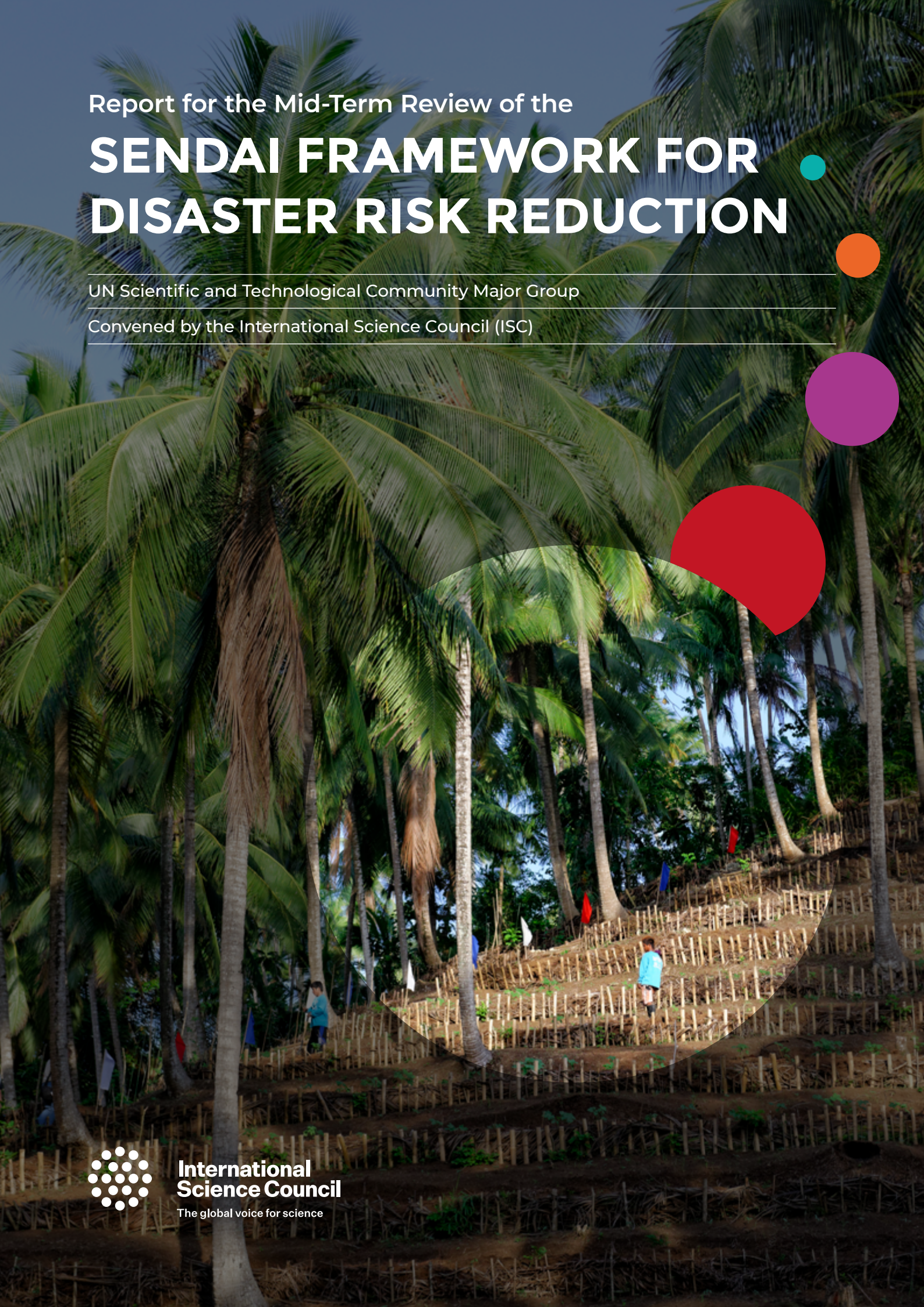
Report for the Mid-Term Review of the

SENDAI FRAMEWORK FOR DISASTER RISK REDUCTION

UN Scientific and Technological Community Major Group

Convened by the International Science Council (ISC)



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Contents

Foreword: Progressing the vision of Sendai

During 2015, the multilateral community took several hopeful steps towards sustainability and wellbeing by entering into a number of agreements including the SDGs and the 2030 Agenda, the SAMOA pathway, the Paris Agreement, and the Sendai Framework.

These agreements were made at a time when multilateral collaboration showed promise and the hope of significant progress towards sustainability by 2030 seemed realistic. But the optimism of 2015 has been replaced by concern. Progress on the sustainability agenda has been impaired by COVID-19, growing geostrategic tension, fracturing commitments to multilateralism and, sadly, a gap between policy intent and action.

The Sendai Framework for Disaster Risk Reduction (2015 – 2030) was a core component of that 2015 package and, like the SDGs, it had a 15-year horizon. It is timely, therefore, that the United Nations Office for Disaster Risk Reduction (UNDRR) is undertaking a midterm review. This report is the contribution of the UN Major Group on Science and Technology into that review. During the past seven years the International Science Council (ISC) has had an active partnership with UNDRR to enhance disaster risk reduction research and provide some of the toolkit through the development of a standard taxonomy for hazard definition and classification.

The core question we face is: has there been significant progress within both the multilateral *and* the national policy and disaster and risk communities to reflect the intent of the 2015 agreement? This report addresses this question and highlights areas of progress and concern. It also makes important recommendations on how we can move forward.

The Sendai Framework was notable for many reasons. There was strong support from nation states and key stakeholder groups. There was a recognition that disaster management required a greater focus on pre-emptive planning, risk identification and

responsiveness and that these had both national and multilateral dimensions. There was a consensus, too, that science had a greater role to play in planning for, managing and recovering from disasters, and that civil society must be involved. The Sendai Framework acknowledged the broad range of natural and anthropogenic disasters that might be confronted, ranging from biological causes (e.g., a pandemic) to an extraplanetary cause (e.g., a space weather event).

Since agreeing the Framework in March 2015, the world has faced the existential threat of a viral zoonotic pandemic. The COVID-19 pandemic has illustrated the complex cascading nature of a systemic disaster. The outbreak quickly shifted from being simply a health crisis to one which affected every aspect of our lives. It touched on every domain of public policy: social care, mental health, education, economics, diplomacy, food security and supply chains. The pandemic continues today and its impact will be felt for a long time to come.

Natural hazards, including major weather events, are increasingly being linked to the existential threat of climate change with more severe impacts on people and infrastructure. While there has long been a focus on physical recovery after a disaster, far less attention has been paid to psychological and social recovery. Recovery is not complete until people feel they have the agency and control over their lives returned, which can take years after physical recovery has been achieved. Yet far less consideration is taken of these longer-term impacts in policy responses and planning. This report by an expert group convened by the ISC defines and explores where the science and the risk science community believe more must be achieved. But rather than focusing on narrow examples, it looks at the broader context and advances in risk-related science of recent years and shows how the Sendai Framework and its agenda should move forward.

This report urgently recommends enhancing resilience by addressing sustainability and reduce environmental degradation and to think through how population movements could exacerbate risk and be better managed to ameliorate compromised wellbeing. It stresses why greater focus on the psychological and social care aspects of disasters is required, highlights flaws in how the costs and benefits of disaster risk reduction are accounted for and makes a compelling argument for redesigning disaster and risk governance into a multi-sector and multi-level model. At a technical

level, the report makes the case for developing multi hazard early warning systems, improving the availability and use of risk-related data and enhancing disaster monitoring to consider vulnerability more holistically recognizing the multi-temporal and multi-scale drivers of risk creation and accumulation.

The report highlights, too, what is (in my view) the greatest barrier to success - namely the interface between risk science and decision making. The issues of risk communication are more nuanced than simply providing an analysis and require new thinking to overcome the cognitive and political biases which impede risk 'listening'. It also stresses the vital need to expand the capabilities in transdisciplinary science and at the science-policy-action interfaces to meet the vision of the Sendai Framework. Knowledge brokers acting at this interface have an important role to play to present evidence in a way that informs policy options but does not determine policy development.

Both the COVID-19 pandemic and climate change illustrate the need for progress to be made if we are to effectively reduce the risks of disasters and their impact, irrespective of their scale. Firstly, there remains a gap between the risk community and the policy community, which is the most urgent area for research and remedial action. Too often, it turns out that risk practitioners had long highlighted the risks, but decision makers could not accept their scenarios as being realistic. This is the central challenge that this report has (perhaps too gently) put on the table. Risk assessments are not of value unless they are responded to. Sadly, there are cognitive and political biases which inhibit investment in prevention and adaptation. We must bridge these and, at the same time, develop national science advice and risk advice systems, which are broad and not restricted to a narrow domain, for example, natural hazards. Similarly given the criticality of multilateral responses, the multilateral community must find more effective mechanisms at every level to reduce risks and respond to complex systemic crises. Secondly, not everything can be left to governments and the policy community. Public engagement and individual and community actions matter. Compliance with social measures had a significant beneficial impact on the pandemic. So too could individual and community actions on climate change.

The private sector has a critical role to play through both direct support and by developing business cases for resilience. Beyond the obvious role of the insurance

sector, good governance in the private sector includes direct accountability for risk management in a way that is not nearly so common in the public sector. This report makes clear, governments have a responsibility to be more transparent and accountable for risk management and reduction. This requires far better systematic organization and the integration of scientific and civil society inputs into policy and political action. It is not acceptable for political decisions to take a non-expert perspective and ignore significant risks. Equally the science community needs to be more systematic and holistic in exploring complex risks, cascading risks, and their consequences. The ISC, other professional societies and academia can play significant roles in developing the cadre of professionals needed to effect evidence-based, just transitions to a more sustainable future.

The Sendai Framework was a major step forward in taking a more complete approach to risk reduction and disaster management. The seven years since its inception have highlighted that there is much more to be done, both within disaster risk science and the policy community. The last three years have shown the need for improved multilateral responses and emphasized that our interests have high mutuality and that the challenges to the global commons extend from global to local. The report is a timely call to both the science and policy communities.

Sir Peter Gluckman
President | International Science Council

Executive summary

This report from the International Science Council (ISC) is a contribution on behalf of the Scientific and Technological Community Major Group to the Mid-Term Review of the Sendai Framework led by the UN Office for Disaster Risk Reduction (UNDRR). It is the work of an interdisciplinary expert group in an array of risks as well as governance, physical and social sciences, policy and finance.

The report identifies achievements in disaster risk reduction (DRR) since 2015 under the Sendai Framework, but also highlights key implementation gaps. The report provides guidance to policymakers, funders, researchers, international organizations and other stakeholders who shape the way we assess, value, manage and monitor risks.

Ultimately, its goal is to support the building of a post-2030 governance framework, which integrates risk reduction as a key determinant of sustainable development and accelerates the implementation of the Sendai Framework as well as embedding risk reduction and resilience in other global agendas such as the SDGs, the Paris Agreement on Climate Change and the Global Biodiversity Framework.

The magnitude and impact of disasters on lives, livelihoods and ecosystems are on the rise, setting back hard-won development gains in many parts of the world. These impacts are reducing the ability of nations and communities to cope with future disruptions as new combinations of stressors, including changes in the climate, are occurring faster than projected. Natural and socio-natural hazards are interacting more frequently with technological and biological hazards, and the effects of environmental change is producing more complex risk patterns, including compounding and cascading impacts, creating the possibility of more disasters. These trends are exacerbating known risks, creating new ones or revealing submerged risks. Typically, traditional thinking places disaster risk reduction as an add-on to climate adaptation. However, successful adaptation – and many of the Sustainable Development Goals (SDGs) – will be impossible to achieve without greater capabilities for disaster risk reduction being supported across multiple scales. In short, risks are outpacing our capacity to anticipate, manage and reduce the impact

of disasters as they cascade through people's lives, livelihoods, built infrastructure, environments and socio-economic systems.

