or cumulatively over time.

Multi-hazard early-warning systems

In 2017, the international early-warning system community recognized that the incorporation of interacting and cascading risks into communications with the local populace was essential to support more effective community decision-making for appropriate hazard responses. A Multi-Hazard Early Warning System checklist was developed, which specified that such systems must address multiple hazards and impacts of 'similar or different types in contexts where hazardous events may occur alone, simultaneously, cascadingly or cumulatively over time to account for potential interrelated effects […] with the ability to warn of one or more hazards'.[25] The rationale for developing such systems was to improve the efficiency and consistency of warnings through coordinated, compatible mechanisms or capacities, adopting a multi-disciplinary approach for more accurate hazard identification and monitoring of various types of hazards and impacts interrelationships.[26]

---

22 WFP (2022), *Integrating Anticipatory Action and Social Protection*, https://www.wfp.org/publications/integrating-anticipatory-action-and-social-protection; Food and Agriculture Organization of the United Nations and World Food Programme (2023), *FAO-WFP Anticipatory Action Strategy*, https://docs.wfp.org/api/documents/WFP-0000152350/download.
23 Irasema, A.A. and Anthony, O.S. (2019), 'Early Warning Systems: Lost in Translation or late by Definition?', *International Journal of Disaster Risk Science*, 10, pp. 317–331, https://doi.org/10.1007/s13753-019-00231-3.
24 Budimir, M. et al. (2025), 'Opportunities and challenges for people-centred multi-hazard early warning systems: Perspectives from the Global South', *iScience*, 28(5), https://doi.org/10.1016/j.isci.2025.112353.
25 United Nations Office for Disaster Risk Reduction and World Meteorological Organization (2025), 'Disaster Risk Reduction Terminology – Definition: Early warning system', https://www.undrr.org/terminology/early-warning-system.
26 World Meteorological Organization (2018), *Multi-hazard Early Warning Systems: A Checklist*, https://community.wmo.int/sites/default/files/EWS_Checklist_0.pdf?cNCI0mkEKe2FY7nJrkC09atRuoqTCyfc.

However, development of this concept has been limited until recently and there has been only sparse operational application in the Global South.[27] Progress has been made, however, in developing knowledge about how to operationalize early-warning systems that consider all risks faced by communities, and in breaking down silos between sectors. This has occurred through a combination of the EW4All initiative momentum, progress in the multi-risk research community, and discussions within the Risk-informed Early Action Partnership (REAP) and the Anticipation Hub's multi-risk and anticipatory action and conflict working groups.[28] The movement towards impact-based forecasts[29] and people-centred early-warning systems[30] also further supports the need to develop early-warning systems that consider all risks faced by people, to provide them with actionable information in advance of impacts to reduce losses and damages.

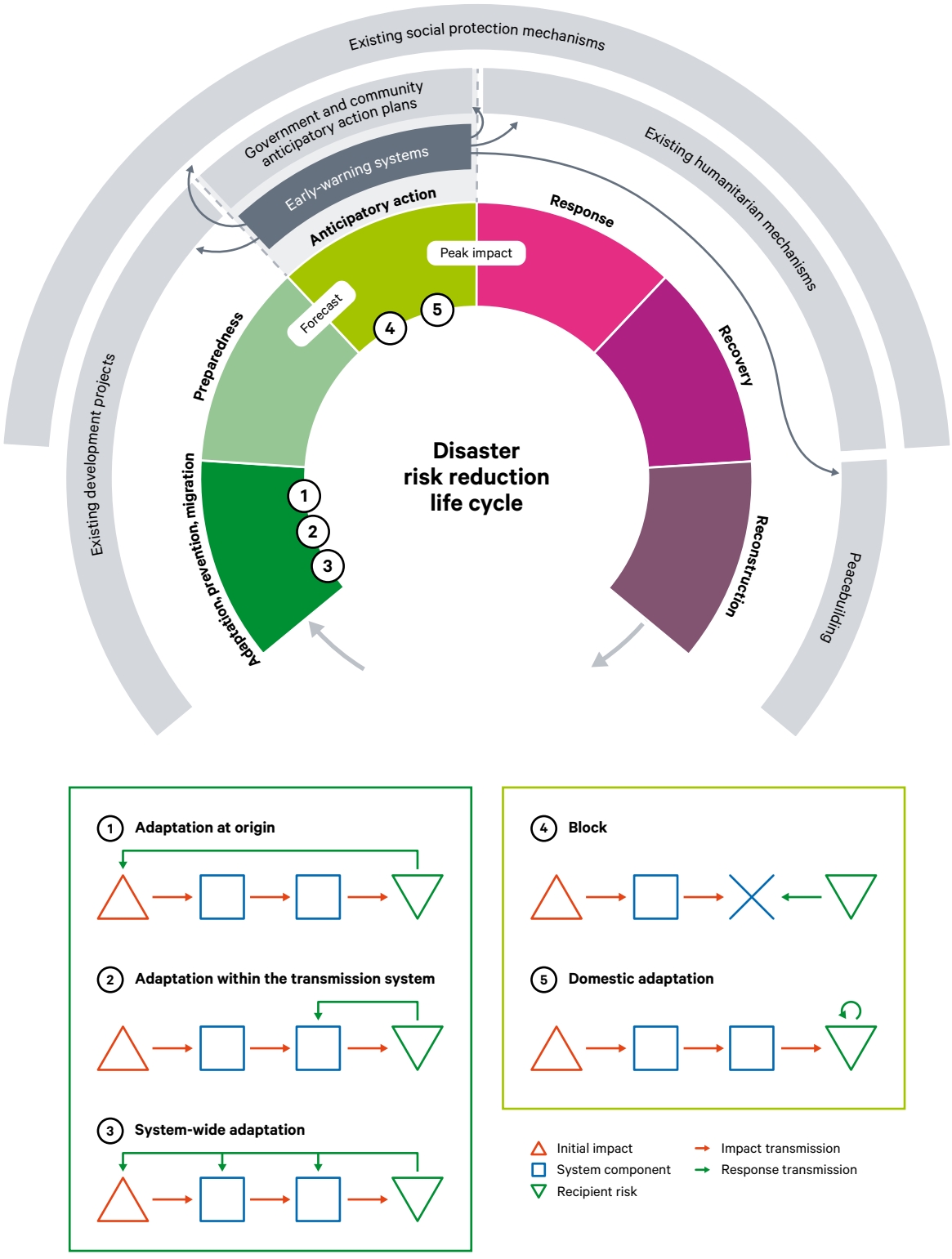
Figure 3 provides a typology of different responses to cascading and compound risks, and relates these to different phases within the life cycle of how a risk evolves. The figure illustrates that the typical focus of early-warning systems – which is on mitigating the final risk(s) experienced by potentially affected communities – is part of a broader portfolio of actions. These can be taken to mitigate and build resilience to cascading risks, not only at the site of final impact, but also at the source and at various points along the risk transmission pathway. Early action can therefore be implemented at different points and windows of opportunity determined by the scale and the focus of the early-warning system. For example, early-warning systems, which focus on the time frame between a hazard being forecasted and its maximal potential impact, may utilize a 'block' response/action to interrupt the cascade of impacts before they affect a given community. Equally, early-warning systems may enable a 'domestic adaptation' response/action that seeks to absorb the impacts in the affected community by reducing community members' vulnerabilities. Conversely, 'adaptation at origin', 'adaptation within the transmission system' and 'system-wide adaptation' are all approaches that may be initiated earlier in the disaster risk management timeline to adapt to, prevent, mitigate or otherwise prepare for cascading risks that are yet to materialize within the focal community.[31]

Some of these approaches require interventions that go beyond the temporal remit of early-warning systems. However, this paper questions whether existing early-warning systems can be remodelled so that they better understand and anticipate some of these more complex risk types, particularly in relation to food security, and facilitate responses that engage with or complement other resilience-building measures throughout the risk transmission pathway – from long-term development programming to humanitarian disaster responses, and through integration into existing social protection mechanisms.

---

27 Budimir et al. (2025), 'Opportunities and challenges for people-centred multi-hazard early warning systems'.
28 Fearnley, C. (2024), 'Multi-Hazard Early Warning Systems – Building warnings for multiple hazards (MHEWS)', UCL Warning Research Centre, https://www.ucl.ac.uk/sts/sites/sts/files/briefing_note_mhews_final.pdf.
29 World Meteorological Organization (2021), *WMO Guidelines on Multi-hazard Impact-based Forecast and Warning Services (WMO-No. 1150)*, https://etrp.wmo.int/pluginfile.php/16270/mod_resource/content/0/wmo_1150_en.pdf.
30 Budimir et al. (2025), 'Opportunities and challenges for people-centred multi-hazard early warning systems'.
31 Talebian et al. (2025), 'A conceptual framework for responding to cross-border climate change impacts'.

Figure 3. Relating early-warning systems and anticipatory action to broader resilience-building measures and cascading risk response mechanisms



Source: Compiled by the authors, adapted from UN Office for Disaster Risk Reduction (2024), *Anticipatory Action: An innovative tool at the intersection of disaster risk reduction and humanitarian response*, https://www.undrr.org/publication/briefing-note-anticipatory-action-innovative-tool-intersection-disaster-risk-reduction; Talebian et al. (2025), 'A conceptual framework for responding to cross-border climate change impacts'.

Institutions, governance and policy approaches

Early-warning systems require collaboration and coordination across a range of actors (outlined in Table 1) to ensure the right information gets to the right people in the right way, allowing them to take timely action. This includes working across sectors, disciplines and scales.[32] At the national level, responsibilities and mandates are assigned to different components of an early-warning system, which are typically split across different government organizations.[33] National hydrometeorological services are typically responsible for monitoring weather-related observations, operational forecasting activities and issuing alerts. Meanwhile, agriculture ministries and national disaster risk management authorities tend to be responsible for handling risks, including responding to alerts. However, in Global South contexts where resources are more stretched, these agencies frequently respond after the hazard event, rather than beforehand in response to an alert.[34] National Red Cross federations also work closely on the response aspects, and in recent years have made significant advancements in implementing anticipatory action with various local, national and global stakeholders. Non-state actors such as non-governmental organizations (NGOs), civil society organizations (CSOs), media and researchers often play a critical role in national and local early-warning systems and anticipatory action to fill and bridge gaps in national capacities.

Table 1. Critical stakeholders according to the four EW4All pillars for delivering effective early-warning systems

	Pillar 1	Pillar 2	Pillar 3	Pillar 4
	Risk knowledge	**Monitoring**	**Dissemination**	**Preparedness**
International				
State				
UN agencies supporting early-warning systems	●	●	●	
International World Meteorological Organization Integrated Processing and Prediction System (WIPPS) centres		●		
UN agencies providing humanitarian support			●	●
Context-dependent				
Space agencies and international groups	●	●		
International Federation of Red Cross and Red Crescent Societies	●		●	●
Media	●		●	●
Non-state				
Early-action networks	●	●	●	
Private sector	●	●		●

32 Risk Informed Early Action Partnership (2024), *The Role of State and Non-State Actors in Early Warning and Early Action: Capacity Gaps and Collaboration*, https://www.early-action-reap.org/sites/default/files/2024-06/REAP_State-Non-State-Actors-EWS.pdf.
33 Ibid.
34 Šakić Trogrlić, R. et al. (2022), 'Early Warning Systems and Their Role in Disaster Risk Reduction', *Towards the "Perfect" Weather Warning*, pp. 11–46, https://doi.org/10.1007/978-3-030-98989-7_2.

