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Enabling the Effective Use of Technology for Resilience to Natural Hazards and Disasters through International Collaboration

Preamble

Across the world, countries and regions face a wide range of natural hazards. When hazards interact with vulnerable populations, infrastructure, and ecosystems, they become disasters—causing loss of life, human suffering, disruption to essential services and livelihoods, environmental impacts, and economic loss. The consequences can extend beyond affected areas and across borders, disrupting interconnected systems such as supply chains, financial markets, and shared environmental resources.

Technology and international collaboration offer significant opportunities to strengthen resilience to natural hazards and disasters. Advances in Earth observation, remote sensing, early warning systems, numerical modeling, digital twins, drone technologies, and artificial intelligence (AI) can enhance understanding of hazards and risk, support decision-making, and strengthen preparedness, response, and recovery. Yet many promising technologies remain underutilized, inaccessible, or ineffectively deployed because of gaps in infrastructure, technical and financial capacity, interoperability, institutional alignment, and public trust. The risks that countries face are also evolving.

Population settlement in risk-prone areas, poorly planned urban expansion, unsustainable land-use practices, inadequate maintenance of infrastructure, and changes in environmental conditions can amplify the impacts of natural hazards. The Intergovernmental Panel on Climate Change (IPCC) reports that "human-caused climate change is already affecting many weather and climate extremes in every region across the globe."

Together, these changing conditions reinforce the need for forward-looking assessments that are regularly updated to reflect evolving conditions and emerging risks. Therefore, the challenge is not only to develop new technologies, but also to ensure that existing technologies are effectively deployed, appropriately adapted, sustainably maintained, and equitably accessed. Through international collaboration, countries can share data, technology, expertise, and operational capabilities; strengthen resilience across interconnected systems; and ensure that scientific and technological advances translate into improved preparedness and resilience.

Key Messages

Strengthen data collection and availability and the understanding of risk. Accurate data on hazards, exposure, and vulnerability are essential for disaster preparedness, response, and recovery. Countries need stronger observation systems and datasets on infrastructure, housing, transportation and communication systems, supply chains, socio-economic conditions, and vulnerable populations. Forward-looking models need to be regularly updated to reflect evolving conditions and emerging risks.

Enable safe, secure, and equitable access to data and technology. The value of data depends on the ability of users—particularly governments and institutions responsible for protecting the public—to access, share, integrate, and apply them effectively. Expanding access, promoting common standards and interoperability, and developing resilient systems that can function during power, telecommunications, or internet disruptions can strengthen early warning, emergency response, and resilience planning. Decisions on data governance, safety, security, privacy, and access remain the responsibility of national authorities.

Build local skills and capacity and design solutions for local contexts. Technology and data deliver the greatest benefits when adapted to local contexts and integrated with local knowledge, institutions, and operational needs. Investment in education, workforce development, training, exercises, and sustained community engagement can build the capacity needed to operate early warning systems, manage data platforms, interpret risk information, and maintain critical technological infrastructure over time.

Strengthen human decision-making and governance in technology-enabled systems. Advanced technologies should enhance rather than replace human expertise. Effective systems require human oversight, local validation, continuous evaluation, transparency, accountability, cybersecurity, and clear communication of risk and uncertainty. Scientific and technological outputs must be translated into timely and actionable information that supports decisions by authorities, emergency managers, and communities.

Advance international and cross-sector collaboration through co-production. Data, experiences, and insights generated by disasters in one region can provide critical lessons for strengthening preparedness and resilience elsewhere. International collaboration is most effective when framed as the co-production of knowledge and technology rather than the one-way transfer of expertise or solutions. Sustained partnerships among governments, academia, industry, civil society, communities, and international organizations can accelerate innovation, expand access to data and technology, strengthen local capacity, and enable rapid collaboration during and after disasters.

Implementation of these actions will vary according to national and local contexts, including governance structures, legal and regulatory frameworks, institutional responsibilities, risk profiles, and available technical and financial capacity. Progress will depend not only on technological innovation and international collaboration, but also on sustained investment in the systems, institutions, infrastructure, and people needed to translate innovation into resilience. Disasters are inevitable; the imperative is to ensure that we are better prepared when they occur.

