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A Research Agenda for Global Science in Support of Risk-Informed Sustainable Development and Planetary Health

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Prepared by the DRR Research Agenda Core Group; sponsored by the IRDR, ISC and UNDRR (details are in Appendix 2).

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'At no point in human history have we faced such an array of both familiar and unfamiliar risks, interacting in a hyperconnected, rapidly changing world. New risks and correlations are emerging. Decades-old projections about climate change have come true much sooner than expected. With that come changes in the intensity and frequency of hazards. Risk really is systemic, and requires concerted and urgent effort to reduce it in integrated and innovative ways.' (SRSG, GAR2019)

Foreword

Table of Contents

List of Figures and Tables

Executive summary

The emerging Global risk landscape of a pandemic, dramatic changes to climate and biodiversity, social and financial crises, digitalisation and hyperconnectivity, inequalities and vulnerabilities, pose new challenges for disaster risk reduction and its associated areas of climate change adaptation and risk reduction through the Sustainable Development Goals. The trend is for more severe complex impacts with increasing concern about and acknowledgement of systemic, compound, and cascading risks and impacts. Rapid political, social and technological developments in addition to planetary change are contributing to the shifting landscape. The risks can appear to be existential posing a threat to many communities and livelihoods, and ultimately to humanity's existence. The arrival of the Anthropocene Era, where humanity is the major force of planetary change, is clear recognition of our situation; with talk of tipping points, planetary boundaries and biodiversity and ecosystem collapse (Folke et al, 2021).

These challenges are daunting, but because they are driven by development processes they are also amenable to policy and local action. To help meet these challenges by supporting ambitious development action, disaster risk reduction (DRR) needs to be reimagined with much more robust and broader reach working collaboratively across sectors, disciplines and types of knowledge. One overriding need is to go well beyond siloed thinking and "business as usual" if we are to address these closely linked global imperatives successfully. For risk reduction, the need now is to maximise the impact risk science can have on changing this future towards better outcomes. To achieve this, risk scientists and knowledge holders need to collaborate and reach well beyond their traditional networks to those in policy and practice. Further evidence is hardly needed, but the complex systemic risk presented by the Covid-19 pandemic highlights global vulnerabilities, the strengths and weaknesses of global risk governance, and the challenges posed for risk communication in a world with numerous conflicting information sources in an often partisan political environment. It reinforces the need for a different approach.

This Agenda sets out some important areas where additional actionable knowledge is likely to result in reduced risk and vulnerabilities and improved human well-being. It is intended for those working in DRR and related areas of global risk, climate change adaptation and development. We believe it is relevant to those interested in improving current DRR practice as well as those who see the need for more fundamental change.

The Agenda was commissioned by the International Science Council (ISC) and the UN Office for Disaster Risk Reduction (UNDRR) and the development has been led by the Integrated Research on Risk program (IRDR). From the outset the emphasis has been on a collaborative co-design approach with wide iterative consultation. The Agenda has engaged with and reflects the priorities and interests of groups well beyond traditional DRR research and practice, to build the evidence base needed for risk-informed decision-making in all geographies, sectors and scales. To help support additional engagement a number of specialist groups were organised including indigenous knowledge and the private sector.

The research priorities:

The priorities highlight that although much research and progress has been achieved in DRR over the past decade, much of this knowledge is unused due to lack of effective collaboration between all types of knowledge holders, policy and practice. Silos and significant disconnections remain within and between disciplines, as well as between knowledge producers and potential knowledge users. This lack of integration and trans-disciplinary focus has reduced the capacity and impact of disaster risk science in helping to address macro societal challenges, like alleviating poverty and reducing

vulnerability and exposure to all forms of disaster risk.

Based on iterative consultations with a wide range of interests and [stakeholders, actors] the following priority areas have been identified. These can apply to a range of scales from the global to the local, rural to densely urbanised. There is considerable overlap and some priorities are cross-cutting, applying to most, if not all, of the other priorities.

1- Address today's complex Global Risk landscape: How disaster risk reduction can accelerate the transition to a peaceful, safer, equitable, sustainable world within the context of DRR.

Key question: How can research inspire better work to understand the complex interconnections of systemic, compound and cascading risks and impacts, and their connections with vulnerability and exposure.

Potential early result: how can comprehensive risk assessments, that include global threats, systemic impacts, inequalities and vulnerabilities, be undertaken for local communities?

2- Address inequalities, injustices and marginalisation

Key question: How can risk science and knowledge support the most marginalised people and communities to ensure that "no one is left behind", as part of ensuring inclusive justice and equity across humanity?

Potential early result: how can risk science best support the development and adoption of tools that enable practitioners to consider risk and its distributional impacts when defining development strategies?

3- Enable transformative governance and action

Key question: How can transdisciplinary science and knowledge transform access to and participation in governance structures and actions to reduce disaster risk?

Risk reduction, climate adaptation and the achievement of Sustainable Development Goals are intrinsically linked.

Potential early result: what is known across science and other sources of knowledge including the private sector, about integrative governance and action for DRR, climate change adaptation and the SDGs?

4- Understand the implications of new thinking on hazards.

Key Questions include: How can we best identify and understand new forms and newly common extreme forms of hazards; as well as their intersection with either or both vulnerabilities and other hazards?

The ISC/UNDRR 2020 report on Hazards Definition and Classification identifies over 300 hazards, many new to DRR.

Potential early result: how to develop and action impact-based warnings drawing on multiple disciplines and agencies as well as the private sector and civil society?

5- Harness technologies, data and knowledge for risk reduction.

Key question: what factors impede and what support emerging technologies in achieving their promise of risk reduction – rather than risk creation and risk shifting; and how can the technologies be better used to support the SDGs and risk reduction?

Rapid technological advances are driving major changes in our lives and have the potential to contribute to all aspects of risk reduction and disaster management. This theme seeks to inspire research that takes the opportunities to maximise positive impact.

Potential early result: what factors impede and what support the technologies in achieving their promise of inclusive risk reduction – rather than risk shifting or creation?

6- Support regional and national science and knowledge for policy and action.

Key question: what are the distinctive research priorities of different global regions? Regions have distinctive mixes of hazards, exposures and vulnerabilities, which are influenced by complex root-causes, interdependencies, capacities and governance structures.

Potential early result: How can regional research leadership bring substantive global research together with national and local contexts to drive inclusive risk reduction to reduce vulnerability and risk in future development?

7- Support just and equitable transitions, adaptation and risk reduction.

Key question: How to ensure just and equitable transition to a sustainable less risky world?

Potential early result: How can relocations driven by transition, adaptation or disaster risk reduction, be undertaken to minimise the impacts on livelihoods and identity?

8- Measurement to help drive progress

Key question: What do we need to measure and how can measurement be designed to incentivise improved risk knowledge and risk reduction?

Potential early result: how can we best measure progress with reducing risk in development through addressing Priority Theme 2 drawing on current knowledge and experience?