	Pillar 1	Pillar 2	Pillar 3	Pillar 4
	Risk knowledge	**Monitoring**	**Dissemination**	**Preparedness**
Regional				
State				
Regional meteorological services		●		
Regional development bodies			●	●
Context-dependent				
Regional early-action networks	●	●	●	
Media	●		●	●
Non-state				
Private sector	●	●		●
National				
State				
Disaster management agencies	●	●		
Cabinet offices	●			
Infrastructure providers	●			
Land use and urban planners	●			
Scientific and technical agencies	●			
National meteorological and hydrological services		●	●	
Energy utilities		●		
Military authorities		●		
Public health authorities		●		
Emergency managers			●	
Police			●	
Telecommunication authorities			●	
Civil protection agencies				●
DRR and management departments				●
Health authorities				●
National weather services				●
Context-dependent				
Research organizations	●	●	●	●
Media	●		●	●
National Red Cross and Red Crescent Societies	●		●	●
Aviation authorities		●		
Social media		●		

	Pillar 1	Pillar 2	Pillar 3	Pillar 4
	Risk knowledge	**Monitoring**	**Dissemination**	**Preparedness**
Non-state				
NGOs	●	●	●	●
Private sector	●	●		●
Citizen scientists	●	●		
Community representatives involved in DRM	●			
Insurance sector	●			
Humanitarian agencies		●		
Local monitoring stations, community-owned		●		
International Telecommunication Union			●	
Private sector communication companies			●	
Radio stations			●	
Subnational				
State				
Disaster management agencies	●	●		
Local government		●	●	●
Context-dependent				
Early-action networks	●	●	●	
Media	●		●	●
Schools and education sector				●
Non-state				
Local chamber of commerce, local businesses	●	●		●
Community-based DRR and emergency management committees	●			●
Communities using traditional techniques to monitor conditions		●		
CSOs and community-based organizations			●	●
Local volunteers			●	
Radio stations			●	

Note: DRM: Disaster risk management; DRR: Disaster risk reduction.
Source: Developed from figures 1 and 2, Risk-informed Early Action Partnership (2024), *The Roles of State and Non-State Actors in Early Warning and Early Action*, https://www.early-action-reap.org/roles-state-and-non-state-actors-early-warning-and-early-action.

Responsibilities across non-natural hazard-related risks are further divided, or in some cases unclear or unassigned. In some contexts, national hydrometeorological services work with agriculture departments so that agricultural extension services (alerts and relevant information) can be delivered to farmers. UN agencies such as the Food and Agriculture Organization (FAO) and WFP focus on food security. Humanitarian organizations, both international and national, are often among the most active actors for tracking local conflict dynamics and impacts on displaced populations.

Transboundary early-warning systems are not commonplace and face challenges such as data sharing.[35] The flow of information is typically dictated by administration boundaries and cross-country relationships rather than how hazards and risks affect geographies and people. However, there are some examples where regional bodies support cross-country collaboration and provide regional forecast information, for example: the Regional Integrated Multi-Hazard Early Warning System (RIMES) in Africa and Asia; AGRHYMET Regional Centre in the Sahel (a specialized regional climate and disaster risk data facility of the Permanent Interstate Committee for Drought Control in the Sahel – CILSS); and the Climate Prediction and Applications Centre (ICPAC) of the Intergovernmental Authority on Development (IGAD), a monitoring centre providing climate services to 11 East African countries that is accredited by the World Meteorological Organization.

At the global level, more initiatives are emerging to facilitate learning on early-warning systems across contexts and sectors. In addition to the UN EW4All initiative, REAP, formed in 2019, brings together a range of early warning early action (EWEA) stakeholders across the climate, humanitarian and development communities with the aim of making one billion people safer from disasters by 2025. Furthermore, the Anticipation Hub established by the Red Cross serves as a platform for promoting knowledge exchange, learning, guidance and advocacy on anticipatory action. It operates both virtually and in person, uniting partners across the Red Cross Red Crescent movement, universities, research institutes, international non-governmental organizations, UN agencies, governments, donors and various network initiatives.

Capacity-building for early-warning systems is being linked to climate-risk financing. Doing so better positions early-warning systems to receive financial support, for example through the G7 and V20 partnership on the Global Shield against Climate Risks and the cross-regional partnership between the African Union and European Union within the Global Gateway Investment Package. The latter has committed a total of €1 billion to support initiatives led by the African Union, focusing on early-warning systems.[36] However, these opportunities must be supported by stronger ambition and clarity on how early-warning systems can be operationalized to support anticipatory actions that reduce losses and damages.

35 Ibid.
36 Inter-Agency Standing Committee (2024), 'Grand Bargain Caucus on Scaling Up Anticipatory Action'.

Food security early-warning systems

When they first emerged in the 1980s, food-security early-warning systems were focused on preventing famines, largely in response to the devastating 1984–85 famines in Sudan and Ethiopia. Since then, they have become more technologically advanced, better resourced and more widely applied. This progress has led to fewer lost lives and livelihoods where early-warning systems are effectively implemented.

Figure 4. Global food crisis risk monitoring systems to enable early warning for early action

Source: Vos, R. et al. (2024), 'Chapter 2: Food Crisis Risk Monitoring: Early Warning for Early Action'.
Note: see Annex 1 for further details on each early-warning system.
IPC/CH: Integrated Phase Classification / Cadre Harmonisé (FAO, WFP and multiple partners); FEWS NET: Famine Early Warning System Network (USAID-funded); VAM1: Vulnerability Analyses and Mapping and Hunger Map LIVE (WFP); VAM2/CARI: Consolidated Approach for Reporting Indicators of Food Security (WFP); VAM3: Global Market Monitor (WFP); GIEWS: Global Information and Early Warning System (FAO); FAOSTAT: FAO Statistics database; GEOGLAM: Crop Monitor (Group on Earth Observations Agricultural Monitoring); CropWatch: (Chinese Academy of Science); AMIS: Agricultural Market Information System (multi-agency, multi-country/G20); FAS: Foreign Agricultural Service (USDA); FSP1: Food Security Portal: Excessive Food Price Variability Index (IFPRI); FSP2: Food Security Portal: Food and Fertilizer Trade Restrictions; Fertilizer Market; and Production and Stocks Trackers (IFPRI); FSP3: Food Security Portal: Domestic Food Price Monitor (IFPRI); FSP4: Food Security Portal: Vulnerability Analysis Dashboard (IFPRI).

As with other early-warning systems, those that focus on food security have proven effective in identifying hazard types and assessing population exposure, especially in single-hazard scenarios. But their capacity to address broader forms of risk needs strengthening. For these systems to be truly effective in complex, multi-hazard environments, they must develop an understanding of both the dynamic vulnerabilities and multiple interacting hazards and socio-economic dimensions that influence the risk faced by vulnerable populations. Communities facing threats to food security often encounter intersecting and cascading risks that do not occur in isolation; rather, these risks amplify one another, and cascade dynamically over time. Current food security monitoring typically relies on either agricultural commodity and market information or acute food insecurity analysis (Figure 4). Yet multi-hazard early-warning systems must holistically integrate these and other drivers (see Figure 1) to provide a comprehensive picture.[37]

Agricultural market monitoring concentrates on factors that may impair food access and availability, although the focus is often on commodities and wholesale prices rather than on food products and the retail environment. Production factors are often remotely sensed, and international commodity-market information is widely available, but market data within countries often must be gathered in person, which results in variations in the type and completeness of information available from one country to another, posing limitations for inter-country comparisons.

Acute food insecurity monitoring directly estimates degrees of food insecurity from country- or local-level data. Information availability is limited to a select number of countries and focuses predominantly on undernourishment rather than broader and more chronic food insecurities; in some cases, time-series data are not available. These early-warning systems on agricultural markets and food insecurity are disjointed. They thus provide a limited understanding of how global price shocks are transmitted to national and then local contexts, and of which structural vulnerabilities increase direct, indirect and cascading risks.[38] Furthermore, the use of different methodologies and varying coverage of vulnerable populations can mean that different early-warning systems for acute food insecurity yield dissimilar estimates of the severity of food crises, which complicates forecasting and early-warning processes.

37 Vos, R. et al. (2024), 'Chapter 2: Food Crisis Risk Monitoring: Early Warning for Early Action', in IFPRI (2024), *Global Food Policy Report 2024*, https://gfpr.ifpri.info/2023/04/11/food-crisis-risk-monitoring-early-warning-for-early-action.
38 International Food Policy Research Institute (IFPRI) and AMIS (2023), 'Facilitating Anticipatory Action with Improved Early Warning Guidance', podcast, https://www.ifpri.org/event/facilitating-anticipatory-action-improved-early-warning-guidance.

03 Evaluating early-warning systems to improve food security

Research across global, regional and local contexts – including case studies in Bangladesh and Senegal – shows that scaling up existing food security early-warning systems is impeded by technical limitations and an insufficient focus on structural vulnerabilities.

This chapter assesses existing food security early-warning systems against the four pillars of the Early Warnings for All (EW4All) initiative to evaluate their capacities to understand, issue alerts and respond to cascading risks that affect food-system functions and food security outcomes. Progress against the four pillars of effective multi-hazard early-warning systems is assessed using global, regional, national and local perspectives to analyse (i) the extent to which existing siloes within these systems render them inadequate, and (ii) how the complex risks faced by populations, including those who are most marginalized can be comprehensively understood. The analysis draws on insights corroborated from global key informant interviews, national and regional consultations, and community-level focus groups, with dedicated research on 'missing voices', in complex multi-risk contexts in Bangladesh and Senegal. These case studies from the cities of Satkhira and Faridpur in Bangladesh, and the region of Kaffrine in Senegal provide context for how multi-hazard early-warning systems can be strengthened based on existing foundations of early-warning approaches.

Bangladesh

In Bangladesh, the multi-level study focused on river deltas and coastal communities. Satkhira and Faridpur were chosen due to the impacts from increasingly destructive annual monsoon seasons, coupled with river floods and rising sea levels, as well as increasing salinity of agricultural soils in coastal areas. In recent years, the country has made progress in improving food security. Yet, 21 per cent of the population still experience moderate to severe food insecurity.[39]

Senegal

In 2022, nearly 27 per cent of people in Senegal were food-insecure and food price inflation affected households, which typically spend 50 per cent of their income on food. In some regions, such as Kaffrine, agricultural activity is the main source of income for more than 90 per cent of households. This region was chosen due to multi-hazard impacts, including floods, drought, wildfires and locusts, and because current national early-warning systems do not capture potential triggers for these events, or subsequent impacts.

Pillar 1: Risk knowledge (hazards, exposures, vulnerabilities)

While the early-warning system and anticipatory action communities conceptually recognize cascading risks to food security, particularly compound risks, the operational understanding of these threats remains limited.[40] Attention is increasingly being paid to multi-hazard approaches that take into consideration concurrent or sequential hazards. However, understanding is less advanced regarding how multiple hazard interactions can influence underlying exposures and vulnerabilities to individual hazards. Knowledge of broader multi-risk dynamics lags behind multi-hazard understanding (Box 1).

This knowledge gap – exacerbated by limited systematic risk assessments and coordinated data flows – prevents empirical tracking of how these risks evolve across borders or sectors, or when multiple risk factors converge.[41] This was seen in Bangladesh and Senegal, where certain hazards are not yet adequately understood or addressed – such as those without dedicated warning systems (e.g. heatwaves), or when food security is compromised by a confluence of hydrometeorological and other risk factors like market price fluctuations or conflict that affect access to food.

---

39 IPC Technical Working Group (2022), *IPC Analysis Report on the Chronic Food Insecurity Situation Bangladesh*, Dhaka: Food Planning and Monitoring Unit, Ministry of Food, FAO and WFP, https://www.ipcinfo.org/fileadmin/user_upload/ipcinfo/docs/IPC_Bangladesh_Chronic_Food_Insecurity_2022June_report.pdf.
40 Alexander, D. and Pescaroli, G. (undated), 'Understanding Compound, Interconnected, Interacting and Cascading Risks: A Holistic Framework', *Risk Analysis*, 38(11), https://doi.org/10.1111/risa.13128.
41 Some examples of food insecurity monitoring, through FEWS NET and underlying Integrated Food Security Phase Classification (IPC) protocols, more effectively integrated various drivers of food insecurity to some extent, using vulnerability indicators for current projections and for up to four months ahead (short term) or eight months ahead (medium term) – until the recent USAID funding cuts brought FEWS NET to a sudden halt.

Box 1. Multi-hazard risk and multi-risk: what's the difference?

According to Kappes et al.,[42] in the early-warning community, multi-hazard risk refers to the evaluation of risk that accounts for the effects of multiple hazards. At the same time, multi-risk pertains to the assessment of various economic, ecological, social and other types of risks (including their hazard, exposure and vulnerability components). Either of these can trigger a sequence of secondary events; therefore, this paper uses the term cascading risks for both.

Zschau and others reason that climate change and globalization increase the need for a multi-risk perspective.[43] Existing early-warning systems focus on hazard and exposure forecasting; vulnerabilities are less comprehensively understood, despite being a key factor in how risks are experienced.