Introduction

Across the world, countries and regions face a wide range of natural hazards that vary in frequency, intensity, complexity, predictability, and impact. Heavy rainfall, earthquakes, landslides and mudflows, droughts, wildfires, tropical cyclones, heat waves and cold waves, tsunamis, sea level rise, and volcanic eruptions are among the many hazards affecting communities worldwide. These hazards are referred to as natural hazards to differentiate them from chemical, biological, technological, and societal hazards.[1] However, their impacts can be caused or amplified by human activities, including population settlement in risk-prone areas, poorly planned urban expansion, unsustainable land-use practices and exploitation of natural resources, inadequate maintenance of public infrastructure, and climate variability and change. The Intergovernmental Panel on Climate Change (IPCC) reports that "human-caused climate change is already affecting many weather and climate extremes in every region across the globe." Together, these changing conditions reinforce the need for forward-looking assessments that are regularly updated to reflect evolving conditions and emerging risks.[2]

When hazards interact with vulnerable populations, infrastructure, and ecosystems, they become disasters that cause loss of life; human suffering; widespread disruption to essential services, livelihoods, and the environment, and economic loss. Disasters are usually experienced locally, but their consequences can extend across regions and borders—disrupting interconnected systems such as global supply chains, financial markets, and shared environmental resources, while driving population displacement and migration. Beyond their devastating human losses, natural hazards and disasters inflict substantial economic losses. In 2025 alone, the direct and associated costs of these events totaled approximately US$224 billion and were largely attributed to weather events.[3] Separately, the United Nations Office for Disaster Risk Reduction (UNDRR) estimates an annual cost exceeding US$2.3 trillion when



indirect, cascading, and ecosystem impacts are included.[4] Based on another estimate, economic losses from natural disasters have grown by 5–7 per cent per year after adjusting for inflation, about twice as fast as global GDP.[5] Without stronger resilience measures, the share of national resources needed to address disaster impacts will continue to rise.

This statement focuses specifically on how international collaboration in data sharing and technology use can strengthen resilience, defined here as preparing for, absorbing, recovering from, and adapting to adverse events.[6] Despite national disaster risk-reduction strategies and major initiatives such as the Sendai Framework for Disaster Risk Reduction and the Early Warnings for All initiative (EW4All), risk-reduction efforts often fall short.[7] Challenges to these efforts include underfunding, limited knowledge of exposure and vulnerability, insufficient integration of social and behavioral dimensions, and insufficient capacity to sustain effective measures over time.[8]

In today's interconnected world, the resilience of individual countries is intrinsically linked to the strength of regional and global networks. International collaboration can facilitate sharing of data, technologies, expertise, and operational capabilities across borders (see Appendix A). Some national directives call for greater integration of data and technology into disaster risk-management plans.[9] However, many promising technologies remain underutilized, inaccessible, or ineffectively deployed, particularly in regions with limited technical and financial capacity and in Small Island Developing States which are at the frontline of climate-related disasters.[10] Barriers include inadequate digital and communications infrastructure, shortages of skilled personnel, recurring operation and maintenance costs, insufficient interoperability, weak alignment with local institutions and decision-making processes, and limited public trust.

The scale and sophistication of existing and emerging technologies to support disaster risk management are quickly expanding. Remote sensing, Earth observation, crowd-sourced mapping, mobile surveys, early-warning systems, numerical modeling, and AI offer potential to enhance the speed, precision, and accessibility of collaborative disaster risk management.[11] Satellite systems increasingly provide near-real-time, wide-area, high-resolution observations, and emerging technologies such as digital twins can support scenario analysis, stress testing, planning, and the assessment of alternative recovery pathways. The use of AI and machine learning (AI/ML)-enabled tools in hazard monitoring, damage assessment, and operational decision-making is increasing.[12] Many technologies are mature and deployed across regions, supporting activities such as flood forecasting and monitoring, drone-enabled imaging and wildfire detection, cyclone response, tsunami early warning, and humanitarian coordination. However, challenges related to internet dependence, technical capacity requirements, cybersecurity, privacy, and user support prevent their broader use.