9- Foster interdisciplinary and multi-stakeholder collaboration

Key question: Why is so much knowledge apparently unused? There are many areas where it is well applied which could provide starting points for learning and change.

Potential early result: what are the most effective ways of developing and supporting networks of practice and knowledge to enable exchange and development of ideas and interaction with those in policy and practice?

Pathways to impact and transformative change

The Agenda concludes with a non-prescriptive section on implementation. In summary, this Research Agenda is intended to help connect knowledge, policy and practice, foster innovative thinking and encourage greater research investment in priority areas. The Agenda also can help connect all knowledge holders including scientists, funders, the private sector, policy makers and practitioners across disciplines and sectors to encourage new types of partnerships across traditional

silos to find new approaches to address today's global challenges. To achieve this transformative democratisation of science, it advocates networks and communities of practice, with an "open science" approach.

1 Introduction

Solutions to the combined risks and crises facing humanity and the planet can be found through the collaborative efforts of all types of relevant knowledge and policy resources to drive change. Many of the major global crises and threats are well known: the Covid-19 pandemic, climate change, ecosystem and biodiversity collapse, and financially and socially induced risks. Less well known are the day-to-day crises and risks impacting much of the globe through inequalities and vulnerabilities, often exacerbated by globalisation, digitalisation and unsustainable development. Disaster risk has therefore come to occupy a central place in global development with science required to work more effectively, innovatively and collaboratively to cope with the global context of intensifying risk exposure and vulnerability. Coherence between the 2015 Sendai Framework for Disaster Risk Reduction (hereafter, **Sendai Framework**) and parallel major UN frameworks concerned with addressing risks, for example, the Sustainable Development Goals (**SDGs**), Paris Agreement on Climate Change, New Urban Agenda, Addis-Ababa Action Agenda and Agenda for Humanity, will assist with addressing inequalities and instilling risk reduction as a critical function of development.

The global risk landscape, and human responses to risk, are therefore undergoing rapid and profound changes (Steffan et al. 2015). The arrival of the Anthropocene Era, where humanity is the major force of planetary change, is clear recognition of our situation (Folke et al. 2021). The global trend is for more severe and complex impacts; reflected in increasing concern for and acknowledgement of complex and systemic risks, with impacts cascading through social, economic and environmental systems. This reflects the growing interconnectivity and interdependence across and within human, technological and biophysical systems; and highlights the potential for physical and socio-economic tipping points to create significant systemic impacts.

The Covid-19 pandemic is not only a systemic risk but lacks clear boundaries in space and time. The virus and the response it has engendered highlight the complexity of global risk and the fragility of human systems, including the weakness of global risk governance that is often disconnected from local risk realities and governance efforts. It has also highlighted the challenges posed by an environment awash with misinformation and a multiplicity of diverse information sources. Existing approaches to thinking about and managing risk are being overwhelmed by the pandemic's systemic nature, which shows how global risks can fundamentally alter how humanity lives, even if not threatening our existence.

Rapid political, social and technological developments, in addition to climate change, are contributing to the shifting landscape. One overriding need is to go well beyond siloed thinking and preserving the status-quo if we are to address these closely linked global imperatives successfully. Returning to, and supporting, the status quo is what many DRR and resilience approaches aim to achieve, but this entrenches existing vulnerabilities and other risk drivers, and limits the potential for transformation.

These challenges are daunting, but because development processes drive them they are also amenable to policy and local action. Almost half the urban infrastructure anticipated for 2050 is yet to be built; new open and integrated data systems allow complex challenges to be resolved; much COVID-19 recovery planning incudes increased public and political acknowledgment of the centrality

of social vulnerability reduction as a strategy for building resilience to multiple, and as yet unknown risks. To realise these opportunities requires reimagining DRR, to extend it from a singular focus on major events, to a proactive inclusive risk based approach with climate adaptation, vulnerabilities and development to address the causes as well as consequences of disaster. Risk science must motivate the search for opportunities and solutions – building on the success of contemporary DRR with its major reductions in the human toll from disasters through warning systems, emergency management, and enhanced preparedness.

To identify knowledge gaps and priorities, and to build the evidence base needed for risk-informed decision-making in all geographies, sectors and scales, the Agenda developed here has engaged with and reflects the priorities and interests of groups beyond traditional DRR research and practice. This consultative process is set out below and in Appendix 1.0. It includes disaster risk scientists, researchers, academics, and technical institutions in both the public and private sectors, traditional and Indigenous knowledge holders, as well as funders of research and practice. The Agenda also calls for an integrated, inclusive systemic approach to risk reduction with prominence given to the issues of justice and equity.

The Agenda helps to both identify the needs of stakeholders and actors working at country, regional and international levels and to itself be guided by those needs. It will also guide the development of research to address those needs, as well as to help solve broader issues. The Agenda's audience are all those engaged in DRR and related risk, resilience, adaptation and development action as practitioners, policy makers, researchers and knowledge holders. This extends to those working on all aspects of vulnerability, and to those funding research and practice for risk and development, as well as the associated areas of human and planetary change.

This Agenda document contains the detailed rationale and process for developing the Agenda, a review of the trends and status of disaster risk knowledge, the research priorities comprising the Agenda, and an implementation guide (Figure 1.1). Additional detail and supporting material is found in appendices and hyper-links. The Agenda does not have a set timespan, and is intended to serve as a framework to guide and inspire, rather than prescribe. It will be a reference document for communities of practice to draw on, debate and adapt to contexts and priorities. The Agenda's implementation is in the hands of all disaster risk related actors and stakeholders across the world, and its success will depend on trans-disciplinarity and multi-sector collaboration at all levels.

287

288 *Figure 1.1 The three major components of the risk research agenda*

289

2 Developing the Research Agenda

2.1 Organisation

The Agenda was commissioned by the International Science Council (**ISC**) and United Nations Office for Disaster Risk Reduction (**UNDRR**) with the development led by the Integrated Research on Disaster Risk (**IRDR**) program. From the outset the emphasis has been on a collaborative co-design approach with wide consultation.

Two groups were established to support the development of the Agenda (see Appendix 1 and 2, for details of the groups and the consultation process): a Core Group, and an Expert Review Group (ERG) (refer Figure 2.1). The Core Group is responsible for guiding the development of the Agenda and providing input, while the ERG provides input and commentary from diverse perspectives. Membership of the Core Group consists of representatives of the ISC, UNDRR, the IRDR Scientific Committee and IRDR Executive Director and other IRDR and external members. The Expert Review Group consists of Core Group members, plus IRDR ICoE's (International Centre's of Excellence) and National Committees, representatives of the Science and Technology Advisory Groups (STAGs), as well as a wide range of people from diverse backgrounds (science, advocacy, funders, private sector) outside the IRDR community.

To ensure that sectors and sources of knowledge that are often excluded were included, a number of specialist sub-groups were established to support the ERG. These included: indigenous knowledge and the private sector.