The estimated average annual direct economic loss from disasters has increased from circa US$70 billion in the 1990s to US$170 billion in the 2010s (UNDRR, 2022). This is almost certainly an under-estimate. Should current trends continue, the number of disasters could increase to 560 each year by 2030, up 40% during the lifetime of the Sendai Framework (UNDRR, 2022). The impact of disasters is more than just their economic impact. Disasters also undermine social and ecological systems and are themselves made worse by the depletion of resilience of these systems.

The quality and availability of information on risk and disasters has increased significantly in the last three decades. The decline in deaths from disasters involving hydrometeorological hazards can be largely attributed to improvements in early warning systems and disaster response capabilities. However, major information gaps remain, including in monitoring and measuring progress against the outcomes of the Sendai Framework (Mizutori, 2020). For example, little data on the indirect or cascading impacts of disasters is available to anticipate abrupt and non-linear changes or understand the potential consequences of disaster events. Moreover, few countries have multi-sectoral approaches, such as integrated water resource management, land use planning and climate adaptation and mitigation strategies, which address the many drivers of risk.

There has also been limited progress in implementing national and sectoral policies through budgetary mechanisms and intersectionality. Land use planning remains fragmented because it is based on political and administrative boundaries which are inconsistent with how cities function, or is not long-term. Such disjointed management causes a lack of coordination between jurisdictions, inequities in the provision of public services, and delays in decision-making.

Funding remains fragmented and sometimes creates perverse incentives by prioritizing short-term post-disaster financing needs over long-term risk reduction. Despite the evidence, tight budget constraints and trade-offs render decision-makers reluctant to invest in reducing the underlying drivers of the social construction of risk or to do so at a scale necessary to reduce the likelihood of emergent risks. Disaster-

related spending remains largely driven by reactive and compensatory investments for post-disaster response. Also, funding mechanisms are too often spread across institutions (or government levels) or are constrained by institutional mandates. There is still a long way to go to advance prospective risk reduction measures which fully incorporate risk reduction into the conception and planning of both public and private investments.

The participation of civil society and science and technology institutions in risk reduction policy making remains limited. The accountability of the public and private sector for their risk management and reduction actions such as the monitoring and enforcement of building codes in some areas is limited. The refusal and delay by some governments to act on COVID-19 recommendations from the science community shows the increasing challenge of mainstreaming science into decision-making.

In summary, it is highly unlikely we will meet the Sendai Framework goals by 2030 given current trends in DRR and the limited progress in meeting other global agreements such as the SDGs, climate and biodiversity targets.

WHAT SHOULD WE DO NOW?

1. There is an urgent need for a sustained focus on building resilience by halting and reversing environmental degradation, restoring depleted buffers and nature's capacity to absorb shocks and adapt to changing conditions. Nature-based solutions can address biodiversity loss and the deterioration of ecosystem services simultaneously, which will help climate change mitigation and adaptation, enhance disaster resilience, and deliver development co-benefits.

2. Displacement, if not anticipated and managed, can have devastating impacts on people and vulnerable social groups. In destination areas, unmanaged population flows lead to overcrowding, social tensions, limited access to services, housing, and livelihoods. In areas of origin, displacement leads to a loss of adaptive capacity, and contributes to insecurity, most acutely among women and children. Anticipating and addressing all the impacts of population movement potentially exacerbated by climate change will be essential to avert, minimize, and address damages and losses.

3. The increasing frequency and magnitude of disasters as well as their cumulative impacts heighten mental health problems which undermine DRR responses and recovery in the long term. Such submerged risks (which are caused by loss of livelihood, trauma, and migration pressures) need to be addressed through health systems which include mental health solutions.

4. Current development paradigms undervalue nature. The focus on short-term returns externalizes the cost of risks to third parties and the environment. The 'predict-then-act' approaches, short-term cost-benefit analyses, the undervaluation of natural and social capital, the invisible or underestimated benefits of prevention, all contribute to embed risk creation and accumulation, undermining sustainable development.

5. There is an urgent need to redesign disaster and risk governance into a multi-sectoral and multi-level model which more effectively serves the global goals of reducing risk and vulnerability, leaves no one behind and which strives for sustainable development. This requires a much stronger focus on territorial risk governance across regions and locales. Different risk drivers are interlinked and manifest themselves in territories where stakeholders coexist with risks everyday. Without robust and consistent territorial governance in regions and at the local level, changes in policies or international commitments will have little impact (UNDRR, 2021a). Territorial governance is more comprehensive and distinctive than risk governance. While risk governance has a sectoral connotation, territorial governance has broader characteristics as a framework that sustains systems and processes such as land-use planning, natural resource management, social and economic development of territories, and the planning and implementation of resilient infrastructure. As such, territorial governance is not specific to the disaster risk management sector, but governance on the drivers of risk as a whole (UNDRR, 2021a). Such a governance model extends well beyond emergency management to encompass vulnerabilities, exposures and contextual sensitivities, as well as the benefits of prospective risk reduction.

6. Improvements in financing arrangements for post-disaster purposes must be accompanied by increased (and flexible) financing for ex-ante risk reduction. This financing must reach the most vulnerable. If not, current trends mean the resources

required for response and post-disaster recovery will continue to rise and global efforts to ensure adequate financing will fall increasingly short of their objectives. Dedicated financing for risk reduction should go hand-in-hand with research, innovation, and learning on ways to use existing capabilities more effectively.

7. The development of better multi-hazard early warning systems (MHEWS) is essential to anticipate and act against future disasters. MHEWS linked to social protection will allow countries to provide better targeted support to the most vulnerable in the event of disasters. These MHEWS must become fully integrated information systems embedded in practice which address the full scope of hazards, how hazards interact temporally and spatially and include reliable and up-to-date risk information including on population vulnerability. Critically, they must be accessible and available to displaced people and those at risk of displacement, so they themselves can take anticipatory action.

8. Improvements in the quality of risk data are crucial. Also, it is critical to broaden the availability of risk data and increase the technical and financial capacity to use data for DRR at national and local levels. We must invest more in information quality and standardization, broadening data sets and the application of effective methodologies in sectoral and land use planning.

9. Disaster monitoring must move beyond assessing event-related damage and loss to address the multi-temporal and multi-scale drivers of risk creation and accumulation. Comprehensive and integrated monitoring of vulnerability is needed. This should include vulnerability assessments and adaptive capacity, as well as the monitoring of resilience, for instance, by integrating disaster-related losses of ecosystems and ecosystem services into systems monitoring.

10. A major challenge is communicating risk, complexity and uncertainty to better inform decision-making. But little work has been done to assess how present efforts in communication are perceived by stakeholders including policymakers. To prevent risk creation, manage disaster risk and build resilience, risk assessments must better understand how existing processes of risk communication are perceived by those affected and those making decisions which affects the lives and livelihoods of others.

11. Sustained transdisciplinary collaborations which bring together multiple perspectives from stakeholders, policy and scientific communities, can play a major role in building understanding, trust and context-specific knowledge and pathways for action. This is especially important in the face of fast-evolving or uncertain evidence. Sadly, there is a lack of enabling capabilities or enough transdisciplinary science professionals available to keep up with the growing demand for risk-based information services which can result in minimizing system complexity and backgrounding the need to foster transformative responses. There is an urgent need to develop a cadre of transdisciplinary professionals who can expand the interface between science, policy and practice and drive use-inspired research. Building such science-policy-practice interfaces is a key part of the capacity and institutional development needed to improve communication and coordination across the knowledge to action continuum.

SUMMARY TABLE OF KEY RECOMMENDATIONS

1.	Strengthen territorial level risk governance in regions and at the local level that addresses the drivers of risk across sectors.
2.	De-fragment finance to align investment with risk reduction goals at global, regional and local scales.
3.	Develop community-led nature-based solutions to enhance the protection of natural buffers that reduce risks and achieve co-benefits for sustainability.
4.	Develop multi hazard early-warning systems to anticipate and reduce the impacts of disasters and cascading risks across timescales.
5.	Develop integrated information systems to monitor the depletion of natural resources ahead of dangerous thresholds to support anticipatory action and prospective risk reduction.
6.	Evolve traditional risk assessment and improve methods for risk identification, mapping and reporting as to increase transparency, and as key inputs for early warning, risk management and infrastructure siting and design.
7.	Pilot new ways of communicating risk information and its implications for risk management and sustainable development.
8.	Develop a cadre of genuinely transdisciplinary professionals to expand the interface between science, policy and practice.

1

Introduction

This report from the International Science Council (ISC) is a contribution on behalf of the Scientific and Technological Community Major Group to the Mid-Term Review of the Sendai Framework led by the UN Office for Disaster Risk (UNDRR). It has been created by an interdisciplinary expert group appointed by the ISC with expertise in an array of risks as well as governance, physical and social sciences, policy, and finance.

The report identifies developments and achievements in disaster risk reduction (DRR) in line with the goals of the Sendai Framework and highlights key implementation gaps. It is not a detailed review of Sendai but an attempt to provide guidance for a post-2030 governance framework, which should integrate risk reduction as a key determinant of sustainable development and help policymakers, funders, international organizations and other stakeholders who shape the way we assess, value, manage and monitor risks.

The team hopes the report will accelerate the implementation of the Framework and embed risk reduction and resilience building more holistically in other global agendas such as the SDGs, the Paris Agreement on Climate Change, the Global Biodiversity Framework, which also address the drivers of risk.

Ultimately, the Group's goal is to improve risk reduction and risk management in preventing disasters.

Since 1990, there have been over 10,700 disasters worldwide, affecting over 6 billion people. Floods and storms accounted for 42 percent of these events and 50 percent of the people affected (Figure 1). The worst year was 2002, when a severe drought in India and a series of droughts, storms and floods in China affected 658 million people. Earthquakes are the deadliest disasters, accounting for 50 percent of all disaster related deaths since 1990.

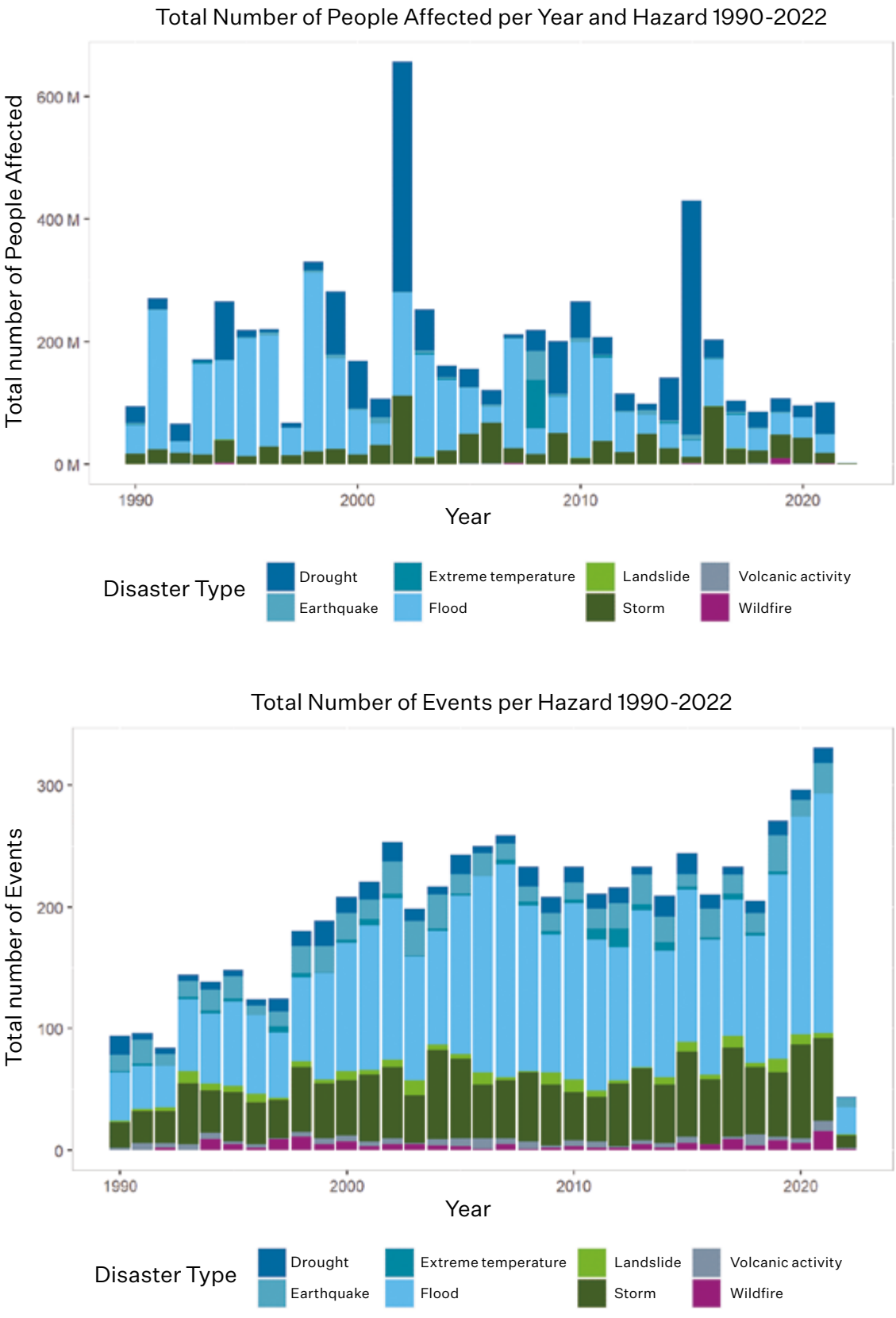

Figure 1: **Global hazard situation 1990-2020**

Source: T+TI, 2022 (Based on EM-DAT data 2022. https://www.emdat.be/, last accessed June 2022)