Moreover, existing early-warning systems are often ill-equipped to address the multifaceted threats to food security, particularly from non-natural hazards. Even in established multi-hazard early-warning systems, such as the Regional Integrated Multi-Hazard Early Warning System (RIMES) for Africa and Asia, knowledge and applied consideration of how risks proliferate from non-natural hazards is significantly weaker than for natural hazards such as floods, for which direct risk are well understood and forecasting is well developed.[44] While many early-warning systems facilitate anticipatory actions to bolster communities' food security, these actions are often undermined by a lack of consideration for the structural causes of chronic food insecurity. In Bangladesh, for example, agrarian communities frequently affected by floods and cyclones receive patchy information from a natural hazard early-warning system that does not explicitly relate these events to food security outcomes. Communities intuitively understand that the availability of food will be compromised due to impacts on food production and local supply chains, but the warnings lack the direct information necessary for effective preparedness. This increases the risk of delaying any pre-emptive response when underlying conditions for food insecurity exist. People's safe and consistent access to nutritious food is compromised by the confluence of hydrometeorological and non-hydrometeorological factors; these compounding dynamics are rarely sufficiently codified in response protocols to permit an automatic triggering of predetermined actions.

Beyond the technical limitations of many early-warning systems to understand cascading risks, research in Bangladesh and Senegal revealed significant gaps in understanding how risks impact communities, often leading to maladaptive measures after a hazard occurs. Generally, existing early-warning systems also have insufficient focus on structural vulnerabilities, which influence how different shocks

42 Kappes, M. et al. (2012), 'Challenges of analyzing multi-hazard risk: a review', *Natural Hazards*, 64, pp. 1925–1958, 10.1007/S11069-012-0294-2.
43 Zschau, J. (2017), 'Where are we with multihazards, multirisks assessment capacities?', in Poljansek, K., Marin Ferrer, M., De Groeve, T. and Clark, I. (eds) (2017), *Science for disaster risk management 2017: knowing better and losing less*, European Union, pp. 98–115, https://doi.org/10.2788/688605.
44 World Meteorological Organization (2022), *Assessment Guidelines for End-to-End Flood Forecasting and Early Warning Systems*, https://library.wmo.int/viewer/58245/download?file=1286_en.pdf&type=pdf&navigator=1.

affect food security outcomes in different contexts for different peoples. These unaddressed vulnerabilities often compound other drivers of acute food insecurity, such as poverty, conflict and climate change.[45] For example, predictable increases in food insecurity vulnerabilities arise from the degradation of agricultural land due to deforestation in Senegal, or reduced agricultural productivity due to salinization in Bangladesh's coastal areas. Nonetheless, as risk contexts become more complex, it is increasingly difficult to use knowledge of chronic food insecurity drivers as reliable proxies for assessing and forecasting vulnerabilities to cascading risks.

There are significant institutional barriers and resourcing constraints to scaling up multi-hazard early-warning systems to address more complex risk cascades.

There are significant institutional barriers and resourcing constraints to scaling up multi-hazard early-warning systems to address more complex risk cascades. Whereas it is fairly straightforward to predict hazards like a cyclone track or a drought season by using established forecasting techniques, understanding cascading multi-risk contexts is considerably more difficult for four key reasons.

First, the sheer breadth of possible risk proliferations and their interactions is vast. While direct connections between drought, floods and food security are well understood, the complexity increases when considering how meteorological factors are connected across time and geography, or how non-meteorological factors cascade through complex human systems, influenced by political decisions, market sentiment or conflict. Such complexity is beyond the predictive capabilities of even the most sophisticated models.

Second, coordination across expert communities can be challenging due to differences in time frames, geographic focus points, terminology, operating procedures and professional incentives, the latter of which can be in conflict. Barriers can also arise from datasets that are not readily interoperable from a technical perspective, or where institutions are predisposed to trust their own data and remain sceptical of information developed in other organizations.

Third, despite good intentions, institutional coordination is frequently prohibited by remit and resource constraints. Some early-warning systems or market monitoring initiatives may have limited funding or political capital to operate effectively in certain geographies or address specific risk dynamics, despite recognizing that doing so limits a more comprehensive understanding of risks. Even if there is willingness to advance knowledge in a broader risk landscape, actors still face the hurdle of insufficient resources or mandates to do so.

45 Vos et al. (2024), 'Chapter 2: Food Crisis Risk Monitoring: Early Warning for Early Action'.

Finally, the challenge of scale further complicates matters. National-level risk assessments are unable to capture the granularity or nuance of local-level impacts to food insecurity. Conversely, local-level risk assessments are resource-intensive, not replicated at scale and therefore currently fail to capture cascading risk factors that are developing beyond local boundaries.

The combined effect of these limitations significantly impedes the development of impact-based approaches to anticipating food insecurity outcomes, making the mobilization of necessary funding particularly challenging.[46] Given the novel and inconsistent interactions of different risk transmission vectors, the significant data or model gaps in understanding these dynamics, and the rapidly changing contexts in which they occur, it is unviable, in most cases, to set quantitative parameters for 'hard' triggers to disburse funds or mobilize resources in anticipation of future food security impacts. This means that 'soft', qualitative triggers, derived from nuanced risk assessments and grounded expert judgment, are key. However, without clearly defined parameters, acting on such contextual expert knowledge risks being hampered by institutional mistrust and political capture.

Pillar 2: Detection, monitoring and forecasting (observations, analyses, triggers)

Although several early-warning systems address factors that negatively impact food security, current systems are not comprehensive, coordinated or connected to the affected communities. Monitoring of food security – which involves the continuous observation and collection of near real-time data – primarily takes place at global, regional and national levels. A critical link to subnational monitoring is often missing. Similarly, forecasting – which includes using data gathered through monitoring to predict the future occurrence, intensity and potential impacts of a hazard – often only occurs either at the regional or national levels, and lacks more detailed subnational intelligence. This disconnect creates a significant gap between high-level analysis and the on-the-ground realities of vulnerable communities.

Comprehensive food security monitoring at the national level is rarely mandated, and where it is, authorities may not have the authority to issue alerts. Experts in international organizations therefore typically analyse forecast data from regional and national stakeholders, such as national hydrometeorological centres, disaster preparedness units, relevant ministries, district authorities and CSOs. While monitoring for food security indicators and outcomes is sometimes informed by the monthly food price bulletins or vulnerability assessments of national agriculture ministries, global early-warning information often fills gaps or validates data when national granularity is insufficient. Given resource constraints, the focus is placed on forecasting infrequent extreme events, such as famine prediction, rather than on comprehensive monitoring and assessment of lower-level but more frequent threats to all four pillars of food security. Existing national assessments and

46 Food Security Cluster (2023), *Strategic Plan 2023–2025*, https://fscluster.org/sites/default/files/documents/strategic_plan_23-25_0.pdf.

regulatory instruments are also fundamentally limited by a narrow focus on localized hazards, and they largely fail to anticipate and manage risks that may cascade across regions or sectors.[47]

These disconnects extend from international to domestic contexts and occur between entities concerned with agricultural commodity markets, retail food prices and food security outcomes. For instance, while initiatives such as the Agricultural Market Information System (AMIS) track transboundary risks affecting international commodity markets, there is no continuous chain of risk ownership that connects how these dynamics may ultimately affect food security outcomes in different contexts.

Risks can also cascade through other sectors into food systems. These cross-sectoral cascades are well evidenced – for example, how environmental systems interact with health systems and impact nutrition (illustrated by the fact that changes to the climate can introduce new zoonotic diseases that can compromise people's ability to utilize nutrients). However, they are not front and centre in early-warning and early-action efforts. Therefore, key data may be poorly monitored, entirely missing or fragmented. In Bangladesh, air temperature is commonly recorded but the temperature of water, which is critical for aquaculture and understanding heat stress on crops, is not consistently monitored. This leaves a vital gap in tracking these impacts. The Missing Voices research interviews in the case studies for this paper captured examples of such cascading impacts on community food security:

> 'For four consecutive seasons, my millet fields were affected by pests. It was very hard.'
> **Older man with cardiovascular disease and low income, Senegal**

> 'There was a fire last year that swept through [the village]. There were no human casualties, but horses, goats and sheep perished, along with a large quantity of food.'
> **Older person, Senegal**[48]

The siloed nature of hazard monitoring and risk management approaches impair both food-related early-warning systems, and those that are not food security-focused. Monitoring is often confined to specific hydrometeorological agencies with narrow, single-hazard mandates. Similarly, community-level early-warning mechanisms are often disconnected from national systems and lack feedback mechanisms for communities to report the risks that they experience. For example, in Bangladesh, coastal floods and dam breaches often destroy aquaculture and crop fields, yet these events are not systematically monitored.

Further compounding inadequate monitoring is the considerable overlap and inconsistency in information produced by different food security early-warning systems, leading to both redundancy and conflicting data. The use of different methodologies for monitoring acute food insecurity can yield dissimilar estimates

---

47 See for example Talebian et al. (2025), 'A conceptual framework for responding to cross border climate change impacts'; Adams, L. et al. (2021), *A Just Transition for Climate Change Adaptation: Towards Just Resilience and Security in a Globalising World*, Adaptation Without Borders Policy Brief 2, Stockholm Environment Institute, http://www.sei.org/publications/just-transition-climate-adaptation.
48 Excerpts from Practical Action (2025, forthcoming), *Missing Voices in Early Warnings: cases from Bangladesh and Senegal*.

of the severity of food crises, which complicates decisions about when to act.[49] Guidance by FAO and WFP states that it is essential for agencies to use standardized food security measurements 'to ensure comparability and consistency of outcome indicators'.[50] Doing so requires agreement on common indicators at global and regional levels, as well as further transparency in reporting. Despite an overabundance of food early-warning systems in some areas, there is an absence of mechanisms suited to tracking rapidly emerging situations. Many systems are infrequently updated, backward-looking and more suited to slow-onset natural hazard-driven emergencies. Global monitoring of agricultural production conditions and market movements offer some real-time data, but these do not directly translate into food security outcomes. Equally, initiatives such as AMIS that require transparency in national data (such as around reserves and stock levels), can come under strain during periods of heightened geopolitical tensions between member states – for instance, Russia and Ukraine. WFP's real-time monitoring of deteriorating conditions shows promise over conventional forecasting methods and integrates a range of variables like economic drivers, conflict and changes to seasonal patterns, but accuracy remained below 5 per cent for 60-day forecasts[51] and further research on tracking of non-natural drivers of food insecurity more accurately is needed.

Donors are often more willing to commit to more visible elements of early warning early action systems such as preparedness activities, than to the crucial 'build funding' that is required to understand 'what to prepare for' and to strengthen the core components of the anticipatory action ecosystem.

A more widespread and thorough integration of different causal risk factors is often limited due to resource constraints, specifically the high cost and difficulty of funding data collection at the required temporal and spatial resolutions. Donors are often more willing to commit to more visible elements of early warning early action systems such as preparedness activities, than to the crucial 'build funding' that is required to understand 'what to prepare for' and to strengthen the core components of the anticipatory action ecosystem. The consequence is that data are often contextual and less capable of supporting decision-making.[52]

Existing challenges have been exacerbated by the disruption of USAID funding. Most notable has been the interruption and ongoing impact on work by FEWS NET, a leading provider of timely, evidence-based and transparent early-warning

---

49 Haan, N. and Hague, M. (2022), *The Ukraine crisis is a wake-up call for improved global food security analysis – Insights from G7 Principles*, Commercial Agriculture for Smallholders and Agribusiness, https://casaprogramme.com/wp-content/uploads/2024/06/Haan-Nick-and-Hague-Mathias-November-2022-The-Ukraine-Crisis-is-a-Wake-up-Call-for-Improved-Global-Food-Security-Analysis-Insights-from-G7-principles-CASA.pdf.
50 FAO & WFP (2023), *Anticipating food crises – Common principles to address challenges relating to Anticipatory Action*, Outcomes of the Anticipating Food Crises Workshop, Rome, https://www.wfp.org/publications/2023-anticipating-food-crises-common-principles-address-challenges-relating.
51 Piovani, D. (2024), 'Forecasting Trends in Food Insecurity with Real-Time Data', *Earth and Environment Springer Nature*, https://communities.springernature.com/posts/forecasting-trends-in-food-insecurity-with-real-time-data.
52 Inter-Agency Standing Committee (2024), 'Grand Bargain Caucus on Scaling Up Anticipatory Action'.

information and analysis of current and future acute food insecurity in 30 of the world's most food-insecure countries. Efforts are under way to address some of these limitations, including through novel applications of technology, to provide insights that are more actionable in anticipatory contexts. For example, the WFP HungerMap provides near real-time data that build on machine-learning algorithms to identify evolutions in key drivers of food security risks, and short-term forecasts of populations at risk of acute food insecurity.[53]

Even with technological advancements, identifying precise, actionable triggers for when to deploy resources remains challenging in the context of cascading and novel risk transmission pathways. Monitoring for forecast-based financing linked to climate triggers is fairly advanced (including among private insurers using parametric insurance instruments to determine when to disburse resources). But identifying similar probabilistic quantifiable trigger thresholds may not be viable in other noisier contexts such as conflicts or complex risk cascades. Appropriate thresholds will differ both by sometimes unpredictable interactions of risk vectors and by different populations' varied exposures and vulnerabilities to different system components. It is critical to recognize that vulnerability within communities is also not homogenous, with some groups being more adversely affected than others on account of their reduced coping capacity. There is a need for inclusive risk assessments and capacity-building, especially for marginalized groups. As food security risks become increasingly complex, more efforts to build international partnerships and capacity for using scientific models and data are crucial to provide accurate, actionable early-warning information that accounts for the nuances of these multi-hazard and multi-risk scenarios.