Figure 2.1 The organisation structure and process of Agenda development

2.2 Process

The Agenda was developed iteratively through multiple consultations with, and input from, the groups mentioned above between late 2019 and mid 2021. The formal iterations are set out in Appendix 1. In summary, the iterative consultation process included the following steps:

1. Surveys of the IRDR Community (IRDR Scientific Committee, International Program Office, International Centres of Excellence, National Committees) to identify key literature sources and establish the initial draft research priorities.
2. A review and analysis of the scientific literature (see Appendix 3), to establish the state of research, gaps and needs across DRR, resilience and other themes;
3. Consultations were iterative with the IRDR community and 19 member Core Group with frequent interactions including one-to-one discussions; the 45 member ERG was used for strategic input early on in the process and then for detailed feedback and commentary on a complete draft in April 2021. The April version of the Agenda was also available through the

ISC webpage, along with a survey on the draft Agenda which returned 57 responses. Specialist groups consisting of indigenous representatives and the private sector were established and provided valuable input;

4. Presentations and discussions at IRDR Science Committee meetings, APSTCDRR (and other meetings);
5. A major session of 2021 IRDR Conference was dedicated to the Agenda;
6. A pre-final draft of the Agenda presented at the 2021 IRDR Conference, June 2021, to seek its endorsement.

Figure 2.1: A process of Iterative engagement with diverse stakeholders.

2.3 Principles and key questions guiding agenda development

The development of the Agenda has been informed by a number of principles. These were developed and agreed by the Core Group to articulate and frame our approach. The Agenda is intended to:

1. Be responsive to the new Global risk, development and planetary health contexts and actively supports coherence across major UN agreements on DRR, climate change, planetary health, Sustainable Development Goals etc.

2. Take a systemic and multi-risk perspective, capturing emerging, dynamic, complex and cascading risks, and gives attention to the appropriate response space.
3. Focus on policy relevance and outcomes.
4. Inform processes to implement and achieve collaboratively the Sendai Framework for DRR, the Paris Agreement on climate change, and the SDGs targets, as part of the 2030 resilience agenda.
5. Be consultative and collaborative across disciplines, domains and stakeholder and actor groups – in line with the Sendai principle of transdisciplinary collaboration;
6. Recognise DRR as essential to the development process and improved human well-being.
7. Engage with traditional and other forms of knowledge, and where practicable promotes co-production of knowledge.
8. Promote ethical inclusive approaches to research and research results.
9. Consider how research is funded, and how the results could be implemented.
10. Go from theory to practice by focusing on impact for both policy and practice;
11. Be flexible and adaptable to changing circumstances.

In summary, the principles are about: encompassing global risk and including systemic and emerging risks; advancing coherence across the substantive areas encompassed by major Global agreements on DRR, climate, SDGs, and other critical issues as part of the 2030 resilience agenda; emphasising collaboration and being inclusive of disciplines, regions and forms of knowledge; promotes ethical and inclusive forms of knowledge and research; being relevant to policy and practice; and flexible and adaptable to changing circumstances.

3 Context and rationale for a new Agenda

Why is a new global risk -science research agenda needed, rather than amending the present settings of risk science networks, platforms and research programmes? The rationale for a new risk science research agenda is found in: the emerging global risk landscape; changes in thinking about disasters and risk; the need for coherence across the areas encompassed by major global agreements relevant to reduction of risks and vulnerabilities (Appendix 3.0).

[Figure 3.1 will outline the key themes of this section]

3.1 The global risk landscape

The global risk landscape is undergoing rapid and profound changes across DRR, climate change and sustainable development. The trend is for more severe and complex impacts and there is increasing concern about and acknowledgement of complex, cascading and systemic risks. Unprecedented climate and weather shocks and stresses being associated with economic and humanitarian crises, potentially driving conflicts, internal displacement and large-scale international movements of people, as well as crises precipitated by accelerated warming in polar regions and major changes to ocean ecosystems, are some of the more obvious signs of these changes.

The Covid-19 pandemic is not only a cascading and systemic risk, but is itself framed in many different ways (e.g. Wicke and Bolognesi 2020). The virus and the response highlights the complexity of global risk as it plays out over multiple scales in space and time. In keeping with many high profile risks, Covid-19 is portrayed in mainstream media alternatively as war, as a fairness issue, as a geo-political issue, as a public health issue, and as about competence of politicians, the public sector and leadership – among other framings. At different times and from different perspectives, these may all be reasonable.

This rapidly evolving landscape is characterised by multiple definitions and frames varying by sector, discipline, circumstances and worldviews – however even within and across disciplines there can be distinctive ways of defining and framing risk. Risk can, through intentional and unintentional actions, be shifted between organisations, agencies and social groups in ways which redistribute (rather than reduce) risk, and transfer and exacerbate vulnerabilities (Eriksen et al, 2020). This is not simply the risk shifting of insurers, but for example the legal shifting of risk from power companies onto the people of Texas evident during the 2021 winter storm.

The consideration of the word ‘risk’ in disaster research and policy encourages enquiry into broader risk contexts (i.e. risk without disaster) and underlying causes of disaster events. There is now greater emphasis on ‘process’ rather than event or outcome (Davis, 2019). The formulation of risk as the function of hazard, exposure and vulnerability (plus capacity) is a foundational framework in the study of disaster across research and some sectors such as insurance, as it encourages interdisciplinary analysis of the natural (i.e. hazards, environment) and the social (i.e. vulnerability, exposure, capacity) dimensions of risk (Wisner, 2004). It is acknowledged, however, that this and some other dominant risk framings are derived from Western scholarship, and in a global sense there is no single view of what risk is and how it is formulated, and there is need for more diverse ways of knowing and understanding risk (see Gaillard, 2019).

For example, a participant in the indigenous engagement stated:

> *“I mean it's obvious that it’s a completely different understanding of risk for indigenous communities. In my experience, in New Zealand and the Pacific and Southeast Asia as well, in*

some ways there is no real understanding, or no concept of risk in traditional cultures. Pre-European or pre-colonization, it's been very much a case of adapt and survive… and through those adaptation strategies, knowledge is developed and solutions have developed, and responding or response, were they responding, not really, I'm not sure, but living with many of the challenges they faced in the environment."

There are also sectors where risk can appear to be ignored: for example risk can appear to be treated as an externality in current development models; and groups that focus on the perceived benefits, for example through economic analysis, argue that the risks are small compared with the benefits. Many countries, sectors and companies have their own standards and protocols for formally assessing risk, often drawing on ISO-1300, the international risk management standard, which frames risk in terms of failure to meet objectives. The are many disciplinary and sectoral approaches to risk. These range from the mathematical modelling of engineering, insurance and the finance sector; the approaches used by the society and technology research community, and cultural and social theorists; the increasing use of the SDGs to frame risk for public and private organisations; and the strong social justice frames brought to bear by environmental and climate justice, human rights and labour advocates.