In 2021, the Emergency Event Database (EM-DAT) recorded 432 disastrous events related to natural hazards worldwide. These accounted for 10,492 deaths, affected 101.8 million people and caused approximately US$252.1 billion in economic losses. However, little is known about the long-term impacts of disasters as they filter through economies, communities and ecosystems.

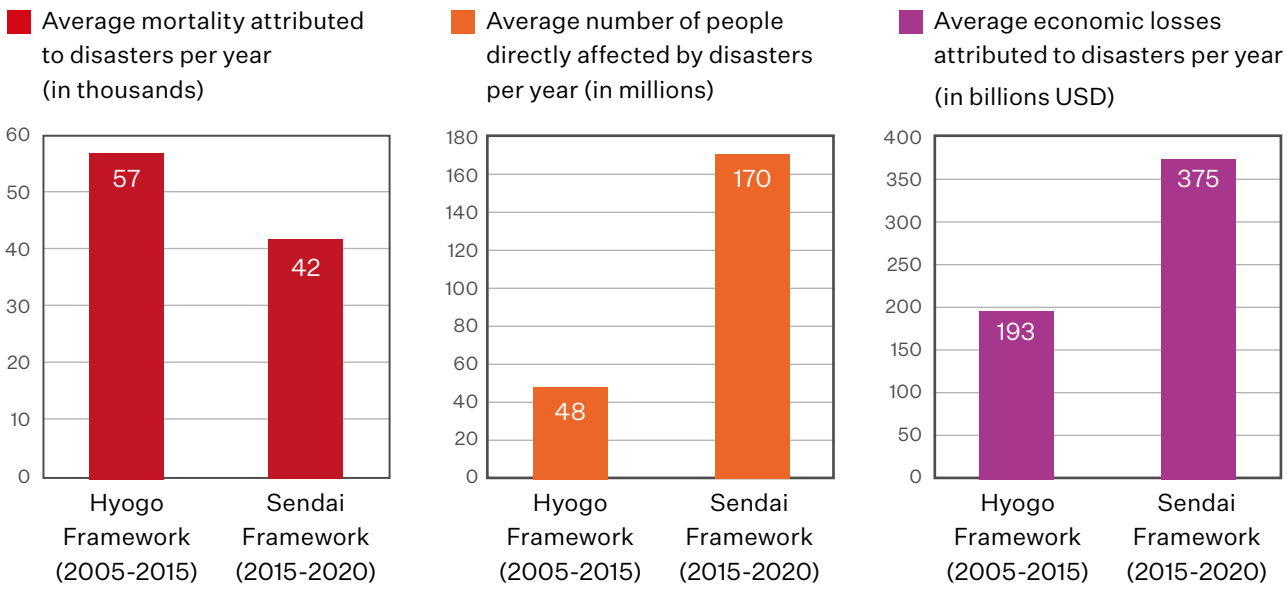

Figure 2: **Global estimates of mortality, people affected and economic losses over the period of the Hyogo Framework and first years of the Sendai Framework.**
Source: Sendai Framework Monitor, based on data reported by countries in early 2022.

As shown in figure 2, the trend is an increase in the number of people affected by disasters and in the economic impacts of disasters, while mortality has decreased.

Under the Hyogo Framework of Action (HFA) 'era', effort was directed to understanding risk and mainstreaming disaster risk management into national agendas. The Sendai Framework is designed to evolve this view by working at all levels, simultaneously. It encompasses a range of natural, technological, biological and environmental hazards and aims to end the 'era of hazard-by-hazard risk reduction.'

The authors of this report take the view that risk must not fall to any single institution, sector or global framework, but should be a shared responsibility. Success can only be achieved through the synergistic implementation across key global agreements, rather than through a single mechanism alone.

II

Review of the Sendai Framework (2015-2022)

A. ACHIEVEMENTS SUPPORTING THE SENDAI PRIORITIES

While it would be simplistic to attribute achievements in DRR to any single standard, actor or initiative, The Hyogo Framework for Action and Sendai Framework have underpinned major positive developments:

1. A significant global reduction in deaths from disasters involving hydrometeorological hazards, which can be attributed (largely) to improvements in early warning systems and overall disaster response capabilities (WMO, 2021).

2. A significant advance in reducing risk to critical infrastructure such as schools and health care facilities (UNDRR, 2022) in countries such as Colombia, Chile, Mexico, Nepal and Tonga, where major advances in retrofitting and structural and functional security have been implemented.

3. The growth of insured assets in the face of rising economic loss related to disasters. According to SwissRe, close to 45% of disaster-related losses at a global level in 2020 were insured, a growth from 40% of insured loss over the period of 1980-2018 (UNDRR, 2022). However, disaster insurance cover remains very low in many developing countries. For instance, insurance has covered just 7% of aggregate economic losses from flood events in emerging markets in the last 20 years, compared to 31% in advanced economies (Swiss Re Institute, 2022).

4. An increase in regional, national and subregional strategies for disaster risk reduction. By 2020, 125 countries had adopted disaster risk reduction strategies (UNDRR, 2022).

Beyond these positive developments, it is important to note other progress made and the challenges impeding implementation under the four priorities defined in the Sendai Framework.

Priority 1: Understanding disaster risk

Understanding disaster risk in all its dimensions of vulnerability, capacity, exposure of persons and assets, hazard characteristics and the environment must be the basis for more effective disaster risk management in the future. Paradoxically, while our knowledge of the physical aspects of hazards is increasing, much of that knowledge is not being used effectively or at a scale to ensure robust decision-making beyond emergency responses. Countries still lack multi-hazard risk data on differential vulnerabilities at the required resolutions and cross-domain interoperability problems are hindering proper risk assessment, model characterization, classification and description (e.g., loss estimate models etc.)

Most risk modelling approaches are still inaccessible to risk managers because of financial or contractual barriers. However, efforts are underway to change this, including new open-source approaches such as the Oasis Loss Modelling Framework and initiatives such as the Global Risk Modelling Alliance and the Global Risk Assessment Framework (GRAF), which support a better 'understanding of the changing nature of risk' and of solutions for climate and disaster resilience.

Many development partners help countries improve their disaster risk information. For instance, the Asian Development Bank supported the Government of Bangladesh in promoting the sustainable development of its agriculture, water resources and other sectors by improving stakeholder understanding of their exposure to the variability of climate change and how that exposure combines with other risks and hazards. Significant global efforts have also been made to enhance disaster risk information and assessment. The UNDRR's DesInventar Disaster Information Management System, for example, provides a free open-source service which supports the systematic data collection, reporting and analysis of the impacts of disasters. While disaster damage and loss statistics tend to be dominated by countries or regions with large populations or high value assets, DesInventar provides local information to facilitate dialogue between actors, institutions, sectors, provincial and national governments about risk management. Despite these improvements, 53 percent of countries do not have accessible, understandable disaster risk monitoring that is fit-for-purpose.

While global disaster databases are important, they have biases regarding the types of risk, time span, accounting, thresholds and spatial coverage resolution (Moriyama et al. 2018, Mazhin et al. 2021). These are obstacles to science-based analyses of the drivers, impacts and the effectiveness of DRR policies. Efforts to upgrade the quality, access and utility of disaster data, including disaggregated data by age and gender of human casualties are underway, but this must be accelerated to enable better evidence-based policy making.

Priority 2: Strengthening disaster risk governance

Governance establishes the culture, policies, regulations and processes which form the structure under which an organization and its assets are managed. Though advances have been made in governance, for example, the International Federation of Red Cross and Red Crescent Societies (IFRC) has supported more than 95 countries in strengthening their legislation on disaster risk reduction, much remains to be done. In fact, improving risk governance remains the main challenge to achieving more effective risk reduction.

One of the challenges is the lack of coordination and communication between the scientific community and decision-makers. The science community's call for preventive investment and action is often ignored because of misunderstandings about what constitutes 'acceptable' evidence or how that evidence can be turned into action (or even how to prioritize DRR against other pressing issues). This is a problem, especially in low-income countries, because risk governance often has longer term returns.

Regional, national and civil society organizations are key to improving risk reduction. Evidence shows governance mechanisms which engage public, private and civil society capabilities together promote better, more sustained interactions and capacity building than one-off projects, grants, and post-event relief (e.g., Shaw and Izumi, 2004).

The private sector plays a central role in DRR through risk transfer mechanisms, the provision of goods and services, livelihoods for those at risk, and through the

creation of markets for many aspects of the risks. One example of the private sector engagement in DRR is the strategic partnership called the Private Sector Alliance for Disaster Resilient Societies (ARISE). This is the first systematic effort from the private sector to align their activities with the Sendai Framework for Disaster Risk Reduction (2015-2030) through voluntary commitments. At the time of writing, there were 29 participating national private sector networks across the world. Collectively, these networks represent thousands of companies from every sector. They provide space for capacity building, tools and help disseminate best practice between the public and private spheres including, most recently, around the challenges of COVID-19. Other initiatives include the Insurance Development Forum (co-chaired by the World Bank, UNDP and the finance sector), is executing practical public/private partnerships projects in a number of climate-vulnerable countries in support of the InsuResilience Vision 2025, which aims to lift 500 million people out of the protection gap by 2025.

Box 1: An Example of Public Private Financing

In 2006, the Cabinet Office of Disaster Preparedness and the Ministry of Finance of Japan created a new low interest loan for companies which are committed to DRR and business continuity management. This scheme was implemented by the government affiliated Development Bank of Japan (DBJ) and continues today. The loan applicant is screened for their disaster preparedness and business continuity management. Those who pass are eligible for the low interest loan. From 2006 to 2021, 421 applications worth 536 billion yen (approx. US$412 million) were made available for seismic retrofitting of warehouses, factories, railways, bus terminals etc. DBJ provides advice to the recipient companies to refine their business continuity management. Shiga Bank, a local bank, created similar special loans in their operational economic areas.

There are however unanswered questions about the sustainability and effectiveness of the voluntary efforts of the private sector, which need further independent evaluation. The private sector must acknowledge and engage in supporting public sector initiatives, including resilient infrastructure development, from which much of their downstream benefits are developed (Mazzucato, 2011).

Priority 3: Investing in resilience

Investments in DRR minimize the loss of life and assets, improve socio-economic and environmental conditions, enhance human well-being and boost the resilience of countries and communities (e.g., IPCC 2012; GCA 2019). The GCA estimates that US$1 trillion in the incremental cost of making infrastructure more resilient in developing countries would generate US$4.2 trillion in benefits (GCA, 2019).