Pillar 3: Warning dissemination and communication (access, understanding, actions)

Early warnings are only as effective as the early actions that they prompt. Taking pre-emptive action is contingent on whether alerts are communicated to local populations in a clear, understandable and actionable manner.

Despite efforts championed by the International Telecommunication Union (ITU) and partners, as well as the pivotal focus of the EW4All initiative to strengthen last-mile connectivity, a critical disconnect persists between early-warning system capabilities and the food security realities faced by vulnerable communities. Monitoring of food security risks is typically conducted at the global, regional and national levels. Yet, much of the progress in improving global data quality, forecasting and early-action triggers is far removed from local contexts,[54] where early action is necessary for the most effective and comprehensive response. A fundamental gap remains in how this information is linked to the subnational or community levels. This siloed architecture of risk governance undermines the premise of people-centred early-warning systems: ensuring that those most at risk are equipped with timely, clear and actionable information.

53 Vos et al. (2024), 'Chapter 2: Food Crisis Risk Monitoring: Early Warning for Early Action'.
54 Missing Voices research interview conducted by partner organization, Practical Action, with marginalized community in Senegal.

As of 2023, only about 45 countries had implemented mobile early-warning systems based on cell broadcast or location-based SMS.[55] According to the ITU, 95 per cent of the world's population has access to mobile networks,[56] presenting opportunities to use cell broadcast or SMS warnings to target people in at-risk areas and improve early-warning systems. [57] To do so, current efforts focus on enabling the regulatory support needed to assess communication capacities at the national level to accelerate public dissemination, a key aim of the EW4All initiative. However, in both Bangladesh and Senegal, this diverges from how communities broadly receive disseminated early-warning information, most commonly, via traditional media.[58] Even in countries that have established food-related alerts, opportunities are missed to reach communities, undermining the effectiveness of early action. This is mainly due to issues over monitoring, coordination, access to dissemination streams, coverage and disruption of mobile networks, the rural digital divide and social exclusion.[59]

Box 2. Communication and early-warning alerts in Bangladesh and Senegal

In Bangladesh, alerts can be disseminated through regular, localized channels through phones and online digital weather boards, and most alerts are disseminated via the internet, television, radio or text alerts to community leaders and people in affected areas. Formal communication with policymakers, donors and partners often takes the form of reports, meeting minutes, newsletters and policy briefs. While the diversity of formats and delivery channels increases the likelihood of reaching target audiences, this progress is hindered in terms of access and understanding by low levels of literacy and a lack of access to technology.

Community volunteers, such as those from the Bangladesh Cyclone Preparedness Programme (CPP), play a crucial role in disseminating warnings, but its reach is limited in coastal areas.[60] The Missing Voices study found that those initiatives that did provide food security alerts were often not accessible to at-risk communities, delaying preparedness action and risking uptake of coping mechanisms harmful to longer-term well-being, particularly for marginalized people who lack financing and/or social support mechanisms. The Missing Voices study also found the same to be true of those initiatives in Senegal.[61]

---

55 Gray, V. and Grangeat, A. (2023), *Digital transformation and early warning systems for saving lives – Background paper*, ITU's Telecommunication Development Bureau (BDT), https://348009b017.clvaw-cdnwnd.com/f8e05cb7ef5356c2007609c0b248618a/200000210-9861c9861e/d-gen-digital transfor.01-2023-pdf-e.pdf?ph=348009b017#:~:text=The key objective of the,provide people with actionable advice.
56 Ibid. p. 7.
57 Missing Voices interview conducted by partner organization, Practical Action, with marginalized community in Bangladesh and Senegal.
58 Ibid.
59 World Meteorological Organization (undated), 'Programmatic Framework – Pillar 3', https://earlywarningsforall.org/site/early-warnings-all/early-warnings-all-programmatic-framework-country-level-implementation/programmatic-framework-pillar-3.
60 Missing Voices study, Bangladesh (unpublished). For methodology, see: Practical Action (2023), *The Missing Voices Approach Manual*, Rugby, UK: Practical Action Publishing, https://practicalaction.org/knowledge-centre/resources/the-missing-voices-approach-manual.
61 Missing Voices Study, Senegal (unpublished).

Efforts are underway to advance connectivity through the expansion of telecommunication services and automated warning messages. However, such improvements will be insufficient unless more accessible guidance is made available on how individuals and communities can prepare. The EW4All initiative's global scope lends itself to high-level policy interventions, which are essential but cannot in themselves address the gaps in communicating potential impacts that emerge early in cascading, cross-border risks (for example, in relation to disruption to food supply or reduced food usability).[62]

Structural gaps persist at the national level, where ministries, administrative units and other stakeholders fail to coordinate with one another in practice. Even when national monitoring is mandated, there is often no clear authority to issue food-related alerts. Risk communication typically falls under national disaster preparedness ministries, in partnership with service providers for network connectivity, and pieced together by international organizations drawing on fragmented data from national meteorological services, agricultural ministries, disaster preparedness units, district authorities and civil society. In the absence of localized, granular data and contextual analysis, global-level forecasts and models are used to fill gaps. However, existing tools and warning systems are optimized to detect extreme events, such as famine prevention, not the more subtle but critical signs of food insecurity, such as price volatility, disruptions of food access, reduced dietary diversity or reduced nutritious value of food, that precede severe outcomes.

Structural gaps persist at the national level, where ministries, administrative units and other stakeholders fail to coordinate with one another in practice.

The failure to monitor cascading risks compounds this issue. While initiatives such as the AMIS provide insight into global commodity markets, there is no end-to-end system that tracks how disruptions in trade, climate or health systems ripple through to affect food security at the household level. These disconnections were voiced in the Missing Voices interviews, where individuals in Bangladesh and Senegal shared experiences of repeated crop failures, livestock loss and disrupted food supplies with no warning or coordinated response. Key data are either missing or under-prioritized, impacting the timely issuance of an early-warning alert. The inability to embed cascading risk frameworks into multi-hazard early-warning system design can severely disadvantage timely, pre-emptive communication to mitigate risks before they escalate, as available early-warning systems fall short of analysing how impacts ripple between trade and food systems, or health and food systems.

Even when alerts are distributed well, hazard-specific warnings can be technical, which limits local comprehension and the ability of communities to understand what preparedness measures they must take. This hinders the effective use of meteorological data, even in single-hazard warnings, let alone where communities

62 Zschau (2017), 'Where are we with multihazards, multirisks assessment capacities?'.

face multiple risks. For instance, flood-specific warnings are often too technical in Bangladesh, limiting local communities' understanding of them and reducing their ability to take appropriate preparedness measures. The Bangladesh Missing Voices study found that fewer than 10 per cent of respondents consistently understood hazard-specific alerts.[63] Similarly, in Senegal, lack of training and restricted access to technological tools affected the ability of local populations to understand warnings.

The gaps in warning dissemination and communication are often characterized as an absence of data but could more accurately be described as an absence of usable, trusted and timely data for decision-making at the community level. Many warning systems are more suited to diagnosing and alerting to shocks that have been experienced in the past, rather than anticipating potentially new future ones. Community-led warning and dissemination, where they exist, are good at localizing alerts, for example where local CSOs, such as Jokolanté in Senegal, are initiating weather alerts followed by voice calls in local languages to offer advice on preparedness actions. However, sustaining such initiatives over the long term is difficult due to the costs associated with this and the lack of recurrent funding.

Reconceptualizing people-centred early-warning systems

Currently, at the global level, progress in communication and dissemination of early warning focuses on improving digital connectivity and misses nuances such as potential disincentives to communicate risks at national and subnational levels – an example of this could be a perception among politicians that spending on visible relief efforts in the wake of a disaster may afford them greater acclaim than invisible and potentially redundant investment in improved warning systems. Furthermore, although dissemination channels for early warnings are diverse, they are hindered by community-level barriers to accessibility, according to focus group discussions in the case study countries. Some individuals may face barriers to accessibility to otherwise common dissemination sources due to race, gender, ethnicity or sexual orientation. Communities that are harder to reach may need additional dissemination efforts. The specific needs of those communities should be better accounted for in existing protocols, which require analysis of multidimensional vulnerabilities that can disrupt their ability to receive early-warning information before a disaster impact.

What emerges is a need for multi-hazard early-warning systems that are not just technically sound, but also inclusive, participatory and grounded in local realities. For example, the Missing Voices study in Bangladesh and Senegal highlights how unequal access to information deeply impacts food security, particularly for women-led households, older people and those with disabilities.[64] These groups are frequently excluded from formal early-warning systems and must rely on informal sources of information that are not always reliable or timely. Prioritizing their access to information is crucial – not just in format or connectivity to mobile systems, but in timing, language, trust and delivery.

63 Missing Voices study, Bangladesh (unpublished).
64 Missing Voices Study, Senegal (unpublished).

Practitioners of anticipatory action in international humanitarian organizations have long emphasized the importance of people-centred early-warning systems, and their insights are crucial for shaping inclusive risk communication. Therefore, our understanding of people-centred early-warning systems must move beyond relying on improved data and connectivity alone. Unlike approaches focusing on (single and multiple) hazards, embedding cascading risks methodology in early-warning systems with a focus on the impacts on people can account for the different ways individuals within communities may experience and respond to risks differently, such as to their food security. To be successful, this people-centred approach must ensure local voices are not just recipients of alerts, but active contributors to its development, interpretation and use will be key to building more inclusive, responsive, and ultimately effective warning and dissemination systems.

Pillar 4: Preparedness and response capabilities (plans, practices, resources)

Pillar 4 focuses on ensuring early warnings translate into timely, anticipatory actions that save lives and livelihoods. This requires the establishment of preparedness plans and operational protocols at local, subnational and national levels. In current early-warning systems, these protocols tend to be set at a national or district level with pre-agreed activities, intended to be nimble and adaptive, with reiterations and revisions made after each activation or every few years. They rely on accurate forecasts of impacts and agree on likely triggers for action to be able to inform and link to appropriate early or anticipatory action protocols or activities (at national, institutional or local levels). However, evidence from case studies in Bangladesh and Senegal reveals several systemic and contextual challenges that impact the effectiveness of preparedness and early action to food insecurity.

National policy frameworks increasingly consist of adaptation, resilience and immediate disaster response approaches. However, there remain frequent disconnects between these long-term strategies and the necessary immediate, early action and humanitarian relief. In practice, the emphasis tends to fall on short-term relief efforts, with limited integration of anticipatory approaches linked to food security and nutrition. Opportunities to align early action with broader food security strategies are missed, particularly in the context of transboundary and cascading risks that require systems analysis beyond local and direct impacts.[65]

Effective early-warning systems, when properly designed, can interrupt cascading impacts before they affect vulnerable populations by making the most of the critical window between forecast and impact. Additionally, such systems can facilitate localized adaptation by reinforcing food production, supply chains and storage infrastructure, ultimately reducing vulnerability and bolstering community resilience.

65 Easton-Calabria, E., Ahmed, A., Mohamed, D. and Singh, A. (2023), *Anticipatory Action in Complex Crises: Lessons from Ethiopia*, Boston: Feinstein International Center, Tufts University, https://fic.tufts.edu/publication-item/anticipatory-action-ethiopia.