This indicative set of ways of seeing risk has now been joined by a range of concepts highlighting risk as an immense challenge for both humanity and the planet: systemic and complex risks, and risk as existential (for an up-to-date summary see Folke et al. 2021; policy oriented examples include (among others): Global Assessment Report on DRR or GAR (UNDRR, 2019); Centre for the Study of Existential Risk (CSER); the 2020 UN Development Report; Global Risk Report 2021 of the World Economic Forum). These concerns have led to new fields with a focus on global catastrophic and existential risks which are events that can bring humanity, or parts of humanity, to collapse (eg CSER).

A systems approach to risk is one approach to understanding the increasingly connected and complex social-ecological systems within which risks manifest (see the Global Assessment Report on DRR (UNDRR, 2019)). However, conventional framings of risk still often overlook temporal and spatial collisions of different hazards, or the collision of extreme events with slow onset events or protracted crises (Keys et al., 2019; Phillips et al., 2020). Anthropogenic changes and globalization processes further compound risks. Concepts such as compound risk, systemic risk, cascading risk, 'Natech' risk, and Anthropocene risk have emerged as alternative framings attempting to capture the dynamic nature of risks in 'modern' systems.

The notions of systemic risk and Anthropocene risk center on interdependency as a driver of risks. The former focuses on networked elements while the latter calls attention to the context of linkages. Adopted from the financial management field, systemic risk refers to risks rooted in interconnected components of a whole. Events affecting a component may result in the collapse of the whole system. Systemic risks tend to be large scale, non-linear, inter-connected and stochastic in nature (Lucas et al., 2018; Renn, 2020). The interconnections often become clear only as a crisis unfolds.

The idea of Anthropocene risk (Keys et al., 2019) is an attempt to explain emerging global risks and how they arise, with humanity seen as the main driver of change on the planet. Understanding Anthropocene risk requires holistic and systemic approaches (Folke et al. 2021). These more complex risks, or ways of thinking about risk, are emerging as sub-disciplines with their own substantial research efforts. They reflect a merging of global environmental change, escalating inequalities, digitalisation, economic and social issues and crises, which are creating both new forms of larger risks and uncertainties, and also entrenching end exacerbating many day-to-day risks.

The focus on global risk stems from growing concern about the prospects for humanity and the life supporting capabilities of the planet. The threats are seen as complex and intensifying, but are subject to a range of interpretations. Regardless of the exact severity of the threat, the implications are high levels of disruption to the lives and livelihoods of much of humanity, disruption or partial cessation of the global flows of goods and services, including the ecosystem services underpinning humanity, and undermining future and reversing past achievements of the SDGs, climate adaptation and disaster risk reduction.

This global focus should not obscure the reality for many people that it is the everyday risks, vulnerabilities and crises they face that are of major concern. Global risk is nevertheless important here to the extent that it is connected to, and a driver of, these local issues; and can also provide opportunities for risk reduction with consequent improvement for human well being.

Consistent with ways risk is framed and viewed, and with the imperative of collaboration across disciples, sectors and forms of knowledge, this agenda uses multiple framing in developing its priorities. Risk is highly pluralistic in nature, with multiple interconnections, dimensions, multiple scales and complex multiple impacts. We need to work with these diverse elements and with uncertainty and surprise across planetary and social systems.

4 The disaster risk field: Evolution and emerging issues

4.1 Science and research

Modern disaster studies in the fields of geography, sociology, anthropology and engineering (among other fields) have developed since the 1950s, although the field has long antecedents. The journal *Disasters* began publication in 1977, for instance. During this period, disaster knowledge and practices have evolved from an emergency management framing to a broader perspective encapsulated by DRR (Davis, 2019). It has seen a shift in priority and focus from responding to disaster events (i.e. an *ex-post* approach) to proactively managing and reducing risks (i.e. an *ex-ante* focus). As mentioned earlier, risk is often seen as a function of hazards, exposure and vulnerability (and capacity) – and this frame has become foundational to how disaster processes are conceptualised.

Crucial to progress in understanding and managing disaster risk is 'disaster science', which spans both natural and social sciences, and cuts across various disciplines, including environmental, earth, economics, geography, engineering, sustainability, ecology, sociology, political science, law, education, health, anthropology and other sciences and sources of knowledge, as well as their specific branches. Figure 4.1 and Figure 4.2 show both the almost exponential growth in scientific publications over the last 50 years, and the disciplinary origins of bodies of disaster-related literature (see Literature Review Working Paper for more details, Appended).

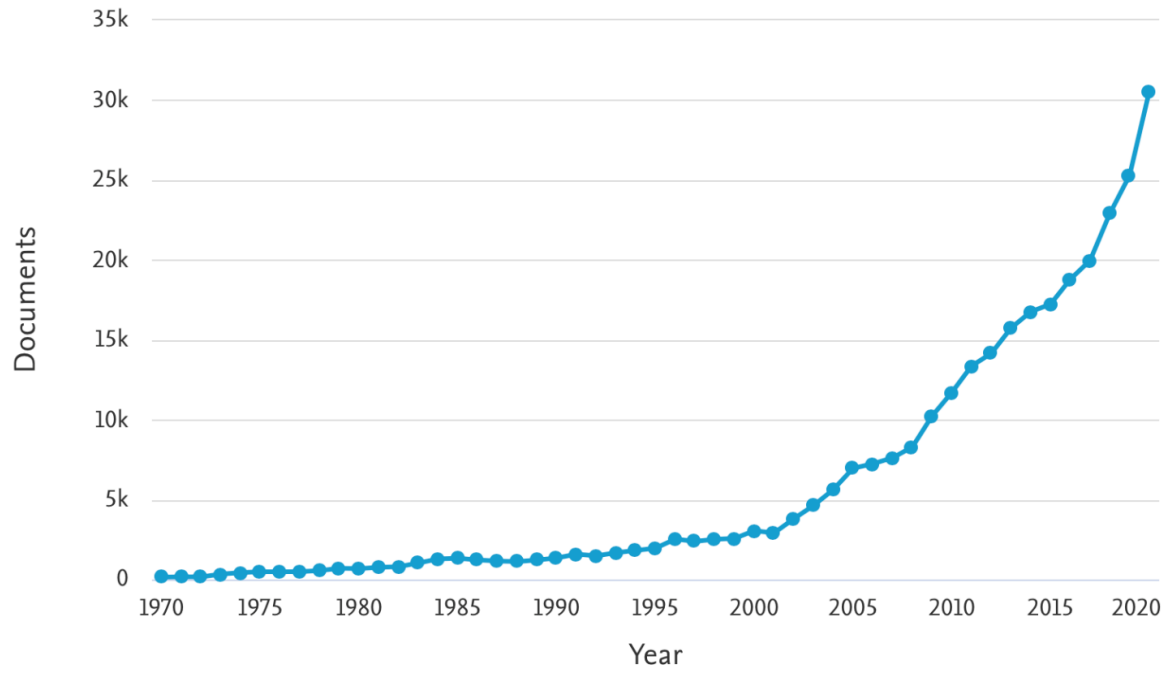

Figure 4.1 Literature search results per year (1970-2020)