Rather than prescribing solutions, this statement draws attention to five highly interlinked opportunities that need to be considered as an integrated whole, rather than as separate areas for action. The proposed actions are directed to national and local governments, non-governmental organizations, technologists, researchers, and community leaders, and are designed to enhance the availability and use of existing and emerging technologies everywhere.



OPPORTUNITY 1

Strengthen Data Collection and Availability and Understanding of Risk

Accurate data on hazards, exposure, and vulnerability are essential for disaster preparedness, response, and recovery. Advanced technologies rely on these data to inform the design of efficient tools for assessing hazard threats and modeling risk scenarios. Given the impacts of climate variability and change, including those driven by human activities, there is an increasing need for forward-looking models that are regularly updated to reflect evolving conditions and emerging risks. However, significant data gaps remain in many areas, particularly infrastructure, socioeconomic conditions, the social dynamics of disaster response and recovery, and the vulnerability of specific populations and regions—limiting the understanding of risk and the ability to effectively target investments and interventions. Addressing these shortcomings requires strengthening the collection, integration, and use of diverse datasets. The following actions can help strengthen data availability and risk understanding:

Expand terrestrial, marine, airborne, and satellite-based observation systems to monitor hazards, Earth-system processes, and the protective functions of ecosystems, with sufficient spatial and temporal resolution. Improved temporal and spatial coverage enables more accurate monitoring of rapidly evolving events, better characterization of hazard behaviors and local conditions, earlier prediction of emerging risks, and comprehensive assessment of how ecosystems (e.g., forests, wetlands, mangroves, coral reefs, and floodplains) reduce risk. Together, these capabilities can support more timely and effective preparedness, response, and recovery efforts. In the context of geological hazards and risks, instrumental data alone cannot capture the full temporal and spatial spectrum of potential extreme events. Fundamental research anchored in field observations and geological archives, paired with historical records, monitoring, and modeling, is also needed.

Strengthen datasets related to exposure and vulnerability, including infrastructure, housing, transportation and communication systems, supply chains, socioeconomic conditions, and the social dynamics of disaster response and recovery. Vulnerability is determined not only by the intensity of the hazard, but also by the distribution of resources, infrastructure, and services to the individuals and communities affected. These datasets are essential for understanding who and what is at risk. They identify populations and assets that may be disproportionately affected, including women, older people, people with disabilities, Indigenous Peoples, displaced populations, and those without access to health care and essential services.

Address algorithmic bias and data inequities that may arise from limitations in data availability and analytical approaches that can disadvantage specific populations or data-sparse regions. Biases in data or AI-trained algorithms can systematically misrepresent or overlook vulnerable groups and regions. Assessing model performance across relevant geographic and population characteristics—alongside greater transparency about data sources, representativeness, quality, and limitations—is particularly important when models are applied in data-sparse regions. Addressing these issues improves the validity and robustness of analytical tools and strengthens equity in decision-making.



OPPORTUNITY 2

Enable Safe, Secure, and Equitable Access to Data and Technology

The value of data depends not only on their availability, but also on the ability of users to access, share, integrate, and apply them effectively. Fragmented systems, inconsistent standards, unequal access, and vulnerabilities to power, telecommunications, or internet disruptions, continue to limit access to critical data and technologies when they are needed most. The following actions can enable safe, secure, and equitable access to data and technology:

Expand access to high-resolution datasets, computational infrastructure, emerging technologies, and cross-border data-sharing mechanisms, particularly in low- and middle-income countries. Strengthening of cross-border data access enables more effective monitoring and management of hazards that transcend national boundaries, reduces disparities in technical capacity, helps close resilience gaps, improves preparedness, and supports more coordinated and timely responses to hazards.

Promote interoperability through common standards, harmonized data formats, and shared, secure cloud-based analytical platforms that enable the integration, translation, and analysis of data from satellites, and cross-regional airborne and ground-based systems within a common framework. Interoperability helps bridge diverse datasets across jurisdictions, disciplines, and technologies to provide a comprehensive understanding of hazards and risks. It ultimately supports coordinated decision-making, particularly during rapidly evolving events that requires information from multiple sources and regions. Systems need to support offline functionality, tested fallback procedures, and resilient access to data and communication systems to maintain continuity during power, telecommunications, or internet disruptions.