Furthermore, most food security early-warning systems are structured around hazard detection, rather than impact forecasting. As a result, warnings may fail to reflect or communicate the nuance of food security risks at the household level. For instance, the inability to capture upstream disruptions in supply chains, informal food markets or livelihood assets means critical triggers for early action are missed. This is compounded by challenges in identifying diverse exposures and vulnerabilities in multi-hazard environments at the intersection of natural hazards and socio-economic stressors, such as food price spikes or reduced remittance flows, which can deepen food insecurity without triggering a formal alert.

Implementation plans and procedures for response to early warnings

At the national level, anticipatory action protocols establish early-action measures that are underpinned by finance that is ready to be allocated as soon as a certain – often quantitative – threshold is met or the 'right point of intervention' is reached, often easier to identify in sudden impacts like floods, than more slow and complex impacts.

When upstream risks are better monitored at the regional and national levels, communities could be given more lead time in preparing their communities' resilience to food shocks – before a disaster.

Analysis of the complex food crises in Ethiopia by the Academic Alliance for Anticipatory Action found ongoing challenges in determining 'the right moment' for anticipatory action. These challenges stem from varying timescales for an effective early response, as what might be seen as an early intervention for one crisis, e.g. droughts or supply chain shocks, could be a delayed response to another, such as in coastal flooding, where communities must act very quickly.[66] In Bangladesh and Senegal, some research participants indicated that if they received alerts on the likelihood of food security threats early enough, they could take some preventative measures, such as harvesting or securing food. When upstream risks are better monitored at the regional and national levels, communities could be given more lead time in preparing their communities' resilience to food shocks – before a disaster.

Early action can be taken at multiple stages, depending on the scope and design of the early-warning system. For instance, systems focused on the 'forecast-to-impact' window may support a 'block' intervention to stop cascading effects before they reach a vulnerable community. Alternatively, these systems may enable a 'domestic adaptation' response to help communities absorb impacts by addressing underlying vulnerabilities. Other approaches, such as 'adaptation at origin', 'adaptation along the transmission pathway', or 'system-wide adaptation' intervene earlier in the

66 Ibid.

disaster risk management cycle (see Figure 3),[67] and while some of these fall beyond the remit of anticipatory action – from recovery to preparedness – these strategies aim to prevent or reduce cascading risks before they manifest at the community level.

While there is always a risk of false warnings, preparedness increasingly pays dividends in the long run. Corroborated data can help diversify and support decision-making. Already in some instances, even if the forecasted impact does not occur, earlier action to protect high-risk individuals is taken due to the lower cost and relative efficiency of acting early to save lives or livelihoods. Such actions, often referred to as low-regret triggers, should be reflective of the needs and vulnerabilities within communities. In some instances, advancements in real-time monitoring can bridge this knowledge gap with tools like WFP's Vulnerability Analysis and Mapping (VAM) mechanism.[68] However, where real-time monitoring lacks a connection to national or international food systems data, decision-makers may lack the necessary evidence to initiate a response.

All these systems are contingent on funding that is premised on the principle that acting early reduces the costs of response, saves lives and livelihoods. However, early warnings are often not converted into early action. Reasons for this can be diverse, including a lack of timely funding, governance or coordination gaps in implementing early-action protocols, disconnects between access to disseminated warnings or a lack of warnings themselves.

Furthermore, even when pre-arranged finance is available, disbursement of funding often depends on meeting specific quantitative thresholds. However, such thresholds are more effective in simpler contexts and fall short in complex, cascading risk contexts and in relation to existing vulnerabilities. Research by the Stockholm Environment Institute (SEI) suggests that in adaptation contexts, integrating 'concern assessments' alongside a technical risk assessment could enhance decision-making. These assessments can improve understanding of community perceptions on threats to food access, availability, usability and stability. This can help 'systematic[ally] analys[e] …perceived impacts that communities associate with a hazard, its cause and consequences'.[69] This allows space for distinctions between communities, those marginalized within them, and how they are affected differently by impacts.

> 'Last year I had a difficult time, my harvest was not good. Two or three months after the rainy season, I already knew that there would be a risk of food insecurity.'
> **Widow caring for son with a cognitive disability, Senegal[70]**

For example, some types of food relief in anticipatory action may increase the food security of one group but undermine the food security of another due to the cascading and transboundary risk context, for example pre-positioning food aid in a location that distorts local markets and affects producers' incomes. To avoid

---

67 The disaster risk management cycle refers to a continuum of activities that help manage disaster risk by (1) prevention and mitigation, (2) preparedness, (3) response, and finally (4) rehabilitation and reconstruction. Each stage is tied to the progression of a disaster, from stages 1 and 2 before any impact, stage 3 includes activities that help minimize loss of life and livelihood immediately post-impact, and stage 4 is the medium-long term activities that help communities rebuild post-impact.
68 Piovani (2024), 'Forecasting Trends in Food Insecurity with Real-Time Data'.
69 Florin, M.-V. and Burkler, M. T. (2017), 'Introduction to the IRGC Risk Governance Framework', revised version, p. 52, https://doi.org/10.5075/epfl-irgc-233739.
70 Excerpt from Practical Action Missing Voices study.

trade-offs and unintended impacts, early action often takes the form of cash and voucher assistance, allowing more autonomy for individuals to identify and meet their needs and reduce risks of maladaptation, exclusion from food relief and of individuals adopting coping mechanisms that are harmful to their long-term well-being.

Coordination and governance of stakeholders

Social and political considerations often delay the activation of early-action mechanisms, even when forecasts indicate a high probability of impact. When specific ministries or coordinating bodies fail to take responsibility for cascading risks, it can undermine accountability, trust in governments and discourage other stakeholders from stepping in. Such a lack of leadership also creates gaps between ministries and civil society, as well as between those issuing warnings and those who receive them. Communities, as a result, may lack the necessary information for their preparedness. In addition, trade monitoring mechanisms are largely global and regional in scale, often overlooking local realities. This disconnect hampers the trust in early-warning information. Whereas monitoring of acute food insecurity is usually better connected to communities, monitoring in real time is necessary to ensure timely decisions are made. In resource-constrained settings, food availability is often the focus of analysis on a population's food security. Therefore, not all aspects of food security are analysed, creating knowledge gaps in access, usability and stability. Intricacies of building technically sound early-warning systems tend to steer focus away from understanding how well these systems work in practice.

Social and political considerations often delay the activation of early-action mechanisms, even when forecasts indicate a high probability of impact.

However, by centring on communities as end-users of warning information, existing information could be a bridge between global and national trade monitoring, regional and national hazard and exposure mapping, and across all levels up to national-level monitoring of vulnerabilities supported by international humanitarian organizations and civil society. While ample attention is paid to the generation of new, better-quality data, despite good efforts, more can be done on the coordination across existing pockets of data at the global, regional, national and community levels.

Market-based early-warning approaches, such as the Agricultural Market Information System (AMIS), offer insights into global price volatility and commodity trade flows. However, unlike acute food insecurity monitoring, they remain insufficiently connected to community-level risk monitoring. Therefore, communities may feel their food security is already affected before early warning systems record any impact, and this can increase vulnerability to adverse weather or other disruptions to food. In fragile or conflict-affected areas, this disconnect is particularly stark as data collection at the local level can be impeded by fighting and instability. Linking agricultural trade data with localized warning systems could help anticipate food security crises by diversifying data sources to plug any data gaps, where direct

monitoring is constrained. But this requires expanded institutional mandates, flexible financing mechanisms and stronger integration between humanitarian, development and climate finance mechanisms. This is discussed in more detail in Chapter 4 of this paper.

Some countries have made progress in this area and the results illustrate the effectiveness of coordination and community-centred approaches. In Senegal, the national coordinating body on food security (Secrétariat Exécutif du Conseil National de Sécurité Alimentaire – SECNSA) is integrated into the regional Cadre Harmonisé framework,[71] which successfully shares food security assessments with regional organizations, enhancing the effectiveness of early warnings. For example, during the 2017–18 Sahel drought, early warnings using satellite-based tools identified vulnerable regions in northern Senegal, facilitating targeted responses. However, the tool is currently better suited to slow-onset hazards, such as droughts, when compared to rapid-onset hazards as it is unable to capture vulnerabilities that interact with different risks in dynamic ways. Unlike Senegal, Bangladesh's fragmented early-warning system lacks a unified alerting protocol, which limits its ability to reach remote communities with clear, actionable warnings.

This recognition has shaped the evolution of impact-based forecasting mechanisms, which aim to connect early-warning information to specific impacts on communities, thereby enhancing their preparedness. While impact-based forecasting has been piloted in some areas, it is still in the early stages of implementation and needs scaling to support multi-hazard early-warning systems. Impact-based forecasting requires greater coordination between national and subnational stakeholders, alongside support from regional and global actors, to advance risk-informed communication and preparedness.

71 Cadre Harmonisé is based on the Integrated Food Phase Classification (IPC) for the region of West Africa.

04
Finance as an enabler to address cascading risks

Aligning funding for early-warning systems with existing climate finance and social protection mechanisms can strengthen policy cohesion and coordination.

In recent years, forecast-based finance mechanisms that release agreed amounts of funding for response activities to imminent hazardous events have been very effective. In 2024, $111 million was released from pools of pre-agreed financing totalling $248 million, reaching 17 million people worldwide.[72] At times, early action is impacted negatively due to the delayed disbursement of funding. Cost–benefit analysis of investment into early, forecast-based action finds that an earlier response can avert suffering and prevent more severe impacts. Furthermore, such an approach also decreases the overall cost of humanitarian response through greater pre-positioning and early procurement. Additionally, pre-planning enables more time for improving programme design to incorporate preventative measures with potential co-benefits – added positive impacts of an action that go beyond its primary goal – in non-crisis times. This might include, for example, investing in infrastructure adaptations and providing climate-resilient crops and supporting agricultural extension services that can improve the access to and availability of food during future shocks.[73] In the context of a warming planet, as disasters occur more frequently and communities face more complex risks, the need for more funding is apparent.

72 Anticipation Hub (2025), 'Anticipatory Action in 2024: A Global Overview', https://www.anticipation-hub.org/download/file-4973.
73 Wilkinson, E. et al. (2018), 'The evidence base for forecast-based early action', in Wilkinson, E. et al. (2018), *Forecasting Hazards, averting disasters: Implementing forecast-based early action at scale*, ODI, https://www.jstor.org/stable/resrep50335.11.

The costs and benefits of anticipatory action can vary depending on the speed of hazard onset and the degree of instability or conflict in the local context. Whereas acting early during rapid-onset events can often offer value by saving lives, slow-onset events present multiple opportunities to respond early and offer various other co-benefits to build resilience beyond saving lives.[74] Response actions to slow-onset or predictable disaster contexts may be able to achieve greater cost-efficiencies due to greater time available for more thorough planning and because fewer system redundancies may be required. Meanwhile, defining the conditions that trigger funding disbursements is more straightforward in direct rapid-onset events (as these are often more predictable in form), allowing immediate mobilization of finances and steps towards early action. However, opportunities for a more effective response are missed in slow-onset hazards due to uncertainties related to forecasts that can delay action.[75] Consequently, identifying obvious disbursement-triggering events is harder for complex risk formations. As such, preparedness and response activities are being developed in a siloed and ad hoc way rather than benefiting from more systemic funding modalities. As a result, responses are constrained in their ability to address the reality of cascading and compound risks faced by communities. This increases the risk of maladaptation practices in response to shocks and will lead to missed opportunities to intervene at the necessary scale and time needed.

Building this further: investments in the anticipatory action ecosystem

Insufficient commitment to overseas development aid in many countries has tangible consequences, most notably, funding gaps that delay the construction (build funding) and progression (fuel funding) of early-warning systems essential for risk preparedness.