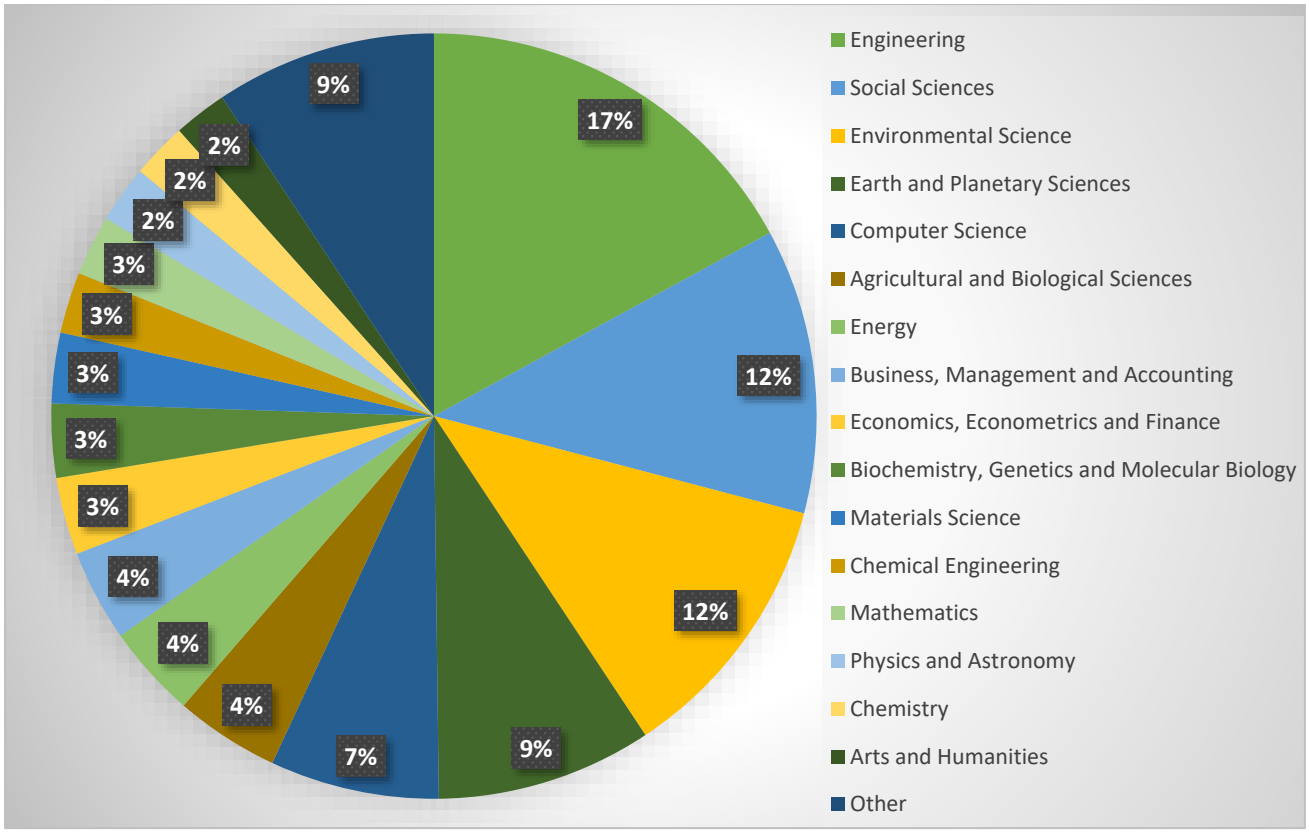

Figure 4.2 Literature search results by scientific discipline (1970-2020, excluding 'Medicine')

Disaster risk science is constantly evolving, its concepts and framings refined, contested, and redefined across diverse and inter-related disciplines. In the context of increased global connectedness, the evolution of risk understanding from 'natural' to 'systemic' is apparent. It is central to the framings of risk, hazard, vulnerability, resilience, and adaptation, among others, and their cascading, compound, and interacting impacts. The increasing role of the social dimensions of risk and vulnerability has foregrounded local, traditional, and Indigenous knowledges and methodologies as critical components of disaster risk science.

Innovations in scientific methods and technologies have enabled new ways of knowing, understanding, measuring, and assessing. The confluence of these trends and progress calls for meaningful and inclusive collaboration across scales, geographies, and disciplines and progressive governance approaches to risk reduction and management. As science and research in these areas continue to grow at an almost exponential rate, multiple agendas, coalitions and processes have emerged at all levels, from global to local, for disaster scientists and researchers to coalesce around in the hope of informing disaster risk policy and practice.

Various gaps and priorities are reflected in scientific literature, inputs to this Agenda, and beyond. First, a growing disconnect between knowledge and action is apparent. The desired shift to ex-ante from ex-post approaches to risk management, for example, has not mirrored equally between disaster risk science development and policy and practice. One reason may be the lag between conceptual and theoretical advances and grounded knowledge and empirical data; another the lack of effective science to policy communication; and another the frequent tension between science and partisan politics.

Second, a holistic understanding of risk is lacking. While there is a plethora of quantitative and qualitative approaches to understand the manifestation, perception of and responses to risk, there is yet no integration of approaches that also account for diverse, place-based ways of knowing and understanding. There is a rise in multi- and trans-disciplinarity, however more needs to be done to integrate different forms of knowledge, beyond science and experts, to include traditional and Indigenous knowledge and approaches. Third, across scales and between regions and nations, knowledge production suffers from significant imbalance and disparities. A future research agenda needs to be conscious of power relations informing and informed by disaster risk science and make space for locally-produced knowledge to help drive understanding and progress.

4.2 Policy and implementation

Global action on disaster reduction commenced at least as early as the 1970s, while formal policy developments can be traced to the 1990s UN International Decade for Natural Disaster Reduction (IDNDR), to the Yokohama Strategy for a Safer World adopted at the first World Conference on Natural Disasters in 1994, to the Hyogo Framework for Action (2005-2015) adopted at the second World Conference on Disaster Reduction in 2005, and currently to the Sendai Framework for DRR (2015-2030), adopted at the third World Conference on Disaster Risk Reduction in 2015. The names of these events and processes alone suggest a gradual shift in thinking of disasters as natural events (or 'acts of God') to broad acceptance that the risk- and development-related decisions and actions that humans take determine disaster impact.

This shift has enabled the imperative to reduce risk to grow in priority on global policy fronts – not least in relation to climate change and sustainable development, encapsulated in Agenda 2030, the SDGs, Paris Agreement on Climate Change, Post-2020 Global Biodiversity Framework, New Urban Agenda, Addis-Ababa Action Agenda and Agenda for Humanity. These agreements and others highlight that DRR is recognised as a mainstream development issue, and provides the global policy foundations for more integrated and holistic risk governance, and more equitable outcomes in improving the condition of people and the planet. Yet, the Sendai Framework for DRR mentions but does not prioritize the need to identify and tackle the underlying causes and drivers of risk, suggesting that science and policy advances are still required. Greater synergies and coherence across the areas covered by these agreements could address this and transform the ways in which risk is conceptualized and governed.