Ensure data management aligns with FAIR (Findable, Accessible, Interoperable, Reusable) and CARE (Collective benefit, Authority to control, Responsibility, Ethics) principles. Adherence to these principles helps maximize the value, usability, and impact of data, respects the rights, interests, and governance of the communities and stakeholders from whom the data originate, and supports adequate data security and confidentiality. A decentralized yet unified data architecture—based on a standardized interoperable framework can provide reliable access to critical disaster risk-reduction tools and reduce vulnerabilities caused by changing international commercial or political environments.



OPPORTUNITY 3

Build Local Skills and Capacity and Design Context-Specific Technological Solutions

Technology and data deliver the greatest benefits when they are co-created with local populations, adapted to local contexts, and effectively integrated with local knowledge, institutions, and operational needs. However, significant skill and capacity gaps continue to constrain implementation in many parts of the world, particularly where competing priorities, such as poverty reduction and infrastructure limit investment in technological systems and innovation. The following actions can help build local skills and capacity and context-specific technological solutions:

Conduct regular multi-stakeholder exercises that integrate existing and emerging technologies into applied preparedness, response, and recovery operations, explicitly testing capabilities against compound and cascading hazards. These exercises can simulate complex disaster chains (e.g., earthquake–landslide–barrier lake–outburst flood; glacial retreat–glacial lake outburst flood–downstream flooding; or El Niño–drought–wildfire) as well as scenarios in which technological or infrastructure failures trigger or amplify cascading impacts. Such exercises can improve coordination across agencies and sectors under realistic, high-stress conditions; identify operational gaps; validate early warning and decision-support systems; and strengthen interoperability among institutions and technologies. Finally, they can improve response timing and build institutional familiarity with emerging tools.

Invest in education, workforce development, and training programs to build local knowledge and skilled personnel to operate early warning systems, manage data platforms, interpret risk information accurately, and maintain critical technological infrastructure. Strengthened institutional capacity helps enhance continuity, reduces dependence on external expertise, and enables more timely and locally informed decision-making. These offerings can include hands-on training, online learning resources, and practical handbooks and guidelines tailored to local needs and available in the local languages.

Integrate traditional, Indigenous, and local knowledge with scientific approaches through trusted and sustained community engagement. Inputs from different knowledge systems enrich local people's ability to sustain their ecosystems and to respond to hazards, exposure, and vulnerability by combining long-standing, place-based knowledge and experience with scientific and technological methods. Together, these perspectives improve the relevance, reliability, and usability of risk information, particularly at the community level.

OPPORTUNITY 4

Strengthen Human Decision-Making and Governance in Technology-Enabled Systems

A strong human–technology symbiosis, wherein advanced technologies enhance rather than replace human expertise, ensure that technology-enabled systems are effective, reliable, and serve the public good by being responsive to complex real-world challenges. Validation of technology-enabled systems still requires human expertise to assess performance against established physics-based, statistical, and hybrid models, and to make decisions when hazard evolution and model outputs are uncertain. While advanced tools can improve data analysis, forecasting, and situational awareness, resilience ultimately depends on decision-making systems that are grounded in public accountability and informed by local context. Resilience therefore requires governance frameworks that ensure responsible and transparent use of technologies. Effective frameworks support human-centered decisions and outcomes, strengthen institutional trust, and avoid over-reliance on digital systems in contexts where human oversight is critical. The following actions can strengthen human decision-making and governance in technology-enabled systems:

Strengthen collaboration on hazard and risk communication, structural and hazard impact modeling, and the application of best practices to support human decision-making across all levels of risk governance. Resilience depends on the translation of scientific and technological outputs into clear, timely, and actionable information that supports decisions by authorities, emergency managers, and communities—from megacities to remote areas. Warnings and risk information need to be available in multiple languages, accessible to people with disabilities and across literacy levels, usable offline, and delivered through trusted intermediaries and multiple, redundant communication channels. Dedicated liaison mechanisms with national disaster-management authorities and research institutions can improve two-way communication. They ensure the appropriate matching of technical expertise to decision needs, and continuous feedback from decision-makers to refine models, tools, and communication strategies.