Data collection has not been adequately funded to date, despite a recent uptick in support for the use of technological advancements. To ensure that societies are equipped with comprehensive early-warning systems, investments in developing cascading risk knowledge and embedding that into all the components of a multi-hazard early-warning system are needed. Traditionally, 'fuel funding' includes various pre-arranged financing mechanisms for response efforts, via pooled funding mechanisms such as the Disaster Response Emergency Fund (DREF), Central Emergency Response Fund (CERF), Nexus' Anticipatory and Emergency Fund, and the Start Network.[76] Fuel funding is ideally, but not always, provided to pooled funds managed by international organizations. Their disbursement mechanisms require the satisfaction of specific thresholds for different hazardous events. These thresholds are often linked to response activities, enabled by the prompt

74 Ibid. pp. 23–25
75 Ibid.
76 Levine, S. and Wiggins, S. (2023), 'How can development partners support food security in protracted crises?', Policy Brief, Supporting Pastoralism and Agriculture in Recurrent and Protracted Crises (SPARC), https://www.sparc-knowledge.org/sites/default/files/documents/resources/sparc-policy-brief_how-can-development-partners-support-food-security-in-protracted-crises.pdf.

disbursement of finance to fund this response.[77] New stakeholders are entering this discourse, ranging from the Green Climate Fund, which finances the deployment of multi-hazard early-warning systems within countries, to the insurance industry.

There are opportunities to build complementarities with broader financing mechanisms and to innovate to de-risk investment in early-warning systems. SPARC (Supporting Pastoralism and Agriculture in Recurrent and Protracted Contexts) research found little evidence that anticipatory action funding modalities will be able to play a significant role in preventing or mitigating serious protracted crises due to a complex interplay of trade, economic, political or environmental factors.[78] In multi-hazard contexts, carrying out anticipatory action adequately can be expensive. Because complementarities do exist in building food system preparedness and early action, there are opportunities to align funding for early-warning systems with existing climate finance instruments.

When there are concerns around the availability of aid budgets and the viability of early-warning systems, there is an opportunity for a more comprehensive, innovative approach that uses diversified financing models to ensure sustainability and communities' access to food.

When there are concerns around the availability of aid budgets and the viability of early-warning systems, there is an opportunity for a more comprehensive, innovative approach that uses diversified financing models to ensure sustainability and communities' access to food. By seeking complementarity between anticipatory action, resilience and social protection mechanisms (see Box 3), more opportunities arise for policy cohesion, better coordination between stakeholders and strengthened narratives for financing.

There is an opportunity to advance financing mechanisms by blending public and private finance. Public finance activities, such as through climate resilience or disaster contingency funds, can help relieve the demands on pre-arranged finance. Funding to EW4All, the Global Shield against Climate Risk, the Systematic Observations Financing Facility (SOFF), the Climate Risk and Early Warning Systems (CREWS) initiative, the Adaptation Fund and the Green Climate Fund can be utilized to contribute to regional and national anticipatory action roadmaps by building core aspects of anticipatory action and count towards donor contributions based on good faith reporting.

77 Ibid.
78 Ibid.

Box 3. Linking anticipatory action and social protection

'Food is always the biggest problem during floods. My small piece of land… gets completely drowned. After that [2020 Faridpur] flood, we suffered a lot. Neighbours sent us food, but I tried to give most of it to my son because he needs medication. We starved a lot during that time and even afterward. Relief is rare – only if the ward member manages to send some rice and pulses.'
Man in Bangladesh, caring for son with physical disability[79]

In the absence of consistent support and adequate funding, communities in vulnerable regions are forced to accept chronic food insecurity as a normal part of life. These gaps are most likely to occur when cascading risks to communities are not well understood and when anticipatory approaches are not mainstreamed into disaster risk, social protection and climate policy, creating gaps in caring for the marginalized. Shrinking aid budgets can exacerbate these gaps. One route to ensure that finance is programmed and delivered in people-centred ways is to link social protection mechanisms to anticipatory action. The International Institute for Environment and Development's research introduced the Anticipatory Social Protection Index for Resilience, which is a self-diagnostic toolkit with 37 indicators to identify where governmental policies fail to deliver anticipatory action and areas to be strengthened in existing delivery mechanisms.[80] Resilience-building through social protection has shown some benefits, including that it makes anticipatory approaches more applicable to longer time frames.

These approaches are being implemented across the sector. In Mozambique, the National Institute for Disaster Management included social protection actors when designing and implementing an anticipatory action protocol for drought.[81] WFP outlined its approach for connecting anticipatory action and social protection in 2022.[82] In its programme in Somalia, it integrated a new anticipatory instrument for droughts into the Somali government's national social protection system.[83] The programme reached more than 117,000 people through cash transfers and 1.2 million people through early-warning messaging and early actions to mitigate the impacts of poor rainfall in the region.

The EU's Directorate-General for European Civil Protection and Humanitarian Aid Operations (DG ECHO) launched a three-year programme in 2021 with the Food and Agriculture Organization (FAO) in Bangladesh, Laos, Pakistan, the Philippines and Vietnam, to set up anticipatory action systems and protocols; to find links between anticipatory action and social protection systems; to implement anticipatory actions; and to strengthen the evidence base.

Linking anticipatory action and social protection can enable different stakeholders to share expertise, coordinate and respond more effectively. In the wider context of aid cuts, doing so also presents an opportunity to diversify funding sources, and innovate new financing tools for uninterrupted assistance.

---

79 Interview from Missing Voices study by Practical Action Bangladesh; Begum, A., Dutta,S., Norton, R. and Venkateswaran, K. (2021), *Post Event Review Capability (PERC) Study: Learning from the 2020 Floods in Faridpur District, Bangladesh to build resilience*, Boulder, CO: ISET International and the Zurich Flood Resilience Alliance, https://www.i-s-e-t.org/_files/ugd/558f8a_140c9333ff864eb18ca7bfed95c4a34b.pdf.
80 Bharadwaj, R. and Mitchell, T. (2022), *Strengthening Anticipatory Risk Response and Financing Mechanisms for Social Protection: A Practical Approach to Tackling Loss and Damage*, International Institute for Environment and Development, https://www.iied.org/sites/default/files/pdfs/2023-03/21286IIED.pdf.
81 Sergio Tomás, P. et al. (2022), 'Integrating shock-responsive social protection into anticipatory action protocols ahead of a drought in Mozambique', Anticipation Hub, 20 January 2022, https://www.anticipation-hub.org/news/integrating-shock-responsive-social-protection-into-anticipatory-action-protocols-ahead-of-a-drought-in-mozambique.
82 WFP (2022), Integrating Anticipatory Action and Social Protection.
83 WFP (undated), 'Somalia Aa Square Cut', video, https://jwp.io/s/BXDK9goi.

05 Conclusion

As geopolitical and environmental turbulence intensifies, a new, systemic approach to food security is critical. Early-warning systems that anticipate multiple and cascading risks can reduce food insecurity and build greater resilience.

Food systems are complex, globally interconnected arrangements. The nature of them increases the exposure of communities to transboundary cascading and compound risks – making negative impacts more likely as localized shocks have the potential to develop into international crises. Addressing food insecurity requires coordinated, systemic responses that tackle the four components of food security: access, availability, utilization and stability.

More broadly, anticipatory action has tangible benefits in reducing direct impacts and response costs of discrete hazard events. Many warning systems are designed around single hazards and are limited in geographic scale. Such warning systems often react to the final risk experienced by communities, underestimating upstream drivers and transmission risk mechanisms in global food systems. Yet the nature of risks to food security is increasingly complex, intersecting and amplified through cascading and compounding dynamics. These risks and dynamics are occurring in contexts of pronounced environmental, geopolitical and economic turbulence due to greater multipolarity, contestation and securitization of food supply chains. Developing and deploying early-warning systems that facilitate anticipation of such indirect and cascading risks to food security is essential to build resilience to the multidimensional and dynamic nature of impacts on local food systems.

In terms of risk knowledge (Pillar 1 of the EW4All initiative), the humanitarian sector is making progress in recognizing, understanding and advancing anticipatory approaches based on early-warning systems that are cognizant of multi-hazard and multi-risk contexts. With regard to food security risks, many humanitarian actors are using both acute food insecurity and market monitoring mechanisms but often combining these in piecemeal ways rather than using them in a more comprehensive way to support decision-making. Knowledge of cascading risks is also advancing further upstream in the disaster risk reduction life cycle (see Figure 3). For example,

more countries are beginning to understand, assess and consider cascading risks in their national climate adaptation plans, however, there is still limited progress in the use of anticipatory action to support early-warning systems.

Regarding detection, monitoring and forecasting (Pillar 2), the fractured nature of approaches to these activities reflects, to a large degree, a fragmented institutional environment and underlying financing constraints. Operationally, this combination limits the ability of even multi-hazard and multi-risk-orientated early-warning systems to identify and monitor the plethora of risk cascades that affect food security outcomes. State actors rarely adopt a multi-risk outlook, resulting in a siloed approach – especially at national levels – to predominantly hydrometeorological hazard monitoring, with insufficient regard to the food security impacts of these and other risks. Among early-warning systems focused on food security, there is a disconnect between on the one hand, monitoring local exposures and vulnerabilities to dislocations in food access and availability, and on the other, tracking and forecasting cross-border risk cascades upstream of community impacts. With FEWS NET temporarily shuttered, and with an uncertain future, due to the US official development assistance freeze, the challenges with monitoring even relatively direct risks to food security have recently deepened. This is further constraining the capacity to forecast more complex risk confluences. At the same time, there is the prospect for increasing the efficacy of tracking complex and systemic food security risks through technological advances and the nascent application of artificial intelligence to modelling and monitoring food insecurity.[84] Ensuring that such technology-augmented approaches stay people-centred and responsive to the varied structural forms of food insecurity and social exclusion will be key to making them fit for purpose.

With respect to warning dissemination and communication (Pillar 3), timely actionable alerts for indirect, compound and cascading food system risks are stymied in many instances by underlying deficiencies in risk knowledge and forecasting. Challenges abound even in communicating more direct risks about food- and non-food-related risks to stakeholders with the capacity to act. Distilling complex terminologies for risk transmission dynamics into representative case studies that are localized and contextualized will aid a greater understanding of linear and non-linear impacts to food security. Strengthened risk communication requires thinking beyond coverage of disseminated data to consider more targeted, actionable risk messaging. Localizing early-warning dissemination channels is also important, with contextual grounding that considers socio-behavioural dimensions, marginalized access, poor understanding of data or gaps in coordination. To determine end-to-end connectivity, an analysis of how dissemination channels reach populations is needed. Communication protocols need greater impetus to put communities at the centre of objectives, understanding their needs by building on food security outcome indicators and stress-testing into national monitoring mechanisms.

---

84 See, for example, Herteux, J. et al. (2024), 'Forecasting trends in food security with real time data', *Communications Earth and Environment*, volume 5, article 611, https://doi.org/10.1038/s43247-024-01698-9; Machefer, M. et al. (2025), 'A monthly sub-national Harmonized Food Insecurity Dataset for comprehensive analysis and predictive modeling', *Scientific Data*, volume 12, article 741, https://doi.org/10.1038/s41597-025-05034-4; Busker, T. et al. (2024), Predicting Food-Security Crises in the Horn of Africa Using Machine Learning, *Earth's Future*, 12, https://doi.org/10.1029/2023EF004211.

In terms of better preparedness and response (Pillar 4), early-warning systems can be utilized at multiple stages of a cascading risk timeline, as illustrated by the response typologies shown in Figure 3. For example, appropriately designed early-warning systems can enable responses that block cascading impacts before they reach vulnerable populations by focusing on the forecast-hazard-impact time frame. Early-warning systems may also enable domestic adaptation whereby impacts are absorbed within an affected population by reducing the vulnerabilities of local food production, supply and storage systems and by increasing communities' underlying resilience. Other response types, such as adaptation at origin, adaptation within the transmission system and system-wide adaptation, can be used for disaster risk management to adapt, prevent and mitigate adverse effects of external shocks on food systems. Key stakeholders will be disaster preparedness, climate resilience and mitigation or civil contingency expertise. Social protection expertise can cut across any of these response types.

Disbursement of pre-arranged finance remains a critical gap in timely crisis response, even with more advanced early-warning systems. These systems require discretionary financial contributions from donors, and operational delays persist due to insufficient funding and coordination. Dialogue mechanisms – such as AMIS's Rapid Response Forum – are essential for engaging globally significant stakeholders, including G20 member countries, to address disruptions in key food commodities like wheat, maize, rice and soybeans. These forums can influence global policymaking and elevate food security concerns. However, their impact is limited by narrow mandates, financial constraints and uneven country engagement. Integrating agricultural market monitoring with acute food insecurity tracking can better align global systems with local realities. This will strengthen the link between global supply chain insights and subnational food and nutrition data, enabling more timely and effective responses to mitigate food insecurity.