[Figure 4.3 signifies the time line for evolution of thinking on DRR showing the confluence of sustainable development, climate change and risk science]

The policy environment is now quite different because the agreements on DRR (Sendai) climate change (Paris) and the SDGs did not exist before 2015, making earlier integration across the domains they cover at best ad hoc and often unofficial. Change is also seen in the rise of trans-disciplinarity which needs to extend much more to include forms of knowledge beyond science and scientists. Traditional science alone is not sufficient to deal with the contemporary complex risk environment, with its emerging risks and growing uncertainties. There are many institutions working on these risks alone and in coalitions with others, including civil-society networks, research and independent policy organisations, UN agencies, think tanks and others with major influence such as the IFRC, World Economic Forum, World Bank and European Commission. The affiliations of those in the agenda's CG and ERG highlight some of the diversity.

The 2020 review of hazards terminology https://council.science/wp-content/uploads/2020/06/UNDRR_Hazard-Report_DIGITAL.pdf with its reappraisal and reframing of what hazards should be included within the scope of the Sendai agreement highlights an aspect of this evolution in thinking. Drawing on Sendai, the review applies a new definition of hazard from phenomena to also include human activities and processes. It sets out a strong case for an "all-hazards approach to achieve risk reduction as a basis for sustainable development". This is intertwined with the systemic complex nature of the contemporary hazards landscape, epitomising the evolution of the whole DRR field, as noted in the report:

> "interconnected, cascading and complex nature of natural and human-induced hazards, including their potential impact on health, social, economic, financial, political and other systems, are all interlinked in the discussions on sustainable development and climate change adaptation."

An important next step for this hazards review is to expand its sources of definitions to include local knowledge and experience.

5 Research priorities

This section sets out the research priorities. The priorities have been developed through the consultations undertaken as part of Agenda development (see Section 2 and Appendix 1), through gaps and needs identified by the analysis of published material (Section 4 and Appendix 3), and by examination of key documents including GAR 2019 and the 2020 Hazard Terminology and Classification report (ISC & UNDRR 2020). The field is very dynamic with new issues and priorities certain to emerge over the short and medium term. The priorities set out below should be read with other major research priority setting exercises in mind such as 2021 Horizon Europe (Section 5); The 2020 UN Research Roadmap for Covid-19 Recovery; the Earth Commission, the report prepared for the 2021 Nobel Summit (Folke et al. 2021), and the 2019 IPBES Global Assessment Report on Biodiversity and Ecosystem Services.

These consultations identified that much research and progress has been achieved in DRR, but that much knowledge remains unused. Silos and significant disconnections remain within and between disciplines and other sources of knowledge, and also between knowledge producers and potential knowledge users. This lack of integration and absence of a trans-disciplinary focus has reduced the capacity and impact of disaster risk science to support action to address macro societal challenges, including alleviating poverty, reducing vulnerability and exposure to all forms of disaster risk, and improving risk governance.

Implementation of many aspects of these higher-level priorities will require major change, and in some cases transformation - whether social and behavioural, institutional, political, policy based and other aspects of transformation within the current risk science and research paradigm. Consequently, a key overarching question is how transformation can be achieved?

It is acknowledged that transformation will rely on identifying diverse pathways for transition, and collectively defining a vision of where risk science should be in a decade from now, how this will be achieved, and how success will be measured. It is likely that there will legitimately be more than a single vision.

In seeking to encourage change towards an integrated approach to risk reduction and human well-being across sectors, funders, sources of knowledge - including trans-disciplinary risk science - the research priorities are set out in a way that includes macro level issues, as well as some more specific technical concerns, and priorities at regional levels (including the complexities of regional differences, development and implementation challenges). The priorities are set out under broad themes, with additional detail in an Appendix 4. Examples where rapid impact or early results are likely to be achieved are highlighted. These are provided as indicative examples where due to a combination of existing knowledge and capacity, as well as institutional support, rapid results are likely.

The priorities are:

1. Understand risk creation and perpetuation: systemic, cascading and complex risks;
2. Address inequalities, injustices and marginalisation;
3. Enable transformative governance and action to reduce risk;
4. Understand the implications of new thinking on hazards;
5. Harness technologies, innovations, data and knowledge for risk reduction;
6. Support regional and national science and knowledge for policy and action;
7. Support just and equitable transitions, adaptation and risk reduction;
8. Measurement to help drive progress;
9. Foster multi-stakeholder collaboration for solutions to risk challenges.

By way of overview, Figure 5.1 illustrates how the themes or research priorities discussed in the following subsections fit together as a whole. Importantly, the themes should not be viewed as mutually exclusive as there is considerable overlap and some are cross cutting across the other priorities. Each area of research fits with the overall objective of augmenting the global risk science and knowledge ecosystem to better address the challenges faced due to intensifying global, regional and local risk context. Most priorities can apply at a range of scales from global to local, and from rural to highly urbanised areas.

Figure 5.1 An overview of the nine research priority areas

5.1 Priority 1: Understand risk creation and perpetuation in the contemporary risk landscape: systemic, cascading and complex risks.

The rapidly evolving global risk landscape demands better understanding of the complex and systemic risks, and of the interdependencies that increasingly confront humanity and the planet. Knowledge of these underpins risk reduction action and avoidance of bio-physical and social "tipping points" which could lead to sudden increases in vulnerability, through loss of livelihoods, food and water security, among other issues, for large sections of humanity. This highlights that many aspects of these global risk issues are grounded within the Sustainable Development Goals, which need to take account of disaster risk as well as the transition risks accompanying change to a more sustainable world (see Priority 7 below). This is because climate change, disasters and unaddressed inequalities and issues of justice can rapidly undermine development gains and lead to the perpetuation and deepening of vulnerability, poverty and other drivers of risk (see Priority 2). Current impacts from disasters and day-to-day problems often worsen vulnerabilities at the same time as some hazards are worsening. Dealing with such impacts is a key element in progress with the SDGs and risk reduction. Further research on these issues is needed to understand disaster risk construction and the intersections between global forces and local impacts. Insights will not simply come from science: other sources including indigenous and local knowledge and the experience of practitioners should be part of future work.

Recommendation 6 of the 2020 Hazards Terminology and Classification report supports this priority:

> "There is an urgent need to investigate further the direct and indirect linkages and effects of natural, biological, technological and other human-induced hazards to identify better and understand cascading and complex hazards and risks in a systematic way. The shift towards a broader view and a more context-dependent definition of hazards requires a systematic approach to risk that considers [the roles of] hazard, vulnerability, exposure and capacity together and better understands their complex interactions..."