Increasingly, multilateral banks are backing climate change mitigation and disaster and climate resilience schemes, including through investments in nature-based solutions. For example, the World Bank, IDB and CAF (Andean Bank), are funding nature-based solutions projects to better address hydrometeorological hazards and the CAF has allocated US$25 billion in 2021-2025 for green solutions. However, the limited technical and financial capacity of local governments remains a major barrier to private sector investment in DRR and funding for preparedness. There is an urgent need to remove barriers which deter private sector support for risk reduction.

Priority 4: Enhancing disaster preparedness and 'Building Back Better'

Numerous governments and other actors support communities to prepare for disasters and encourage them to use 'Build Back Better' (BBB) principles in the recovery and reconstruction phase of physical and social systems. It is essential to strengthen communities' ability to act as first responders. For example, USAID has supported the local, national and regional disaster response capabilities in the Latin America and the Caribbean (LAC) region by training over 70,000 emergency disaster responders to provide timely and effective assistance to people in need. This approach helps in raising awareness of a community's exposure to hazard, prompts improvements in housing and creates a risk reduction culture. However, at the end of 2020, only 50 percent of countries had BBB plans in place and, it is unclear how many of these plans are implemented and evaluated.

Unfortunately, BBB activities can appear expensive in terms of upfront costs and require technical expertise which deters their use. Many smaller scale investments focused on behavioral change or biodiversity conservation in partnership with

local communities can be backgrounded in favor for large visible, technological and structural interventions which may be difficult to sustain. To move forward, governments and development organizations should explore inexpensive or alternative (but effective) options to make local communities resilient to future hazards and support synergies with the Paris Agreement, the New Urban Agenda, and SDGs.

B. RISK, VULNERABILITY AND THE EVERYDAY

Smaller-scale events, which typically fall below the radar of national authorities and the international community, such as floods, landslides, and droughts, do not receive the same visibility, or recovery assistance, as larger ones, leaving people in positions and places of risk (Hewitt, 1983; Albala Bertrand, 1993; Wisner et al 2004; IPCC 2012).

For these people, the cumulative impact of small-scale events is a constant source of loss. In the LAC region, these small-scale events represented 99.7 percent of events recorded between 1990 and 2013.-To move forward, we must recognize that integrating an understanding of the cumulative impacts of 'so-called' small-scale events, (also referred to as extensive risks), will be central to preventative success and reducing intensive risks i.e., the risk from larger events. The process of development in creating risks is open-ended and the interventions points for building resilience change over time (Albala-Bertrand, 2013).

C. TECHNOLOGICAL CHANGE AND DRR

Recent technological advances have strengthened disaster risk reduction, humanitarian interventions and emergency actions. Early warning systems have been applied to many hazards, including earthquakes (Allen & Melgar, 2019), landslides (Guzzetti et al., 2020), rain flash flood (Acosta-Coll et al., 2018), and drought (Funk et al., 2019; van Ginkel & Biradar, 2021). Emerging technologies are also being deployed for disaster risk education and emergency response, for example, machine learning in earthquakes engineering (Wang et al., 2021), forecast-based financing (Bryant, 2022); participatory mapping and crowdsourcing (Nonnecke et al., 2017); and drones (Poljak & Šterbenc, 2020; Rejeb et al., 2021).

These ‘humanitarian technologies’ have facilitated access to information, improved processes and provided infrastructure during humanitarian crises. They have also enabled information to flow to vulnerable groups and furthered their participation, improving inclusiveness is an important and continuing challenge for these technologies (Bryant, 2022). Their continued use is promising, although the energy and mineral requirements associated with new technologies are a growing cause of environmental concern (IEA, 2021).

D. BUILDING 21ST CENTURY INTEGRATED MULTI-HAZARD EARLY WARNING SYSTEMS

Initiatives such as World Meteorological Organization’s (WMO) Global Multi-hazard Alert System (GMAS) have increased the availability of authoritative warnings and information about extreme and high-impact events. Catastrophic events, such as the Indian Ocean tsunami in 2004, have triggered regional programs for building resilience. Both these initiatives have been highly successful. As a consequence, while the world suffers more extreme hydro-meteorological events than before, fewer people are dying. The Global Center on Adaptation has suggested a 24-hour storm warning can cut damage by 30 percent. Investing US$800 million on such systems in low-income countries could avoid US$3-16 billion per year in losses alone and suggests early warning systems (EWS) can generate a tenfold return on investment. Yet still only 70% of countries have early warning systems and, of these, the number and extent of fully functioning systems is not well-documented.

There are challenges to developing better Multi-Hazard Early Warning Systems (MHEWS), however, including the development of robust social and environmental data collection systems at national and local scales, statistically consistent frameworks and improving cross domain interoperability between diverse environmental datasets and institutions. Nevertheless, technological advances can improve the data available for forecasting and early warning systems (Enenkel, 2020), including through the coordinated collection of data via social media and the analysis of crowdsourced data.

Moving EWS from a single event to an end-to-end impact-based system which recognizes the complexity of disasters is a major priority. Recently, practitioners

and researchers have converged on ten essential components that constitute comprehensive or integrated early warning information systems (Fig 3 below), which could provide the basis for a new integrated approach to early warning systems. While acknowledging that there are challenges in developing, financing and sustaining fully people-centered systems for complex risks, Figure 3 illustrates the critical benchmarks that need to be met for such systems.

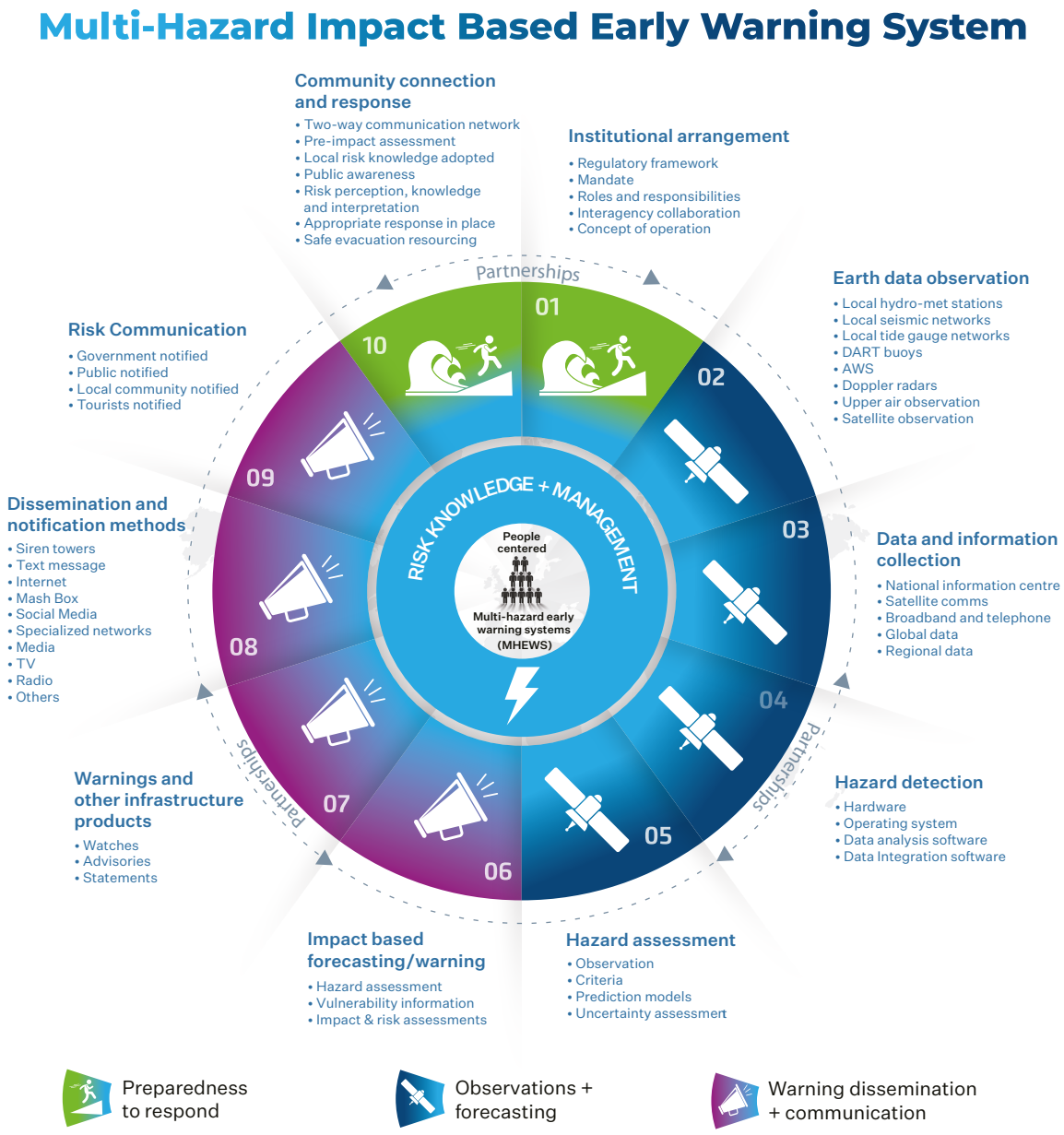

Figure 3: ***End to end impact based early warning system.***
Source: Fakhruddin, 2022. Modified from Fakhruddin & Schick, 2019.

This shift would create a single integrated information system which recognizes that disasters are complex events and can occur simultaneously (or sequentially) with other disasters, for example, earthquakes can trigger landslides or storms can result in flash flooding.

Fakhruddin et al 2020 advocate designing early warning systems as a comprehensive integrated information system which align subsystems on monitoring and forecasting of diverse phenomena, impacts and risk assessment, communication, engagement to inform practice in places at risk, and risk evaluation. Such an approach resonates with a modern view of integrated information systems as being more than just a forecast or a projection and a website. A data ecosystem is critical to ensure a stable transition from the response to the recovery phase, where communities feed information into, for instance, the public health system, and the feedback loop offers a fast and direct way to provide people with details of potential actions they can take.

'Leaving no one behind' requires that MHEWS reach people at risk and displaced people, enabling them to take anticipatory action. Greater investments in early warning linked to social protection would support a country's capacity to provide targeted support to its most vulnerable populations in the event of disasters. Social protection is concerned with preventing, managing, and overcoming situations that adversely affect people's well-being. MEWS designed with the complex and cascading nature of events in mind will contribute to protection and identify windows for anticipatory action taking into account different time scales and demand different responses depending on each situation.

The COVID-19 pandemic has shown the need for multi-hazard assessment and preparation (Potutan and Arakida, 2021). Such multi-hazard assessments can point to how different hazards interact and produce compounding impacts and the development of common protocols for communication of risks. Communities should be part of the MHEWS as observers of thresholds because sufficient equipment for them to monitor hazards may not be available or may be too expensive otherwise.

Because many countries do not have the expertise or resources needed to conduct integrated analysis across hazards, a case will have to be made for up front prospective risk reduction at different scales. Also, early warning systems should

be supported by multi-hazard maps that should include information on population exposure, but also data on the sensitivity and adaptive capacity of a population, so multi-risk hot spots are better targeted for DRR and resilience activities.

E. LIMITATIONS IN MEASURING OUTCOMES

The availability and reliability of data are the bedrock of effective risk reduction and resilience. But studies and experience show there are disconnects in the data which means an incomplete understanding of disaster risk reduction and with opportunities for learning and prevention being missed. For example, the global standard post-disaster needs assessment (PDNA) methodology originally developed by the United Nations Economic Commission for Latin America and the Caribbean, now covers 18 social, infrastructure, productive and cross-cutting sectors, with additional technical guidelines in areas such as gender and integration of conflict sensitivity. However, too few PDNAs post-disaster are completed each year, despite the significant benefits of doing them to inform recovery and expand the understanding of systemic risk over time and sectors.