Not only does considering early-warning alongside other risk-reduction measures help to strengthen preparedness and aid cross-functionality of early-warning systems for resilience, disaster risk reduction and anticipatory action, such an approach also helps to identify opportunities to fund and upscale longer-term resilience-building tools. Conceptualizing early-warning systems and hazard response in this way may aid policy coherence in two ways: first, by accommodating complementary response typologies in different plans and policies (e.g. National Adaptation Plans, Disaster Risk Management, Anticipatory Action Protocols) to ensure better consistency across response frameworks; and second, by identifying opportunities to increase coordination between sectors through the joint involvement or targeting of stakeholders across different cascading risk response archetypes.

Food system risks are wide-ranging in nature: from those that are proximal and direct to those that are transboundary and indirect, from those that are rapid-onset with clear transmission pathways to those that are insidious, and which develop complex risk interaction and propagation dynamics. By taking a more systemic approach to all these types of risks, early-warning systems can enable actions that reduce food insecurity. By embedding these approaches within other disaster risk reduction approaches, such as adaptation and social protection

programming, systemically focused early-warning systems could also contribute to building greater systemic resilience, potentially at multiple points within the risk transmission system.[85] Considering existing investment shortfalls, there is a need to diversify financial and policy instruments with a clear demarcation of risk ownership for different stages of a risk cascade based on the food-security context and multiple overlapping risks. The cost-effectiveness of acting prior to an impact is well understood in the early-warning context, but less analysis focuses on how early-warning mechanisms can reduce the investment required to reduce risks at scale in multi-hazard contexts by intervening at earlier stages of risk cascades.

85 Harris, K. et al. (2024), 'We Are All Connected: What to Know About Transboundary Climate Risks', *Stockholm Environment Institute*, 10 June 2024, https://www.sei.org/perspectives/we-are-all-connected-what-to-know-about-transboundary-climate-risks.

06 Recommendations

Early-warning systems offer a proven method of reducing food insecurity, but the current patchwork of mechanisms, governance and cooperation is not fit for purpose. Improvement of these systems requires shareable and interoperable data, agreements on ownership of risks, and pooled funding that is not reliant on a single source.

Our recommendations centre on three areas:

- Strengthening the governance mechanisms of early-warning systems and anticipatory actions related to food security.
- Improving the understanding of, and responses to, cascading risks to food systems and the food security of at-risk communities.
- Strengthening anticipatory action plans at subnational and national levels.

These are further distilled for actors operating at international, regional, national and subnational levels (see Table 1 for a list of actors at each level).

Strengthening the governance of food security early-warning systems and anticipatory actions

The cross-border cascading impacts of many food crises, such as increased refugee flows, social unrest and trade disruptions, means shared governance should be a common interest, to prevent adverse economic and social impacts domestically and internationally. Governance mechanisms, including system frameworks, clear roles and responsibilities, and standard operating procedures for early-warning systems (FEWS NET, GIEWS, AMIS, etc.), need to be developed in a way that engenders multi-level coordination and collaboration across global, regional, national and subnational levels. Such mechanisms should be founded on interdisciplinary understandings of food systems. Food security considerations

should inform joined-up approaches to early action, recovery and preparedness plans, and food security coordination should be integrated into disaster risk reduction frameworks that countries already support.

International level

1. Ensure adequacy of funding and build longer-term finance resilience:
The current model of anticipatory action funding, characterized by precarious short-term donor cycles and reactive responses, requires fundamental restructuring to achieve sustainable impact. Governments must shift from dependency on external humanitarian funding towards building indigenous capacity for early action and resilient agri-food systems. This transition necessitates strategic partnerships between national governments, climate finance institutions and disaster risk management actors to develop comprehensive financing strategies that integrate climate adaptation, disaster preparedness and anticipatory action in unified frameworks.

2. Make data from different communities interoperable:
Food systems intelligence related to areas such as market dynamics, climate risk, conflict indicators and health–nutrition linkages should be more thoroughly integrated by actors operating existing global early-warning systems.[86]

- Data on these dynamics produced in line with Pillar 2 by food security forecasters should inform regularly updated risk scenarios on emerging drivers of food insecurity for use by regional or national government and civil society actors responsible for Pillar 3 and 4 implementation.
- International forecasters, researchers and international food-security focused institutions under Pillar 1 should share data- and scenario-driven information on complex risks and work with early-warning system actors to build this understanding into existing or emerging early-warning systems. This would enable the data and early-warning systems to be used more strategically to inform timely and coordinated action under Pillar 4 and beyond to anticipate, prevent and mitigate systemic and multi-modal food system risks.

3. Integrate mandates of existing systems and initiatives forecasting food security impacts:
Working through the existing coordination mechanisms of the Global Network for Food Crises, or a similar body, an operational working group comprised of food security experts and early-warning system actors should seek to improve the integration of systems and initiatives – such as FEWS NET, VAM and AMIS Market Monitor (See Annex 1). This type of initiative could support better communication (Pillar 3) and informed decision-making, enable more integrated and comprehensive real-time risk assessments, and improve links between global market monitoring and acute food insecurity warning systems.

86 For example, this is demonstrated in the World Food Programme's VAM approach that combines traditional assessment methods with advanced technologies to anticipate vulnerability and food security crises across multiple risk domains.

- To support this, data-sharing agreements and interoperable data standards should be established by early-warning information producers,[87] humanitarian actors and government authorities – with clear ownership and permissive data infrastructure and access rights – to ensure efficient data production and exchange between international organizations, across sectors (e.g. food security, conflict, disaster risks etc.), and between international, regional and national actors under Pillar 2.

4. Enhance the profile of cascading risks in food security early-warning systems and anticipatory governance:[88]

- Better coherence, coordination and sustainable financing are needed to prioritize and invest in early-warning systems that consider cascading risks to food security and that strengthen risk reduction, recovery and preparedness. This could include:
  - Governments establishing contingency (risk reduction) funding pots at national level and utilizing international climate adaptation funds, such as the Loss and Damage Fund, for building early-warning systems.
  - Donors allocating grants to 'missing voices'.
  - Civil society organizations (CSOs) leveraging anticipatory action funding under Pillar 4, to ensure sustained support for preparedness, response and resilience-building. They should equally monitor and advocate for allocations and disbursements that measure up to the $3.1 billion estimated minimum need across all four pillars between 2023 and 2027, as identified by the Early Warnings for All Executive Action Plan.[89]
  - Improved collaboration between donors, government, CSOs and the research community to boost understanding of how and when to use varying financing tools to best ensure coherence, coordination and sustainability of multi-risk early-warning mechanisms.

Regional level

5. Leverage and invest in existing national and subnational networks, alongside scientific forecasting or monitoring capabilities:

- Donors and governments should invest, via climate adaptation and disaster response funding, in regional hydrometeorological bodies (such as the Regional Integrated Multi-Hazard Early Warning System (RIMES) in Africa and Asia).

---

87 For example, Senegal's National Agency of Civil Aviation and Meteorology (ANACIM) works with other West African governments. ANACIM supports regional initiatives that focus on meteorological and climate data rather than food security per se.
88 In this context, anticipatory governance refers to policymaking or planning decisions made before, and with the evidence base on, direct and indirect impacts.
89 World Meteorological Organization (2023), 'Overview of the Early Warnings for All: Executive Action Plan 2023–2027', *Bulletin* 72 (1), https://wmo.int/media/magazine-article/overview-of-early-warnings-all-executive-action-plan-2023-2027.

- Such regional entities should be empowered to improve harmonization of data and shared understandings of risk, incorporating perspectives from global and national actors. This could be achieved by facilitating dialogue and coordination between global and national entities that have differing perspectives, outlooks, data and capacities, to support inter-country collaborations on early-warning systems that consider cascading risks to food security beyond national borders.[90]

National level

6. Improve representation of food security and multi-hazard risk experts across early-warning and disaster response planning, clarifying who owns the risks and how anticipatory responses will be funded:

- Comprehensive, multisectoral governance approaches to early-warning systems should be established. To achieve this, national governments should ensure policies, procedures and organizational structures:
  - Support, incentivize and mandate ongoing coordination between hydrometeorological services, disaster preparedness agencies, humanitarian actors and key ministries such as agriculture, health, trade and bureaus of statistics.
  - Focus on integrating community perspectives and their needs and capacities to receive, understand and act on timely information related to potential food insecurity (Pillar 3 and Pillar 4).
  - Include 'missing voices' in social protection schemes to enable sufficient and contextually appropriate support is provided to marginalized populations before and after adverse disaster impacts.
  - Build on insights, data and recommendations from CSOs with established relationships and connections to local communities at risk from food insecurity. National governments and such CSOs should work together closely to collaboratively improve early-warning systems.
- National governments should clarify risk ownership for cascading food security threats by assigning responsibility to a central authority with high-level expertise (e.g. the Federal Emergency Management Agency in the US) that is empowered to coordinate across sectors, central government ministries and administrative boundaries.
  - The mandated lead for food security within national government should standardize monitoring (Pillar 2) and coordination of food security risks across all four dimensions of food security – availability, access, utilization and stability – to replace fragmented, supply-focused approaches.

90 This could build on relationships, understandings and initiatives developed between countries and UN agencies in established technical food security early-warning forums, such as the AMIS Global Food Market Information Group, and through existing dialogues within regional economic communities.

Improving the understanding of and response to cascading risks to food systems and community food security

To deliver on more comprehensive early-warning systems, technical coordination on improving ways to pre-empt cascading risks is crucial. Those responsible for providing early-warning data under Pillar 2, and government, media and CSOs with a formal mandate to communicate alerts under Pillar 3 and to act under Pillar 4, need to ensure that the information produced is understandable, focused on the potential negative impacts of cascading risks, and that it supports early-action decision-making at appropriate points in a risk cascade. Producing actionable knowledge capable of mitigating harmful cascading impacts requires drawing on and harmonizing disparate sources of information about complex risk morphology, existing response frameworks and contextual vulnerabilities, specifically with regard to food security outcomes.

Regional and national levels

1. Facilitate – and invest – in the transfer and building of knowledge between regional and national experts, ensuring community-centred approaches to strengthen their food system resilience:

- Regional early-warning system entities should take the lead in setting Pillar 1 and 2 data standards in their regions, support inter-county data-sharing platforms, downscale global food security forecast information to support communication and understanding of risks (Pillar 3), and upskill national actors on cascading risk dynamics.
- Government agencies need to integrate monitoring of key drivers of food insecurity and their real-time interactions with natural hazards given the significant food security risks across all disaster types.
    - To do so, Pillar 1 and 2 government actors need to ensure food security risk indicators are contextually appropriate and disaggregated for population cohorts with different characteristics – for example, age, gender, disability – that may increase their vulnerability.
    - Food security experts, and government actors responsible for early-warning system monitoring under Pillar 2 should work together to standardize existing indicators as far as possible, and gaps should be plugged by qualitative or quantitative information from community monitoring, working with local government and civil society actors.
    - Government actors responsible for Pillar 1 should ensure that the datasets and clear diagnoses of cohort resilience transparently inform and support decision-making processes relating to early action, response and recovery under Pillar 4. Food security forecasters should work with regional centres and national mandated early-warning actors and Pillar 4 user groups to work towards impact-based forecasting to unlock more informed, localized risk information and clear communication content that incorporates risks cascading in multiple ways with differential impacts on different cohorts.

  - Food security forecasters and national government and CSOs should share information to strengthen impact-based forecasting.

- Researchers, CSOs and government actors should work together to conduct transdisciplinary risk assessments (such as those outlined in the UK's National Risk Register[91]) for local food systems, strengthening understanding of relevant risk factors and hazard interaction characteristics.
  - Regional bodies and local actors should share their knowledge and learning and evaluations of the efficacy of existing early-warning systems and early-action protocols during previous risk episodes.
  - Donors and government actors (disaster risk management authorities) should invest in food security post-event evaluations, including assessment of the early warning value chain and implementation of early action protocols.

Strengthening subnational and national anticipatory action plans

Early action on food security hinges on the capacity for early warnings to reach at-risk communities that remain in a perpetual cycle of hunger and food insecurity. More support is needed for communities most affected by cascading risks to their food security. This can be achieved through improved stakeholder recognition of responsibilities under pillars 1, 2 and 3 as well as ownership of producing early-warning information that supports Pillar 4 decision-making and actions; investment to integrate cascading risks into early-warning systems and holistic financing of effective systems; and institutional management and coordination across sectors, scales and stakeholders.