Potential early result: how can comprehensive risk assessments, that include global threats, systemic impacts and inequalities and vulnerabilities, be undertaken for local communities? What framing and form do such risk assessments need to take?

5.2 Priority 2: Address inequalities, injustices and marginalisation

Key to reducing risk is further understanding of the dynamic nature of exposure, vulnerability, resilience and capacities. In particular, how can risk science and knowledge strengthen risk governance, policy and practice to best ensure justice and equity, and support the inclusion of the most disadvantaged and marginalised people and communities. Included in this conceptualisation of marginalisation is marginalisation of sources of knowledge outside mainstream science, including indigenous knowledge. Consultations emphasised the need to better understand how the concepts of resilience and vulnerability guide practice. Models of resilience should not overlook power asymmetries, and there are multiple states of 'desired' or 'aspired for' resilience across different global contexts. Practice needs to ensure inclusion of the most marginalised as part of ensuring that no one is left behind as set out in the SDGs and Sendai Framework (IFRC 2019).

At a strategic level, one of the most challenging questions for global risk and the SDGs concerns how to address global inequalities in their many forms? Such inequalities drive increased marginalization and deepening vulnerabilities among many communities in both developed and developing countries. Confronting inequities, injustices and rising vulnerabilities through new social and economic systems at different scales from local to global should be examined (Folke et al. 2021,

provide a current analysis). Consideration should be given to alternative approaches to addressing global inequalities as proposed for example by Thomas Piketty (2014, 2020), who argues for wealth taxes, public and universal provision of quality education and health care, a redefinition of property to limit ownership, and a global transactions tax. A recent OECD reports examine potential alternative economic systems pre and post Covid (OECD 2019; 2020).

Potential early result: how can risk science best support the development and adoption of tools that enable practitioners to consider risk and its distributional impacts when defining development strategies?

It is a fundamental aspirational aim of DRR and the SDGs that "no-one is left behind", yet many marginalized and less visible people are excluded from risk and vulnerability reduction programs. How can we ensure that the most marginalized are included? One issue is the reliable identification of such groups. Rights based approaches, as used in country reports by the UN Special Rapporteur on Extreme Poverty and Human Rights offer one way forward.

5.3 Priority 3: Enable transformative governance and action to reduce risk.

What formal and informal governance arrangements across the public, private and non-profit sectors, and civil society, can promote synergies between the major global agreements to reduce risk and vulnerabilities?

Transformative governance is about driving fundamental change. Ideally multiple stakeholders from multiple scales, from both formal and informal institutions, need to be involved to help trigger shifts towards sustainability (IIASA 2021). This overlaps with but is different from adaptation or DRR where, "strengthening governance is identified as essential to reduce disaster risk" (Amaratunga et al. , 2020, p. 1), but by itself is unlikely to lead to major change.

The rationale for enhancing governance coherence across the substantive areas covered by major global agreements is that it offers opportunities to develop systemic risk governance capable of working across, and undertaking the necessary transformation to implement, the major global mandates for DRR, climate and human well-being. It should also help avoid duplication across complementary research areas, and missed opportunities for trans-disciplinary social reach and capacity development; it should enable stronger science and knowledge based contributions to the SDGs, Paris Climate Change agreement, New Urban Agenda and other international agreements; and enhanced use of existing networks (i.e. ASEAN; http://www.iai.int) within risk knowledge and science. Coherence here refers to consistency, synergies and being mutually reinforcing.

The use of the SDGs for framing risk is under examination in the world of corporate, private and public organisations (PRI 2017), and could be part of the governance needed for transformations to sustainability. It offers an opportunity to achieve both conventional risk reduction as well as the normative goals of the SDGs. However, much more may be required – in many cases regeneration is required beyond sustainability per se. Understanding the role of different actors including mediating actors is key to providing better support for systemic risk governance. A systemic approach to governance will require a move away from institutional and scientific divides that create arbitrary separations for instance between DRR and development.

Full, or even partial achievement of any one of Sendai, Paris or the SDGs requires similar achievement of the others. An overarching question is how can governance best contribute to this essential integration and critical reflection for risk reduction? Therefore, coherence across the global research network and the identification and examination of what is already known will allow focus on producing the required knowledge. Another approach would see emphasis on informal

networking and governance structures, possibly aided by technology.

Potential early result: what is known across science and other sources of knowledge including commerce, about integrative governance and action for DRR, climate change adaptation and the SDGs?

5.4 Priority 4: Understand the implications of new thinking on hazards.

The ISC/UNDRR 2020 report on Hazards Terminology and Classification redefines hazards in the context of DRR, drawing on the Sendai Framework. The redefinition of hazards goes far beyond the traditional hazards of floods, drought, storm fires etc, and extends to most biological technological, some societal hazards, and by extension most of the hazards that climate adaptation and the SDGs are explicitly intended to avoid or redress. It does however not include hazards related to violence and conflict, although some countries are reporting on these hazards under the Sendai Framework Monitor, and "armed conflict" and "social instability and tension" are recognised hazards in humanitarian law (The Hazards Terminology and Classification Report. p30)

The report "was guided by the definition of 'hazard' adopted by the United Nations General Assembly (UNGA) in February 2017". ; namely, "a process, phenomenon or human activity that may cause loss of life, injury or other health impacts, property damage, social and economic disruption or environmental degradation". (Note that in practice some substances were also included.)

Importantly,

> "Hazard information when combined with exposure, vulnerability and capacity is fundamental to all aspects of disaster risk management, from multi-hazard risk assessments for prevention and mitigation to warnings and alerts, to disaster response and recovery, long-term planning and public awareness."

Sources of knowledge and experience outside science, such as local and indigenous knowledge, would be especially valuable in many contexts in this priority. Further work on vocabularies covering the sustainable development goals (SDGs), as well as incorporating local hazard terminology, is recommended for future versions of the 2020 Hazards Definition and Classification report.

Other key issues concerning hazards include:

- ***Understanding new forms, or newly common, extreme hazard behaviour***: this is related to the need to understand emerging complex and systemic hazards and risks. These are emerging from the traditional DRR suite of hazards, for example, extreme flame behaviour in wildfires, extreme heat and atmospheric changes interacting with other potential hazards; as well as occupational hazards; chemical hazards such as persistent organic pollutants and endocrine disruptors; and economic and livelihood hazards arising from Globalisation, and now from a biological hazard in the form of Covid-19, itself arguably, at least in part, a product of Globalisation.
- ***Understanding interactions with other hazards, vulnerabilities etc***. These have sometimes been seen as fairly linear and almost obvious, such as extreme heat and wildfires, but can be very complex and potentially systemic as with Covid-19 that highlights the coupled interactions between human/social environment and nature – and this is with respect only to the virus, rather than the systemic impacts of the disease. Armed conflict constitutes a particular challenge both as hazard, and as a potentially risk magnifying context for other hazards such as flooding or crop diseases. Our knowledge of these potentially very complex interactions is limited; a start would be to determine how research could best address this.