The development of relevant indicators which can measure progress against the outcomes of vulnerability reduction and resilience building are also key in driving positive change. There is a need for evidence-based integrated assessments of economic, social, and environmental components of vulnerability to gauge progress towards meeting the Sendai Framework and the SDGs, but the development of more robust comprehensive indicators remains a challenge. For instance, the Multi-dimensional Vulnerability Index (MVI) may helpfully support the case for increasing aid to Small Island Developing States (SIDS), based on their economic vulnerability. However, expanding the current MVI without reformulating it will not achieve a robust empirically-based measurement of vulnerability, as it does not measure the multi-dimensional nature of vulnerability as presently understood in disaster research or practice.

III

Shifts in context and Lessons identified

A. THE CHANGING NATURE OF RISKS: STRUCTURAL AND SYSTEMIC RISKS

Systemic risks are inherent in all social, technical, financial and ecological systems which themselves are highly interdependent. These risks can be created by changes in human and natural systems (Centeno et al.; Keys et al). Systemic risk can be endogenous to, or embedded in, a system that is not itself considered to be at risk and, therefore, is not tracked nor managed. Systemic risk lacks both the two main characteristics of conventional risk: a well-defined event space with known probabilities and sufficiently well-defined utility indices (Lucas et al 2018). Systems can contain latent or cumulative risks with the potential to impede overall system performance when some characteristics of the system change (UNDRR 2019; UNDRR 2021b) and can be characterized by non-linear cause–effect relationships and unknown tipping points. If those tipping points or thresholds are exceeded, catastrophic change can lead to a new regime (Holling 1986; Holling et al 2002; Renn, 2017). Such non-linear changes can be partially projected, but often contain an element of surprise challenging conventional risks assessments and risk management (Wassenius and Crona, 2022; Levin et al., 2013). Data gaps, organizational silos, and political tensions during crises also pose challenges as decision-makers and others try to cope with the repercussions of non-linear changes and risks (Galaz et al., 2011).

While nature and its co-evolution with human development can be viewed as a complex adaptive system, observing and modelling its nonlinear behavior remains challenging and contested (Norberg et al., 2022), despite growing access to data and theoretical advancements (Dakos et al., 2015; Rocha, 2022). While some systemic risks can be traced, others cannot. They escape monitoring and unfold with limited attention from policymakers. Decision-makers, too, tend to underestimate the social and economic risks resulting from such abrupt shifts in ecosystems and key biomes (Crona et al., 2017; Dietz et al., 2021). Though solutions exist (Díaz et al., 2019), their current rate of implementation is not matching the rate of biodiversity loss (Cumming

et al., 2006), the vulnerability of critical ecosystems and other existential threats stemming from the expansion of the human enterprise (Folke, 2021).

B. FACTORS UNDERMINING RISK REDUCTION

Environmental degradation is a major driver of disaster risk. Healthy ecosystems contribute to disaster risk reduction (DRR) as provisioning, regulating, habitat and cultural ecosystem services reduce vulnerability (MEA 2005). The implication of disaster-related losses of ecosystem services for DRR are not well defined, limiting the identification of effective entry points for interventions (IPBES, 2019; Walz et al. 2021).

The IPBES Report (2019) finds the global goals for sustainability cannot be met on current trajectories. The current negative trends in biodiversity and ecosystems functioning will undermine progress towards 80% of the assessed targets of the Sustainable Development Goals – in particular poverty (SDG1); hunger (SDG2); health (SDG3); water (SDG6); cities and communities (SDG11); climate (SDG13); oceans (SDG14) and land (SDG15). Loss of biodiversity is thus not just an "environmental" issue but also a developmental, economic, security, social and moral question. Statistically consistent indicators are needed to monitor and act on the links between reductions (i.e., submerged risks, in natural and social capital) and shape how hazards become disasters. Such indicators could identify resource extraction, externalities and other uses of the environment, which exceed the environment's capacity to disperse, absorb, recycle or otherwise neutralize harmful effects.

Other factors undermining comprehensive approaches to risk reduction speak to broader development trajectories and social cohesion.

- Globalization means increased connectivity and networked risks. Such connections are part of a growing understanding of telecoupling (Liu et al. 2013) and systemic risks. For a long time, these connections have been viewed as an emergent property of increased global flows of people, materials, and information (Folke et al. 2019; Keys et al. 2019) but have now become increasingly 'weaponized' as part of growing geopolitical tensions. The war on Ukraine and the intended disruption of financial, supply chains, information and energy infrastructure, is a clear example of how global connectivity can be exploited

to advance national security interests thereby increasing risks to people. The resulting food and energy insecurity and its impacts on the world's most vulnerable is evidence of this phenomena (Farrell and Newman, 2022).

- The costs of COVID-19 combined with food and energy inflation related to the war on Ukraine has created an economic crisis for the Global South. Many low-income countries have been forced to cut budgets, while watching their sovereign debt grow which, in turn, is likely to reduce their ability to invest to reduce social vulnerabilities which generate risk.

- The erosion of democratic institutions, the undermining of Free Speech, the rule of law and poor transparency and accountability, such as in building code implementation, are harming the ability of communities to build resilience. Disaster risk governance has progressed through multilateral institutions, cooperation and action. Now with support for these institutions and values is in decline in some areas, further progress could stall.

C. DECISION-MAKING IN CONTEXTS OF UNCERTAINTY AND COMPLEXITY

'Predict-then-act' approaches, which rely solely on projections, can introduce a spurious sense of rigor and blinker decision-makers to the potential for event thresholds (e.g., rapid drought intensification after slow onset, freezing and soil saturation during floods) and surprises (Lempert et al 2018). The disaster risk management community would benefit from designing new knowledge frameworks, which acknowledge and address uncertainty as an intrinsic part of the evolution of knowledge, instead of trying to eradicate it. Long term and sustained observation programs are critical, especially to verify models and the magnitude of events.

Recognizing complexity and uncertainty requires the use of flexible adaptive approaches which accommodate new information and avoid system "lock-ins". Factoring resiliency and redundancy into system design and planning remains the safest approach.

The predominant epistemic framework for disaster risk management relies on the assumption of rational responses to new knowledge sets. Unfortunately, it has been recognized for some time that human decisions are not based just on rational factors.

Decisions about risk are often modified by elements which are not always considered in current decision-making processes, for example:

- Disaster risk and danger are not the same for everybody. Policymakers and providers of disaster risk reduction products and services to communities undervalue how risk perceptions, including cognitive biases, influence decision-making. Technical and scientific recommendations face political adjustments based on non-scientific criteria and imperatives.

- Millions live at high risk of disaster in order to access labor markets near urban agglomerations and earn a living. As Lavell (2019) points out, disaster risk cannot be fully understood if we do not consider opportunity and potential gain for select actors.

- New levels of misinformation, disinformation and fake news (or 'Infodemics' as it was called by the World Health Organization (WHO) destroys trust and damages risk prevention and response. Improved information flow such as between the public health system and the community is necessary for effective recovery. Building meaningful stakeholder trust is critical for DRR management.

- Research and policy on systemic risk has focused principally on the resilience of financial systems, global supply chains and strategic economic infrastructure. Far less attention has been paid to how systemic risk manifests and materializes at the local or subnational scale in low- and middle-income countries and communities.

D. ADVANCING THE UNDERSTANDING OF THE ECONOMICS OF DISASTERS

Economic rate of return tools place greater weight on the short rather than the long term, nudging difficult budget allocations towards other investments and disincentivizing politicians from investing in long-term resilience. Private sector investment opportunities in DRR are further constrained by limited income generating opportunities.

As a result, the bulk of disaster spending occurs post disaster in response to the immediate need to alleviate human suffering and restore livelihoods and economies. The OECD Development Assistance Committee data demonstrates that of the US$140.9 billion provided as official development assistance (ODA) to developing

countries for disaster-related purposes from 2011 to 2022, only 5.2% was provided for DRR and preparedness with the rest for disaster relief and reconstruction (OECD DAC, 2020). We must urgently realign the focus of spending from response to risk reduction to use public and private resources more effectively. A dollar spent on risk reduction can avert much greater future spending on response.

Governments and the private sector need to better quantify and disclose their contingent disaster liability as a basis for reducing risk. For the private sector this means extending the advances made since the establishment of the Task Force on Climate-Related Financial Disclosures in 2015. Likewise, individuals and communities need to 'own' their risk and accept some responsibility for its management.

The assessment of contingent liability is also a key starting point for the development of comprehensive financing required to manage residual risk. The timely availability of adequate financing for post-disaster purposes limits the socio-economic damage of disasters and aids 'Build Back Better'.

Efforts to strengthen financing arrangements for disaster response have continued under the Sendai Framework with notable innovation and scaling up in areas such as anticipatory action and regional risk pooling including the expansion of the Caribbean Catastrophe Risk Insurance Facility and African Risk Capacity. Global initiatives to support enhanced residual risk financing have also sprung up, notably the InsuResilience Global Partnerships launched at COP23, the Insurance Development Forum launched in 2017 and the Global Shield Financing Facility (GS-FF), launched at COP27.

However, global efforts to ensure adequate financing arrangements will fall short of their objectives (and leave communities struggling), if efforts to address underlying risk are not addressed. For example, 1-in-25 properties in Australia are forecast to be uninsurable by 2030 due to the prohibitive cost of insurance premiums or because cover will not be offered (Climate Council, 2022).

Dedicated investment in risk reduction is required. In the past 30 years, there has been an emphasis on mainstreaming disaster resilience measures into other investments. However, this approach will not deliver the scale of investment required. DRR funds and financing mechanisms, such as matching grants, must be set up by governments and

development partners, like the additional earmarked grants the Asian Development Bank has provided to its poorest member countries since 2016.

Even with dedicated financing instruments, resilience funding will remain tight in the future given rising disaster risks, other urgent competing demands for limited development financing, and, in the nearer term, the global economic downturn in many parts of the world linked to the COVID pandemic and the war on Ukraine. So, innovation and learning to do more with less will be key. Resources should be focused on established priorities and follow a multi-hazard approach in order to utilize resources cost-effectively and deliver on resilience and other development gains simultaneously.

The World Bank highlights the need to invest more (and more effectively) in infrastructure by 2030 because infrastructure influences up to 72 per cent of all SDGs (Thacker et al 2019). It suggests investing 4.5 percent of GDP in low- and medium-income countries would achieve SDGs 6 and 13 without raising the global average temperature by more than 2°C. If investments in recovery and post-disaster reconstruction were redirected, in the next decade some countries could meet all of their needs for drinking water and sanitation or allow other countries within a region to come very close to meeting their targets in the Sustainable Development Goals (SDGs). However, currently, regional efforts do not fully incorporate disaster risk reduction into the conception and design of public and private investments.

Box 2: Embedding DRR in public investments

An effort has been made in Ecuador (2019) to include DRR into the conception of public investments. The Planning Secretary of State has included two mandatory tools within the Territorial and Development Plans (PDOT in Spanish) submitted by elected majors. One accounts for Climate Change Adaptation and Mitigation, and the second for Disaster Risk Reduction. They provide criteria for adaptation to climate change and the actions required for implementing risk assessment in their administrative area, urban and rural, identifying their hazards exposure and risk levels. As a result, investment projects submitted for funding and implementation must have embedded actions for DRR. It is expected that if the Organic Law for Disaster Risk Management is approved in 2023, extra funding will be available for DRR from 2024 and the extra funding will be tied to the PDOT.

E. BARRIERS TO SYNERGIES BETWEEN DISASTER RISK REDUCTION AND CLIMATE CHANGE ADAPTATION

Very few countries have a multi-sectoral approach to the drivers of risk. Moreover, progress in implementing national and sectoral policies through budgetary mechanisms and intersectionality has been limited because of:

- Fragmented responsibilities: Ministries or agencies overseeing Climate Change Adaptation (CCA) and DRR at the national level do not always co-ordinate policy agendas (Seidler et al., 2018). Both CCA and DRR need to be mainstreamed across sectors and through local planning processes.