Establish the mechanisms and resources needed to validate local conditions against real-world conditions and to continuously evaluate technological outputs to improve accuracy, reliability, and relevance in operational contexts. By embedding these processes into models, forecasts, and decision-support tools, they can be tested against real-world conditions and local observations, reducing errors and improving performance over time. This action can also strengthen trust in technological outputs by ensuring transparency, accountability, and alignment with user needs and enables iterative refinement of systems based on feedback from practitioners and affected communities.

Develop governance frameworks, with due regard for the social and political differences between nations, that prioritize transparency, accountability, and responsible use of data and technology for the public good. Such governance frameworks ensure that data-driven and technology-enabled systems for disaster risk reduction are reliable, ethical, and effective. Responsible use frameworks help safeguard against misuse, unintended consequences, and exclusionary practices, and support alignment with legal, ethical, and societal norms. For AI and other emerging technologies used in high-consequence decisions, governance approaches need to ensure transparency, human oversight, rigorous testing, cybersecurity, and accountability.



OPPORTUNITY 5

Advance Co-Production of Knowledge and Technology through International and Cross-Sector Collaboration

Data, experiences, and insights generated by disasters in one region can provide critical lessons for strengthening preparedness and resilience elsewhere. To be effective, international collaboration is best framed as the co-production of knowledge and technology rather than the one-way transfer of expertise or solutions, and governments and institutions in collaborating countries need to be engaged with affected communities as equal partners. This approach promotes mutual learning, local relevance and ownership, and the long-term sustainability of technological solutions. The following actions can help advance co-production of knowledge and technology through international and cross-sector collaboration:

Support multinational and interdisciplinary research partnerships that connect fundamental Earth-system science, social sciences and humanities, applied research, technology development, and operational implementation. Such end-to-end collaboration helps ensure the translation of scientific advances into practical tools, services, and decision-support systems for disaster risk reduction. Cross-country learning and exchange of experience can help identify effective approaches, avoid duplication, and adapt solutions to different risk contexts.

Strengthen partnerships across governments, academia, industry, civil society, local communities, and the insurance sectors. Addressing disaster risk requires diverse expertise and perspectives including scientific, technical, social, behavioral, cultural, and economic perspectives. Cross-sector collaboration at the national, regional, and international level can improve access to data, technology, financing, and operational capabilities and ensure that solutions are responsive to societal needs and grounded in local realities. Strong communication and meaningful stakeholder engagement can help build public trust, reduce social conflict and skepticism, and ensure that expert knowledge is informed by local perspectives and needs.

Expand international scientific cooperation in research, technology uptake, technical assistance, and capacity-building initiatives. This action requires sustained investment in institutional capacity, workforce skills, and knowledge exchange at national, regional, and local levels, including among first responders. International scientific networks also need to enable rapid collaboration during and immediately after disasters, facilitating the timely exchange of data, observations, forecasts, risk assessments, models, and expertise to support coordinated decision-making, emergency response, recovery, and continued learning.

Way Forward

Existing and emerging technologies offer unprecedented opportunities to deepen understanding of exposure and vulnerability, strengthen early warning systems, support more informed decision-making, and enhance resilience to hazards and disasters. However, fragmented systems, inconsistent standards, and unequal access currently limit the effective use of hazard-relevant data, leaving many promising technologies underutilized in regions that need them most. Therefore, the challenge is not only to develop new technologies, but also to ensure that those already available are effectively deployed, appropriately adapted, sustainably maintained, and equitably accessed.

Implementation of the actions highlighted in this statement will vary according to national and local contexts, including governance structures, legal and regulatory frameworks, institutional responsibilities, risk profiles, and available technical and financial capacity. Depending on these circumstances, implementation may involve different combinations of national and subnational authorities, scientific and technical institutions, international and regional organizations, the private sector, communities, and other relevant stakeholders, with roles and responsibilities adapted to local needs and capacities. Progress will ultimately depend not only on technological innovation and international collaboration, but also on the willingness and capacity of countries and international partners to invest in the systems, institutions, and people needed to translate innovation into sustained and equitable resilience.