National and regional Pillar 1, 2 and 3 partners should provide more detailed and reliable information to support more informed community-based early-warning systems that enable earlier and deeper understanding of macro risk factors and dynamics through local to global level coordination – from developing food security risk knowledge through to response capacities, preset knowledge sharing protocols and coherent financing strategies. Equally, early-warning systems at national and regional levels should better incorporate community knowledge of particular vulnerabilities and constraints to taking anticipatory action.

International level

1. Build sustainable financing strategies and complementarity with blended climate finance:

- Supported by the Inter-Agency Standing Committee's Grand Bargain Caucus' findings,[92] donors and advanced economies, working with national governments responsible for early-warning systems, should co-develop, test and implement sustainable and diverse financing strategies by identifying and bridging existing

91 HM Government (2025), 'National Risk Register 2025', https://www.gov.uk/government/publications/national-risk-register-2025.
92 Inter-Agency Standing Committee (2024), 'Grand Bargain Caucus on Scaling Up Anticipatory Action'.

shortfalls to scale up and support the longevity of communication protocols under Pillar 3, as well as decision-making functions and preparedness plans under Pillar 4 for cascading risks.

— Seek complementarities with broader financing mechanisms, particularly through innovative risk-sharing arrangements to de-risk investment in early-warning systems and preparedness infrastructure, such as with the Green Climate Fund. Opportunities to partner with the insurance industry or other private finance to provide additional capital and risk transfer mechanisms should also be explored.

Regional level

2. Co-develop indicators based on community and technical food system early-warning risk knowledge, design communication tools for complex risks:

— Regional intergovernmental bodies with a focus on early warning (such as RIMES and AGRHYMET) should engage with national and subnational governments to ensure multi-hazard food security-related early-warning communications, under Pillar 3, reflect multi-risk dynamics, including examples of previous transboundary risk cascades assessed under Pillar 1. Regional intergovernmental bodies with a focus on early warning should work with subnational Pillar 2 forecast providers to co-develop food security early-warning indicators and plans under Pillar 4 that respond to local needs and priorities. Where quantitative thresholds for activating pre-arranged and pre-financed actions are not viable due to context-specific or cascading dynamics, qualitative benchmarks should be established and incorporated into monitoring frameworks. These qualitative assessments should complement quantitative measures to permit more context-appropriate, flexible and inclusive early actions to be taken.

National level

3. Develop integrated tools and frameworks to monitor evolving risk cascades, ensuring this information is used alongside forecasting for pre-empting communication and preparedness plans:

— National forecasting agencies and disaster preparedness agencies should conduct integrated risk analyses of local food systems at scale, albeit contingent on funding and effective governance, under Pillar 1,[93] identifying potential risk transmission dynamics (illustrated in Figure 1), to understand how transboundary risks may cascade and cause context-specific impacts locally.

  — Working with local government and civil society actors, national government entities should build on the improved understanding of food insecurity impact time frames and cohort vulnerabilities, to co-develop better targeted communication and dissemination strategies under Pillar 3 and appropriate response archetypes under Pillar 4, strengthening connectivity between technical early-warning stakeholders and communities at risk.

93 For example, in Kenya, the Kenya Meteorological Department and the National Drought Management Authority jointly conduct integrated risk analyses for drought-prone counties, combining forecasts with livelihood and market data to anticipate and mitigate cascading impacts on food systems.

— National governments should embed early-warning systems and anticipatory action within national strategies on climate adaptation or disaster policy frameworks. This should improve the sustainability of financing such systems and actions and should support mainstreaming anticipatory approaches related to food security across ministries and operational actors.

Subnational level

4. Cascading risks are felt by communities first and foremost. Developing ways of understanding how these impacts are felt requires a stronger subnational onus for implementation, but this is impacted by limited funding at this level.

— Subnational authorities and civil society actors should support community leaders or community preparedness volunteers to engage with specific communities at risk of food insecurity to improve actions under Pillars 3 and 4. This should focus on understanding barriers to accessing early-warning information, issues related to understanding technical forecast information, the cohorts of people most likely to be excluded from developing early-action plans, and those that require additional support to implement early actions to reduce risks of food insecurity.

— Civil society and local government should include local understanding of gaps in the early-warning system (related to cascading risks to food security) and the needs of local communities into plans and strategies at national and higher levels.

— Subnational authorities should be adequately resourced and trained to embed existing community perspectives and practices, including those from 'missing voices' into early action or disaster preparedness plans. Doing so should ensure that such plans complement and support existing community response strategies under Pillar 4 and that food system risk assessments under Pillar 1 reflect varied experiences of vulnerability. This requires concerted engagement with, and willingness to learn from, NGOs, civil society and community representatives.

Annex: Digest of existing early-warning systems to monitor food security

Table A1. Food security monitoring apparatus for early warning

Label	Organization	Name	Type	Description
IPC/CH	FAO, WFP and multiple partners	Integrated Phase Classification/ Cadre Harmonisé	Food security information and early-warning systems	The IPC offers decision-makers key assessments on the severity and magnitude of acute and chronic food insecurity and malnutrition. These assessments are grounded in evidence and built through a consensus-driven approach supporting immediate humanitarian response as well as longer-term policy development and planning.
FEWS NET	US Department of State and (until January 2025) US Agency for International Development (USAID)	Famine Early Warning System Network	Food security information and early-warning systems	FEWS NET provides impartial, evidence-based analysis to help governments and aid agencies respond to food crises and support planning on long-term resilience. Focused mainly on sub-Saharan Africa, it publishes monthly reports using observed and forecasted drought data, vulnerability indicators and expert judgment to locally and regionally assess food security.
VAM1	WFP	Vulnerability Analyses and Mapping and Hunger Map LIVE	Food security information and early-warning systems	VAM1 supplies vulnerability data and real-time food security insights across 80 plus countries to inform WFP planning and resourcing.
VAM2/CARI	WFP	Consolidated Approach for Reporting Indicators of Food Security	Food security information and early-warning systems	WFP's CARI provides 'snapshots' of acute food insecurity situations based on food consumption scores, food energy shortfall, poverty status, food expenditure shares and livelihood coping strategies. WFP uses this information to identify need for emergency interventions.
VAM3	WFP	WFP Global Market Monitor	Mixed information systems	WFP's monthly Global Market Monitor observes price information, covering more than 1,500 markets, on changes in the cost of basic food baskets, alerts for price spikes in local markets and domestic inflation and currency movements as well as an overview of global food commodity price developments.
GIEWS	FAO	Global Information and Early Warning System	Mixed information systems	GIEWS monitors food supply, demand, prices and other key indicators at global and national levels to assess global food security situation.
FAOSTAT	FAO		Mixed information systems	FAOSTAT enables free access to annual crop production, agricultural trade, food balance sheets and other data for 245 plus countries and territories, covering all FAO regional groupings.
GEOGLAM	GEOGLAM	Crop Monitor of the Group on Earth Observations Agricultural Monitoring	Agricultural information systems	GEOGLAM provides open access to timely information on crop conditions, supporting market transparency for the G20 Agricultural Market Information System (AMIS) and serves as an early-warning system for countries at risk of food production shortfalls.
CropWatch	Chinese Academy of Science		Agricultural information systems	CropWatch assesses national and global crop production and related information using remote sensing and ground-based indicators.

Label	Organization	Name	Type	Description
AMIS	AMIS (multi-agency, multi-country/ G20)	Agricultural Market Information System	Agricultural information systems	Serving as an interagency platform for the G20, Spain and seven major exporters or importers of agricultural commodities, AMIS enhances food market transparency and policy responses for food market stability.
FAS	US Department of Agriculture (USDA)	Foreign Agricultural Service	Agricultural information systems	FAS links US agriculture to global agriculture and food supply chain data to enhance export opportunities and provide data on prospects for global food security.
FSP1	IFPRI	Food Security Portal (FSP) Excessive Food Price Variability Index	Agricultural information systems	FSP1 is a real-time early warning system for price trends and price volatility in international markets for key agricultural commodities.
FSP2	IFPRI	Food Security Portal (FSP) Food and Fertilizer Trade Restrictions; Fertilizer Market; and Production and Stocks Trackers	Agricultural information systems	FSP2 details daily updates of food and fertilizer trade restrictions, monthly updates of fertilizer prices and market conditions, and monthly updates of global supply and stocks of key staple foods.
FSP3	IFPRI	Food Security Portal (FSP) Domestic Food Price Monitor	Mixed information systems	FSP3 features an easy-to-use dashboard that tracks monthly trends in domestic food prices, both overall and by major food items. Another dashboard helps users understand how international price changes and other factors affect local food price inflation.
FSP4	IFPRI	Food Security Portal (FSP) Vulnerability Analysis Dashboard	Food security information and early-warning systems	The FSP4 provides a dashboard identifying food insecurity hotspots and vulnerability to different types of global market shocks and other risk factors.

Source: Vos et al. (2024), 'Chapter 2: Food Crisis Risk Monitoring: Early Warning for Early Action'.

About the Authors

Bhargabi Bharadwaj is a research associate in the Environment and Society Centre at Chatham House. Her work focuses on risks to and governance of natural resources within key domains of international affairs, such as trade, security and climate change. Her research explores how developing countries can be supported equitably in achieving net zero, with a special interest in legal and regulatory pathways. Previously, she worked with the UK's Committee on Climate Change (CCC), where she led and supported national assessments of progress on climate adaptation in devolved nations and aided knowledge-sharing internationally. She also worked with the UN in North Korea's complex protracted crisis context, where she co-authored numerous reports on the humanitarian, socio-economic and developmental context. She holds a bachelor's degree in law from the University of Kent and an LLM in public international law, with a focus on transnational environmental law, from the London School of Economics and Political Science.

Richard King is a senior research fellow in the Environment and Society Centre at Chatham House. His work focuses on the sustainability of – and systemic risks to/from – food systems, agriculture, land use and soft commodity resource trade. His recent projects have included examining cascading climate risks in international food trade; policy design in support of climate-smart and nutrition-secure food systems in southern and eastern Africa; and emerging sustainability issues associated with land-based approaches to negative emissions. He was a lead author on the United Nations Environment Programme's (UNEP) most recent flagship environmental assessment, Global Environment Outlook 6 (GEO-6, 2019).

Prior to joining Chatham House, Richard was deputy head of research at Oxfam GB, where he specialized in food and rural livelihoods, particularly in the contexts of climate change, resource constraints and market volatility.

Dr Mirianna Budimir is the senior climate and resilience expert within the Impact, Influence and Innovation team at Practical Action. She leads the organization's work on equitable early-warning systems and provides technical support to programmes across Latin America, Africa and South Asia. She holds a PhD focused on cascading multi-hazards and risk, and serves as the global lead for Practical Action's Missing Voices Approach.

Acknowledgments

This paper has benefited greatly from insights provided by numerous interviewees and participants of a virtual roundtable held in early 2025, as well as from those provided by community members who participated in Practical Action's field work for this project. We thank them all for their time and insights.

Particular thanks are due to Tamanna Rahman, Tariqul Hasan Rifat, Farhana Parvin, Alioune Ndiaye, Alpha Sall, Adama Dia, Colin McQuistan, Anum Farhan, Ruth Townend and Mike Tsang for their much-appreciated contributions to various facets of the research and publication process. Thank you, too, to all those who contributed comments on this paper, including the anonymous reviewers; any errors remain our own.

This research was made possible thanks to funding provided by the Citi Foundation.

Cover image: A woman and her child evacuate their home, which was destroyed by Cyclone Remal, Kuakata, Bangladesh.
Photo credit: Copyright © Niamul Rifat/Anadolu/Getty Images

ISBN 978 1 78413 658 1
DOI 10.55317/9781784136581

Cite this paper: Bharadwaj, B., King, R. and Budimir, M. (2025), *How to bolster food security through global early-warning systems: Countering cascading risks with enhanced monitoring and response preparedness*, Research Paper, London: Royal Institute of International Affairs, https://doi.org/10.55317/9781784136581.

This publication is printed on FSC-certified paper.
designbysoapbox.com

Independent thinking since 1920

The Royal Institute of International Affairs
Chatham House
10 St James's Square, London SW1Y 4LE
T +44 (0)20 7957 5700
contact@chathamhouse.org | chathamhouse.org

Charity Registration Number: 208223