- Different funding structures: Funding mechanisms for CCA and DRR are spread across institutions and levels of government, so planning and implementation can be constrained by the scope of the funding organization causing further silos. At the international level, the Sendai Framework does not have a dedicated funding mechanism, unlike the United Nations Framework Convention on Climate Change (UNFCCC) which has the Green Climate Fund (GCF) and the Global Environment Facility (GEF) as the operating entities of its Financial Mechanism.

- Data availability and use: Despite progress in data availability and climate- and disaster risk-related modelling, finding information or making projections with sufficient accuracy using data which is downscaled to the sub-national level remains a severe challenge (Seidler et al., 2018). Similarly, scaling up local information to coordinate across watersheds and regions is challenging.

- Poor coordination: In low-income countries, there is a need for greater development co-operation in support of CCA and DRR. For instance, urban management remains fragmented because it is based on political and administrative boundaries which are inconsistent with how cities function or with strategic and long-term planning. This causes a lack of coordination between jurisdictions, political conflicts between decision makers, inefficiencies in infrastructure operations, a failure to utilize economies of scale, inequities in the provision of public services and delays in decision-making on climate change mitigation strategies.

- Limited participation: The participation of civil society and science and technology institutions in the design and implementation of risk management policies remains limited. There must be greater coherence and deeper partnerships between CCA and DRR than there is now.

IV

Bridging the knowledge to action gap

A. BUILDING THE FOUNDATION FOR WHOLE OF SOCIETY APPROACHES TO RISK REDUCTION

How information is perceived and used by decision makers (or influences decision-making) is affected by a variety of factors (e.g., trust, credibility, authority). It can be lost quickly if it appears "manipulated" or if it manifests a construal gap on what is important. It is not dominated by one set of factors (e.g., format) or defined by a single perspective (e.g., organizational) and is heavily dependent on both the user's and the information provider's pre-existing knowledge, beliefs and joint experiences.

Many risk studies fail to address the key issues of representation and power asymmetries i.e., who participates (and what values, interests and broader consequences of use they represent), and who is left out or marginalized. Different perspectives compete in processes of transformation, rooted in different world views, mandates and knowledges/ontologies. Trust is founded on capabilities which include rational factors (credible, accessible, and relevant information), and procedural ones (processes for equitable engagement and capacity building), and, in the personal sphere, affinitive and pre-dispositional frames.

Much has been written about the first two forms, especially in the context of co-production. Song et al (2019), Stern and Coleman (2015) and the experience of this report's team recognizes that affinitive trust built through informal, long-term relationships, as well as respect and shared experiences is often absent in many analyses but remains significant for influencing and improving decision-making.

One example of a co-development approach is the 'Medicine Wheel' of the Keeweenaw Bay Indian Community (Fig 4 below) where reverence, respect, responsibility and reciprocity are the boundary conditions for transdisciplinary analyses and partnerships (Shaw et al 2022). The guidance aims for balance between

and among what the Keweenaw call the four seasons (of research): relationship building; planning and prioritization; knowledge exchange; and synthesis and application. Research partnerships with/by/as the Community demonstrate respect for each other's differences, honor reciprocity in actions, exemplify responsibility for differing commitments, and express reverence for shared lands, waters, and living beings. The wheel illustrates how indigenous knowledge can offer much beyond "local" information including insights on balance and respect, which shape human interaction with the environment and each other, in more than transactional ways.

The Medicine Wheel is a practical concept to illustrate guidance with/by/for research partners - it is an interconnected system of teachings relating to seasons, directions, elements, and the cyclical nature of life.

Beginning in the East and moving clockwise, it aims for balance between and among time, space, and all beings, a balance that is sustained when permission and consent are sought.

Research partnerships with/by/for the Community demonstrate respect for each other's differences, honor reciprocity for each other's actions, exemplify responsibility for individual, organizational and community commitments, and express reverence for shared lands, waters, and all living beings.

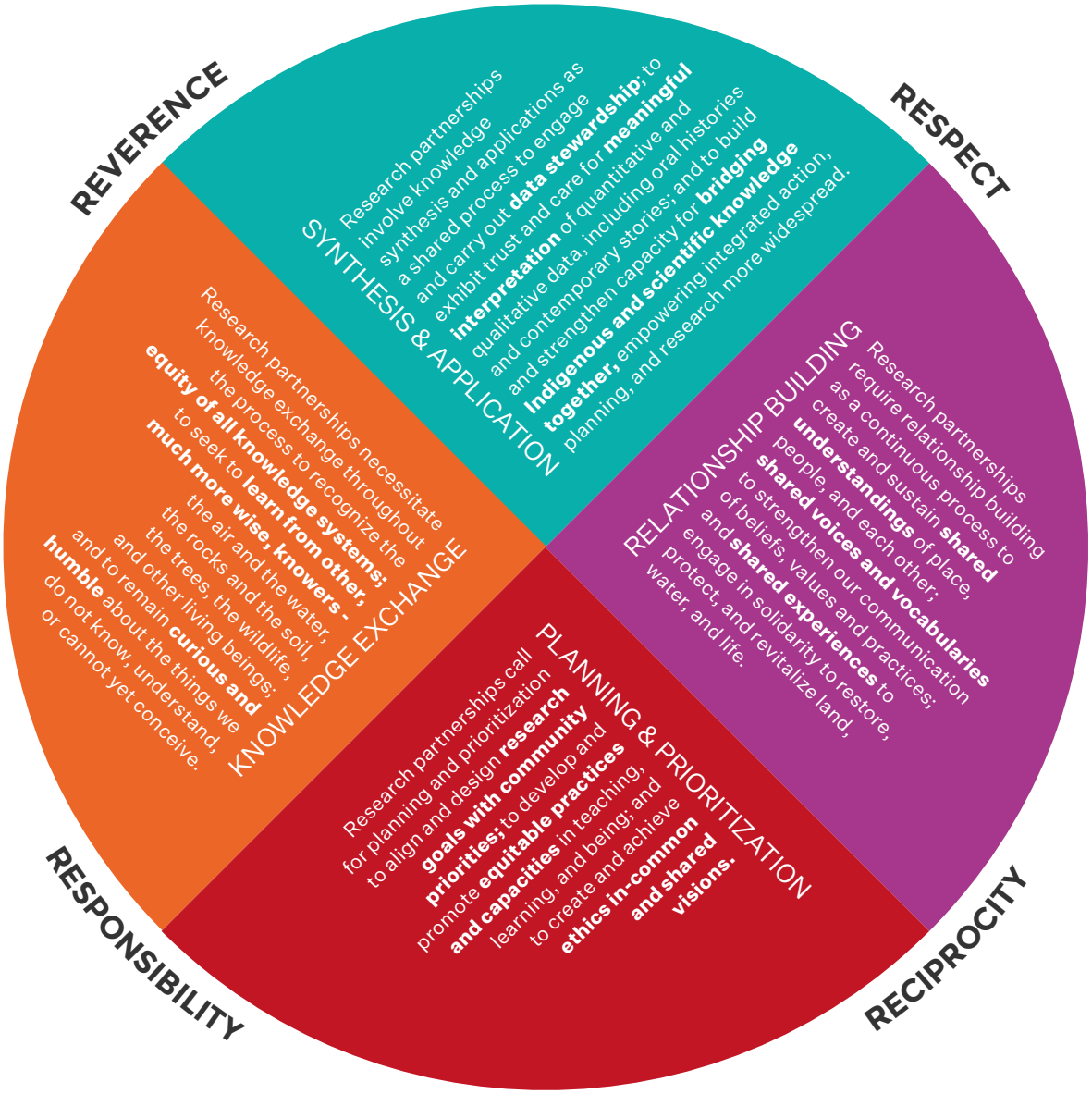

Figure 4. ***The Medicine Wheel of the Keweenaw Bay Indian Community.***
Used with permission from the Keweenaw Bay Indian Community Natural Resources Department

Unfortunately, limited program resources and the practice of rotating staff who may not have the background and social capital built over time with communities, undermines trust and weakens engagement with co-production projects (Song et al 2019). While important, the barriers to expanding transdisciplinary approaches to science are not just financial or transactions costs in time, they also entail professional risks, especially in settings where use-inspired research and services provision are viewed as secondary to traditional academic career paths (Clark et al 2016; Pulwarty et al 2023).-

Another challenge is the lack of enabling capabilities and transdisciplinary professionals. These deficits are happening despite the growing demand for co-developed knowledge and experience and results in minimizing system complexity and the need to foster

transformative responses. There is a need for a cadre of dedicated professionals, not just short-term internships and rotating contractors, who understand and expand the interface between science, policy and practice and are a force to promulgate use-inspired research (Stokes 1997; Pulwarty et al 2009; Dietz 2013, Bednarek et al. 2018).

Clark et al (2016) show that academic credentials may have little meaning or traction in contexts where knowledge is trusted because of personal connections or customary status. Therefore, this report supports the need for new trans-disciplinarians who will operate most effectively with knowledge 'of' the policy process combined with knowledge 'in' the policy process to enable the capabilities of stakeholder communities themselves (Healy and Ascher 1995; UNDRR 2021a).

B. TRANSDISCIPLINARY APPROACHES AND CO-DEVELOPMENT AS A PROCESS

'Transdisciplinary' approaches are 'iterative and collaborative processes involving diverse types of expertise, knowledge and actors to produce context-specific knowledge and pathways towards a sustainable future' (Norström et al. 2020). Transdisciplinary co-development contains processes, such as expert facilitation among different actors and partners (e.g., boundary spanning) from the start of a project, which brings partners together to work collaboratively, and also weaves together different norms and knowledge systems. They differ from conventional knowledge production, where expertise is tightly bound by discipline-specific methods of analysis. Instead, transdisciplinary approaches promote analysis from multiple perspectives, which is especially important in the face of fast-moving or uncertain evidence, and are critical for addressing the complex problems involved in disaster risk management (Norström et al. 2020).

Around the world, pockets of progress in piloting and implementing transdisciplinary approaches offer guiding principles and support options (Tseng, Bednarek and Faccer 2022). These converge on longstanding lessons from the policy sciences and on approaches which are multi-method, contextual, problem oriented and iterative. Promising transdisciplinary practices have been used by the disaster risk reduction community through partnerships such as LaRed. Several resource banks offer critical tools, (such as a handbook developed by the German organization MeerWissen), focused on ocean research co-production or the online research partnerships resource bank developed by the William T. Grant Foundation in the U.S. for education co-design.

Driving positive change through knowledge requires understanding the conditions governing the continuity or transformation of systems and decision-making structures as learning takes place (Pulwarty et al 2023). An agile, flexible approach is an advantage in an environment where changes in scope in response to feedback are to be expected (Buontempo et al 2018).

Ehrlich and Levin (2005), Kinzig et al (2013) and others note that policies will be most effective if they can stimulate long-term changes in beliefs and norms which create and reinforce behaviors which extend the public good. Transdisciplinary professionals in this space are actors skilled and committed to promoting, structuring, and enabling the normative foundations for partnerships. They play instrumental roles in facilitating partnerships and sense-making in which social learning, joint visioning, and shared values and agency are developed, and in signaling, by making desired behaviors and outcomes more visible (Pulwarty et al 2023). More than 'knowledge brokers', are catalysts, champions and integrators who help to overcome the impediments to the flow of knowledge, policies and practices which create failure in a system and other barriers to learning and institutional innovation.

C. THE ROLE OF CULTURE IN POST-DISASTER RECOVERY

A community's relationship with its environment shapes how it responds to change and how it chooses to adapt. The ways communities anticipate and respond through cultural practices can become core parts of their DRR preparedness, a reminder of what they must or must not do when emergencies arise. A community's ability to respond depends also on its perception of disaster. Research shows people begin to forget about past disasters (or reduce their preparations for future ones) after only two generations unless new hazards are experienced, which underscores the importance of nurturing cultural and collective memory of these events.

Historically, disaster management has not used this cultural component to gauge what might be the most applicable system or to decide how best to integrate their services into a particular community. But it is clear cultural expressions can give us a deeper understanding of how communities can best be supported and offer a shared vernacular to help communities access much needed information and aid their buy-in to risk reduction and recovery schemes.