Yet, many countries, particularly those with limited financial, technical, and institutional capacity, struggle to invest in observation systems, resilient communications, data infrastructure, computing capacity, workforce development, and the maintenance of technology-enabled systems. Therefore, higher-resource countries and international partners have an important role in supporting implementation in countries and communities facing the greatest capacity constraints. Recent efforts such as the Bridgetown Initiative, which call for reforms to the international financial system to expand access to financing for climate resilience and development, illustrate the growing recognition of these financing challenges. Financing needs to be predictable and sustained, extending beyond initial technology development to local adaptation, institutional capacity, workforce development, infrastructure, and long-term operation and maintenance.

The urgency of acting on these priorities was underscored repeatedly while this statement was being developed. Since work on the statement began, communities around the world have experienced devastating disasters, including catastrophic floods in Nepal in August 2026, wildfires across Europe and Canada over the summer, and earthquakes in the Philippines and Venezuela in June. These events demonstrate the scale, diversity, and continuing nature of the hazards confronting communities worldwide. More disasters will inevitably occur after this statement is issued; the imperative is to ensure that we are better prepared when they do.

The focus of this statement on technological advancements and international collaboration in resilience to natural hazards and disasters neither diminishes the importance of prevention or risk reduction nor suggests that technology can replace these efforts. Rather, investments in prevention, risk reduction, and resilience can reinforce one another, with technological advances offering tools to strengthen each. The S20 has consistently recognized the importance of addressing the underlying drivers of disaster risk, including exposure, vulnerability, and human activities that can amplify hazard impacts.[13] Building on that body of work, this statement highlights ways that technology and international collaboration can strengthen resilience to hazards and disasters.

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Appendix A

Examples of Collaborative Data and Technology Systems for Disaster Risk Reduction

The examples below illustrate how collaboration across countries, sectors, and institutions can bring together data, models, technologies, and technical expertise to strengthen disaster risk reduction. In many cases, the data, technologies, and expertise supporting these systems are contributed by partners outside the countries or regions in which they operate,

Indian Ocean Tsunami Warning and tropical cyclone forecasting systems: Regional cooperation systems operating across the Indian Ocean that integrate seismic, oceanographic, meteorological, and satellite observations with forecasting models to provide real-time warnings and shared forecast information, strengthening preparedness and response across neighboring countries. See: https://tsunami.incois.gov.in/TEWS/searlywarnings.jsp.

Amazon Basin fire monitoring: A regional fire-monitoring system operating across the Amazon Basin that uses satellite observations and public data to detect individual fires and track smoke emissions, providing timely information through public dashboards to support wildfire detection, response, and management. See: https://amzfire.servirglobal.net/dashboard/.

Mekong Basin flood and drought monitoring: A transboundary monitoring and forecasting system operating across the Mekong Basin that uses data from hydrometeorological stations, satellite observations, and hydrological and meteorological models to produce daily wet-season flood forecasts and weekly drought outlooks, supporting coordinated water and disaster-risk management. See: https://www.mrcmekong.org/flood-and-drought/.

European Flood Awareness System: A pan-European flood forecasting and notification system that integrates meteorological and hydrological observations, satellite data, and hydrological models to provide early flood forecasts and notifications, strengthening preparedness and coordination among national and regional authorities, particularly for transboundary river basins. See: https://www.copernicus.eu/en/european-flood-awareness-system.

Severe Weather Forecasting Programme: A global forecasting initiative operating across nine regions and supporting approximately 85 developing countries that combines global and regional weather observations with numerical weather-prediction models to provide severe-weather forecasts and guidance to national meteorological services, strengthening forecasting capacity and early warning. See: https://wmo.int/activities/severe-weather-forecasting-programme-swfp.

International volcanic–ash monitoring and advisory system: An internationally coordinated system operating across volcanic regions worldwide that combines ground-based and satellite observations with atmospheric dispersion models to track volcanic ash and forecast its movement, providing standardized advisories that support aviation safety and coordinated response across national boundaries. See: https://www.weather.gov/aviation/vaac.

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