An example of this is the 2004 Indian Ocean tsunami which hit Indonesia. Communities which had previous experiences of tsunamis (captured in their local cultures through stories and songs) knew how to prepare. Simeulue, where only seven died in 2004 out of a population of 80,000, had a cultural memory of the 1907 Sumatra tsunami (through the Smong story) which killed 2,000. This was culturally enmeshed intergenerationally with annual practice drills and contributed to the area's quick reaction. Aceh, nearby, saw 150,000 die.

In Japan, a program called 'Ichi-Nichi-Mae (the Day before the Disaster) Project' (initiated in 2005 by one of this report's authors), promotes disaster awareness in seminars using personal stories from a range of people who have been affected by a major disaster. The methodology of this project is published on the Cabinet Office Disaster Management website and is used in Japan International Cooperation Agency (JICA)'s various training courses on disaster reduction. The stories and methodology are now available in other languages to support better risk communication in other regions.

Recent progress in meteorological observation has improved the accuracy of weather forecasts and in the communication of alerts. However, unless people react adequately, these advances are not enough. Motivating people to think about the risks they face and take preventive action remains a major challenge and an area where science and humanities can combine forces. Stories are part the solution to the 'last one mile problem' in disaster reduction.

Culture and cultural reactions, therefore, can function as an important component of how we craft and implement disaster preparedness and understand different approaches to disaster response. Ultimately, this approach will lead to a more equitable, comprehensive, and well received disaster management system. Only when we recognize that nuance is relevant in these scenarios, can we also begin to understand the value of artistic responses in the wake of calamity and how it puts a magnifying glass on our existing practices and the relationship between communities and broader systems.

V

Building 21st Century risk governance and management

Resilience is the capacity to live, evolve and thrive with changing circumstances or abrupt transformation. It includes the capacity to transform to a sustainable future by preparing for and making use of the windows of opportunity that change provides (Walker and Salt, 2006; Folke et al. 2021).

Achieving resilience is not enough, however. Resilience is a first and necessary step for transforming the parameters of the notions of development and well-being. The long-term aspiration must *not just* be to reduce our negative impacts *but also* to enhance the natural protective factors which build resilience so people can prosper and transform out of the material and psychological consequences of disaster risk. To make progress on the Sendai Framework's goals, we must build a new, integrated multi-level governance approach to the drivers of risk to support risk reduction *and* resilience building. The path to achieving this is to develop forms of management which act on root causes, risk drivers and other underlying dynamics and which ensure these are reflected in both planning and implementation. This need has been evident since UNDRR GAR 2009 but has not yet led to commensurate action.

COVID-19 has impacted the way we think about disaster risk management and planning (ECLAC, 2021). The social construction of risk should be considered as a continuous unfolding of risk drivers, factors, scenarios and that their manifestations reflect the dynamics and logic of how development has been pursued. Disasters are moments in this process when risk unfolds and crystallizes at a specific time and place.

The disaster risk management narrative must now emphasize the relevance of moving towards more stable and prospective development conditions i.e., reducing the likelihood of new and emergent risks, especially given the current context of rising global inequality. Similarly, the development agenda must focus on creating capabilities to face shocks, independent of their hazard type and include different interventions as impacts unfold. Simultaneously, efforts should improve resilient

conditions for those without them and establish a more equitable, structural and coherent development.

A. NATURE-BASED SOLUTIONS SUPPORT RESILIENCE

We know that healthy ecosystems reduce the risk of disasters through their ecosystem services (ES). Yet, the impact of disaster-related losses on ecosystems and their services and their implication for DRR are not well understood or acknowledged. Evidence from the literature and Post-Disaster Needs Assessments (PDNAs) related to disaster-related losses from climate-related hazards such as droughts, floods and storms showcases the link between disaster-related losses to ecosystems and their services and the need to integrate this into disaster risk monitoring to get a more comprehensive understanding of disaster-related losses.

The co-benefits of nature-based approaches for risk reduction and resilience-building are significant, in particular, for certain hydro-meteorological disasters (Figure 5 below). The GCA notes, for example, mangrove forests prevent damage worth more than US$80 billion and protect 18 million people from coastal flooding. In aggregate, mangrove preservation and restoration generates 10 times its cost. Novel configurations of land use generate an even larger return on investment than retrofitting alone. These measures require urgent attention and funding.

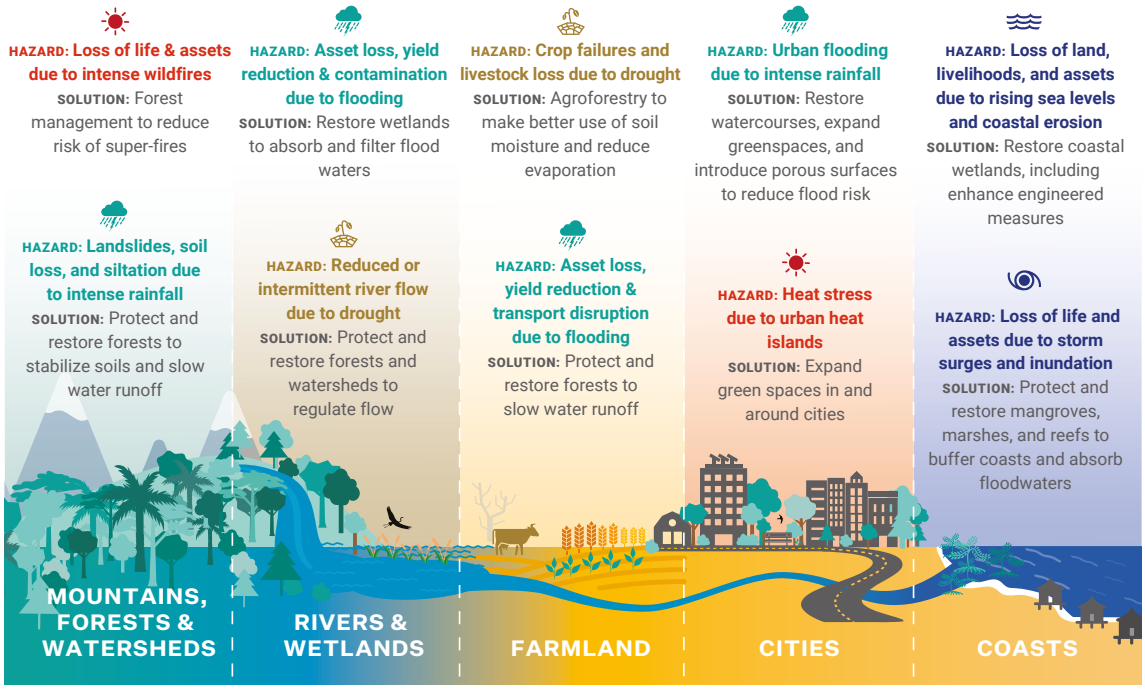

Figure 5: ***How different nature-based solutions can work together across landscapes to build resilience*** *Source:* Global Commission on Adaptation, 2019.

We must acknowledge that theories, norms and belief systems, which treat the biosphere as external to economic and social development underpin behaviors, reduce resilience in a globally connected world.

B. FINANCING

Assets invested with Environmental, Social and Governance (ESG) funds are now estimated at US$35 trillion and are seen as a potential contributor to sustainability (Buller, 2020; Galaz and Collste 2022). However, while these funds appear to be pragmatic tools to fund reduced emissions or reversing ecosystem loss, biodiversity continues rapidly to decline (Buller, 2020). A report to the Stockholm+50 meeting indicated that, in their current format, ESG ratings and most sustainable investment approaches are unable to address the root causes of sustainability problems (Galaz and Collste, 2022). Without a clear benchmark against which to judge the real contribution of a company to a particular equivalence like CO2, ESG investments provide a false sense of progress and are an unverifiable promise of sustainable investments (Crona et al., 2021). Standardizing current ESG metrics without incorporating impact measures will fail to address the issue of accuracy and merely make us more *precisely* wrong.

While well-intended, many financial actions do not deliver as promised or address fundamental complexities and system breakdown (UNDRR 2022; Buller, 2022; Galaz and Collste, 2022). To be effective for economic, social and environmental sustainability, financial capital must accurately represent the actual value of natural, human and social capitals *without* ignoring or minimizing externalities (Stiglitz et al, 2019). Research and experience point to the need to create global and regional coordination mechanisms for aligning innovative financing focused on systemic risks and opportunities for horizonal and vertical implementation and to move from financing adaptation projects to financing adaptive systems.

To this end, Mazzucato and Perez (2014) propose a more ambitious concept of public value that rejects the 'market failure' framework and put public value at the center of the economy. Public value which is created by public sector actors creating and co-shaping markets in line with public purpose. This direction-setting role enables different sectors to collaborate on major societal challenges, such as climate change and inequality.

A major concern for financing DRR is the need to design and invest in projects with a long-term perspective (decades). Currently, business and policymakers work to very different timelines. But social and environmental impacts usually take longer to materialize which means decision-makers need to reframe their timescale for making a 'return' or, in the case of politicians, accept this may come after their own electoral lifecycle.

This poses an issue for Environmental Social and Governance (ESG) funds, too. Many detrimental corporate social and environmental impacts do not have an immediate observable financial repercussion or are not accounted for in the company's accounts or by an ESG metrics (Crona et al., 2021). For example, in spring 2022, policy makers anticipated there would be a significant shock to Ukraine's wheat production which would threaten global food security. EU policymakers suggested abandoning sustainable agricultural practices which form part of the EU's Farm2Fork strategy, to boost short-term production, whereas a reduction of the livestock sector would have been the more effective long-term solution reducing livestock feed by one third could compensate for the loss of Ukrainian grain and oilseed (Pörtner, 2022).

The report for Stockholm+50 (Galaz and Collste, 2022) and the UNDRR GAR 2022 reports both assert that the new planetary reality requires us to rethink the interlinked indicators for human wellbeing, the multidimensionality of financial risks (to value humanity's dependence on the biosphere), and to reduce the stock of submerged risks. Indicators for human well-being must incorporate environmental impacts and further acknowledge human pressures and the risk of reaching local and planetary boundaries or transgressing them.

Furthermore, the study of macroeconomic performance needs to embed the uncertainty in biosphere dynamics and its feedbacks to human pressures, including the risks of passing critical threshold from local levels to planetary boundaries. Only then will indicators meaningfully capture the viability of human well-being (UNDP, 2020). Indicators for macroeconomic performance must also integrate the value of different forms of capital, especially natural capital that is often neglected in national accounting. Tools and approaches do exist. Substitutability of different types of assets (e.g., a coral reef) is limited for all functions and human values. Natural assets, including a livable biosphere, may therefore not be meaningfully translated to monetary values.-

C. MULTI-LEVEL GOVERNANCE FOR RISK REDUCTION

Governance in the 21st Century must recognize the necessity for an international system (or mechanism) which can better address global dynamics, especially those with diffused and interacting causalities and trajectories, such as a changing climate and infectious diseases. To create an effective risk governance framework which gets ahead of disasters, the international community should establish a common understanding of the dimensions and magnitude of the challenge and review the inefficiencies of the current approaches to governance and mechanisms for tackling emerging challenges.

An adaptive governance approach deals with uncertainties and surprises inherent in transforming complex social, technological and ecological systems. It relies on iterative learning, planning, policymaking implementation and evaluation over time (Folke et al., 2005; Lempert et al, 2018; EEA, 2019).

To be effective, adaptive governance requires a process of systematic coordination at global to national scales and national to local scales and back up the chain. The process needs to work vertically (at local, sub-national, national, regional and global levels of government) and horizontally across sectors through collaboration between governments and others (see Figure 6).

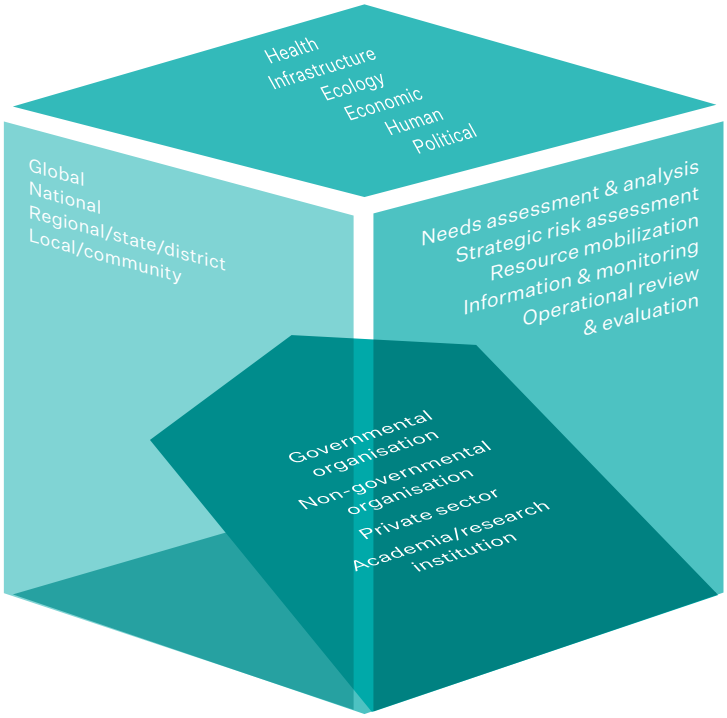

Figure 6: **Effective response and recovery measures for the pandemic crisis require coordination of multiple actors across a number of fields and at various temporal interludes.** Fakhruddin et al., 2020.

Prospective risk management cannot be included in development on ad hoc basis. Effective governance of disaster risk management cannot occur any longer without the close participation of vulnerable groups, non-governmental organizations and the private sector. Many professional groups, civil society organizations, community associations and private sector companies do important work together daily (formally and informally) to aid risk reduction and post-disaster recovery — an approach which should be leveraged and encouraged by governments.

Shifting from systemic risks to system opportunities requires new perspectives, strategies and actions. People across the planet are deeply intertwined and interconnected from the local to the global (UNDRR 2019; Galaz et al 2022; UNDRR 2022). Given these globally and locally networked risks and opportunities Galaz et al (2022) identify four avenues for building the transformative capacities needed to rapidly shift trajectory: defining a new direction; creating enabling conditions; developing capacities to phase-out and helping scale up investments for resilience (Fig 7). Realizing a safe and just future requires the ability to imagine, identify and mobilize co-benefits, through agile global collaborations by experimentation and policy-learning. Actions which halt or reverse biodiversity loss have substantial advantages for broader risk reduction including for climate and other global changes (IPBES 2019).

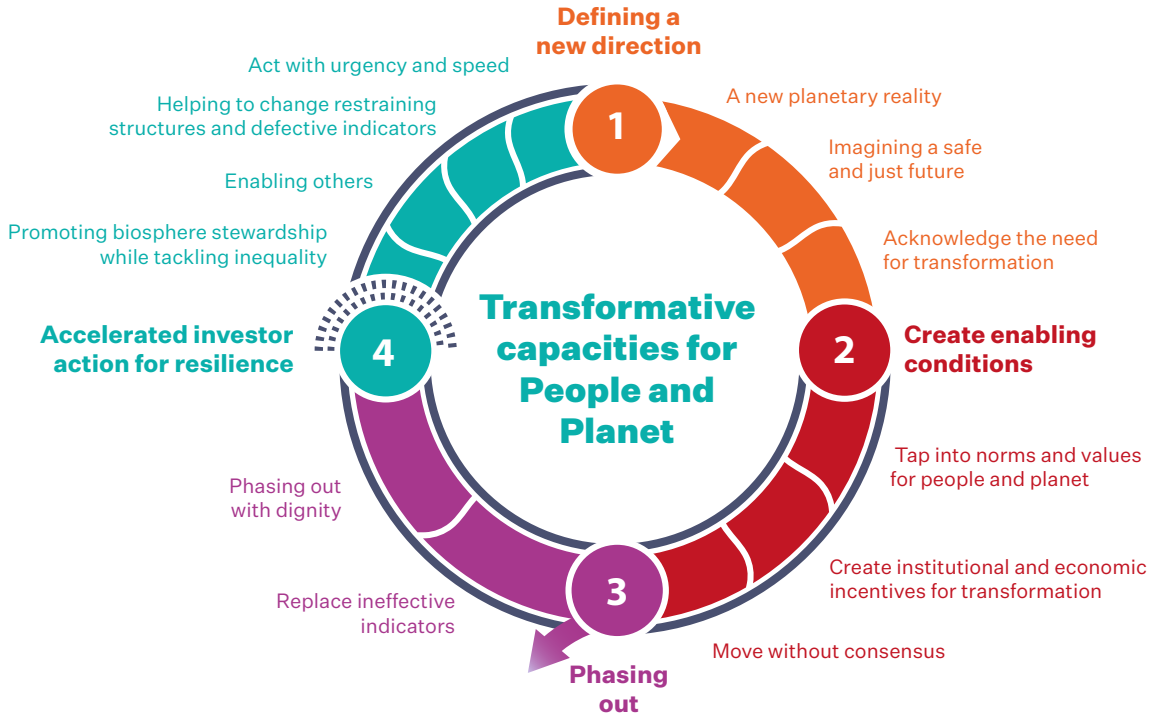

Figure 7: ***Building transformative capacities for people and planet.***
Illustration: Elsa Wikander/Azote

Even where multi-sector institutional systems have been created for DRM, responsibility and policy are still usually anchored in disaster management offices, who often lack the political authority or technical capacities to influence decisions about national and sector planning and investment. Alternatively the responsibility for DRM is mandated to local governments, who often lack the necessary resources and capacities. In central government, this problem would be improved by anchoring DRM in a ministry or office with political authority to ensure policy coherence across development sectors.

Systemic change often generates resistance which prevents policymakers from imposing regulations and pricing instruments consistent with long-term environmental goals. If sustainability is a goal, making efficiency improvements in existing systems of production and consumption alone will be inadequate.

Many practitioners are increasingly concerned with promoting visions that inspire and motivate action and there is a growing interest in the intentional role of discourse in developing shared visions of the futures. Work on narratives, storylines and 'imaginaries' is increasing, not simply as a critical tool, but as knowledge which could enable effective transitions in practice. Even so, co-production can still result in negative outcomes for those not engaged in the decision-making process or marginalized because of limited technical, financial and other resources. Foresight-based planning, for example, is a class of methodologies that can help imagine different futures, encourage long-term, broader system thinking and guide sustainability transformations in the present (Oteros-Rozas et al., 2015; Laura Pereira et al., 2021). Exploring futures and formulating transformative pathways which accelerate the building of a 21st risk governance framework will require asking fundamental questions of procedural equity, including: who has access to the futures that are being imagined? Who is excluded? And what might be the consequences of events and of interventions to those most at risk?

Conclusion

"Progress on disaster risk reduction must be urgently prioritized as a precondition for sustainable development."
António Guterres *UN Secretary-General*

"By deliberately not investing in policies and strategies to reduce the impact of disasters, the world is effectively bankrolling its own destruction."
Mami Mizutori *SRSG*

Risk and disasters are increasing while becoming more complex and interconnected. Previously hidden factors such as poverty and inequality are now accepted as drivers of disaster risk. But risk management has not kept pace with this awareness and is being overwhelmed by this new reality and remains too focused on post-event instead of ex-ante actions.

Business, financial institutions, central banks, governments and others have a major impact on the climate and the resilience of vital ecosystems but remain stuck in a 'business as usual' mindset which fails to acknowledge the need for systemic change. But without risk reduction and improved ecosystem resilience now, we will not achieve the Sustainable Development Goals and the Paris Agreement.

This report shows how different risk drivers are interlinked and manifest themselves in territories where nations, communities and individuals co-exist with risks everyday. Without robust and consistent territorial governance at a regional and local level, changes in policies (or international commitments) will have little impact. Territorial governance is a more comprehensive and distinctive approach to risk governance and provides a framework which sustains systems and processes such as land-use planning, natural resource management, social and economic development of territories, and the planning, standards and implementation of resilient infrastructure. Territorial governance is not specific to disaster risk alone but it incorporates the drivers of risk holistically not just hazards but vulnerabilities, exposures and contextual sensitivities, accountability for implementation and compliance and realizes the consequential benefits of prospective risk reduction. Recent events in

Türkiye and Syria illustrate the need for compliance, and accountability on structural codes. Territorial governance implies a radical, intentional change in paradigm from existing governance structures meant to cope with the increasingly complex and interconnected context in which we live. It also embraces a strategic vision for development focused on human well-being and environmental sustainability.

Countries, the private sector and communities partnerships should aim to complement nature-based approaches and building code requirements, with integrated MHEWS to maximize their effectiveness at proactive risk reduction. Post-event assessments show that early warning systems play a vital role in saving lives and protecting livelihoods. Fully integrated information systems would monitor the depletion of natural resources before dangerous thresholds are reached, such as a country's forest cover percentage and land degradation in exposed regions and communities. By creating and deploying new indicators to guide the protection of natural buffers that reduce risks and ward off disasters, safeguarding the many other benefits of nature for people as well as wildlife and ecosystems.

The report outlines additional observations and changes for moving from risk to resilience in a rapidly changing world. These include the need to:

- Evolve traditional risk assessment and management strategies which are unable to address the systemic and evolving impacts of extremes, variability and change and pilot new ways of communicating risk assessments to a range of actors.
- Broaden the public-private-civil society actor network and decision-making arrangements vertically and horizontally.
- Develop multi-hazard integrated information systems which cross time scales and include indicators of system depletion.
- Develop community-led nature-based solutions which secure and legitimize successful local approaches and engage indigenous knowledge.
- De-fragment finance to align investment with risk reduction goals and ensure finance and the development of capabilities effectively reach and are shaped by those who need it the most.
- Renovate finance to deploy capital at the service of the 2030 Agenda (as well as Human and Ecosystem health and wellbeing) and create an environment which integrates risk and reimagines the relationship between the economy, environment and society. This involves pricing negative externalities and introducing legally binding corporate transparency based on universal standards for risk.

- Develop a cadre of transdisciplinary professionals to expand the interfaces between science, policy and practice and play a key role in integrating knowledge "of" processes (analysis and generalizability) with knowledge "in" the process (experience, context, and practice).

SUMMARY TABLE OF KEY RECOMMENDATIONS

1.	Strengthen territorial level risk governance in regions and at the local level that addresses the drivers of risk across sectors.
2.	De-fragment finance to align investment with risk reduction goals at global, regional and local scales.
3.	Develop community-led nature-based solutions to enhance the protection of natural buffers that reduce risks and achieve co-benefits for sustainability.
4.	Develop multi hazard early-warning systems to anticipate and reduce the impacts of disasters and cascading risks across timescales.
5.	Develop integrated information systems to monitor the depletion of natural resources ahead of dangerous thresholds to support anticipatory action and prospective risk reduction.
6.	Evolve traditional risk assessment and improve methods for risk identification, mapping and reporting as to increase transparency, and as key inputs for early warning, risk management and infrastructure siting and design.
7.	Pilot new ways of communicating risk information and its implications for risk management and sustainable development.
8.	Develop a cadre of genuinely transdisciplinary professionals to expand the interface between science, policy and practice.

As the UNESCO Director-General Audrey Azoulay observed ‘our local, indigenous and scientific knowledge are proving that we have solutions and so no more excuses: we must live on earth differently’. Success will depend on how well social, organizational and economic conditions align to develop a vision, plans and policies for disaster risk reduction and create mechanisms which strengthen risk governance and enhance the management of the risks facing us at a national, regional and international level.

We can do this. But, if we do not harness the knowledge, we have gained to craft a better 21st century risk governance model, we will lose so much that it is almost inconceivable. Now is the time to act and imagine new futures and forms of development for achieving human well- being, instead of wealth concentration and risk accumulation. We hope this report will encourage and guide global players and communities in doing just this.

Annex 1

International Science Council Working Group Report on the Mid-Term Review of the Sendai Framework for Disaster Risk Reduction

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