- ***Targeted impact-based forecasts and warnings.*** Improved early warnings, in terms of reliability and lead-time, are desirable for all hazards, and essential for many where warnings are poorly developed. An early warning system needs to be an end-to-end system consisting of its essential elements that work together to create a single, cohesive and robust process. Accurate forecasts of hazard behaviour, based on understanding of the hazard, are a key input for warning messages. Assessment of exposure to the hazard and the vulnerabilities of what is exposed provides information on likely impacts in the areas needing the forecast and warning (e.g: Relief Web, 2021: n.p). This is also a major focus of the Hi-Weather impact based warning project led by WMO. There are many related activities, for example, the Climate Risk & Early warning Systems (CREWS) Initiative.

Potential early result: how to develop and action impact-based warnings drawing on multiple disciplines, agencies as well as the private sector and civil society?

5.5 Priority 5: Harness technologies, innovations, data and knowledge for risk reduction

Rapid technological advances in Artificial Intelligence, digitalisation and analytical capacity, among other areas, and the very widespread adoption of mobile devices and social media, are driving major changes in our lives and have the potential to contribute to all aspects of risk reduction and disaster management. They can also create new risks and systemic vulnerabilities from the misuse or unintended consequences of the technology. This duality in a hyperconnected world is exemplified by Covid-19 - in how the disease spread, but also in how knowledge and expertise are shared and the related ethical issues. Understanding and managing contemporary connectivity is therefore a key part of resilience building. Specific points emphasised on-going technical developments of relevance to DRR as set out below. In addition to our consultations (see Appendix 1 for further details), this section draws on the expertise of ETH Zurich working on emerging technologies, DRR and the public (2021). It also draws on the expertise of the international Codata group, the IRDR Data Working Group and AIR at the Chinese Academy of Sciences. Codata has produced a report (Next Generation Disaster Data Infrastructure, 2019) which attempts to integrate data needs across DRR, climate change and the SDGs.

Modelling and technical capacity are currently very limited with respect to global and lower level systemic, cascading and compound risks, even though some models such as global climate models and models of the global economy are well resourced and widely used despite many uncertainties. Improved understanding of the emerging global risk landscape is at least partly dependent on better modelling of the underlying processes. Global information and communication technologies can help with risk reduction and the achievement of the SDGs, but they are also leading to other forms of inequality.

Some potential areas for further exploration and study include:

- **Digitalisation** is the defining technological trend of our era. The increased connectivity where everything is being connected to everything else, our dependency, or over-reliance, on such systems including for logistics and retail, and their huge energy requirements, increases social and economic vulnerabilities and creates new systemic risks. Uneven access to the beneficial aspects of digitalistion and its widespread use for surveillance, fraud and misinformation are exacerbating inequalities and creating new forms of vulnerability. These new types of risk affect all stages of DRR and sustainability and are not well understood (Renn et al 2021).
- **Artificial Intelligence (AI) capabilities** are developing rapidly and promise greatly enhanced analytical capability. This is especially the case for complex and novel risks. At present AI lacks

judgement, and brings a range of ethical and legal issues which need addressing;

- **Big data and social media** offers the ability to widen the social reach of risk information and to guide engagement at national and international levels to influence social change, as well as humanitarianism. It can greatly expand the scope of inclusion through crowd-sourced data and analysis (Akter & Wamba, 2019). Through its capacity to visualize, analyze and predict disasters, big data is changing humanitarian operations and crisis management. This in turn raises the issue of how the data and the outputs created from the data, are managed and made accessible[1]. A key issue is the promotion of accessibility and exchange of data from multiple data repositories.
- An overarching issue concerns **the interaction between people and the new technologies**: we need to understand what factors impede and what support the technologies in achieving their promise of inclusive risk reduction – rather than for example risk shifting or creation; and how the technologies can be better used to support the SDGs and risk reduction eg through enhanced public engagement (such as UNDP 2021 UNDP-Oxford-Peoples-Climate-Vote-Results.pdf), and organisation.

Potential early result: what factors impede and what support the technologies in achieving their promise of inclusive risk reduction – rather than risk shifting or creation?

5.6 Priority 6: Support regional and national science and knowledge for policy and action

Each region of the world is likely to have its own unique concerns and priorities for both disaster risk reduction and global risks. (Precise delineation of each region is yet to be settled.) While the Global risk priorities set out above apply in most places, the details, priorities and day-to-day lives of the people will vary. Regions have distinctive mixes of hazards, exposures and vulnerabilities, with their associated interdependencies, capacities and governance structures and trends. They also have their own approaches to, and priorities within, the SDGs and other global agreements, as well as trends in demographics, economies, livelihoods, governments and human security. It is also likely that regional priorities are important at the global level, and should be part of a re-appraisal of the existing priorities. Capacities here refer to the availability of resources, as well as expertise, trained people and governance and inclusion. However, importantly simply having capacity does not necessarily mean it is used effectively.

Members of the IRDR community (the IRDR Scientific Committee, the International Centres of Excellence the National Committees and the Program Office and its own networks) were asked to identify regional concerns where different from the Global priorities already identified. This was seen as a starting point in identifying current key regional issues and priorities. Some examples follow. Further regional engagement is required. The IPCC Regional Assessment reports could also help provide relevant information.

- *South and Central America* – focus on vulnerabilities;
- *North America* – institutional complexities arising from complexity of vertical and horizonal governance responsibilities;

1 Ethical considerations on data access and use as well as recognising the need for data to be 'FAIR' – findable, accessible, interoperable and reusable - are essential. Partnerships for understanding and reporting of disaster related statistics is critical and should include UNECE, the Inter-Agency and Expert Group (IAEG) on Disaster-related Statistics (set up as per the decision (50/116) of the UN Statistical Commission taken at its 50th Session in 2019), UN members states National Statistical Offices with the area of research being of relevance to the UN World Data Forum and other UN reporting mechanisms

- *Asia* – Issues of coherence and governance and highly uneven resoucing;
- *Pacific and other SIDs* – Climate change and justice issues are seen as key: mitigation, retreat, climate evacuation/diaspora. The context is one of small countries with rapid urbanisation, low levels of development and services of all kinds including those related to the SDGs, and low capacities.
- *Africa* – governance, especially for transboundary risks. Conflicts in places, large population movements and limited resourcing;
- *Europe* – all hazards of significance with climate and industrial hazards dominating. A challenge is the development of models of integrated risk management incorporating multi-risk events and their impacts on justice and equity. The context is one of many very different countries, with the EU providing an overarching body assisting with risk reduction and management.

Potential early result: How can regional research leadership bring substantive global research together with national and local contexts to drive inclusive risk reduction to reduce vulnerability and risk in future development?

5.7 Priority 7: Supporting just and equitable transitions, adaptation and risk reduction

The concept of "just transitions" comes from concern that those employed in some sectors will lose their livelihoods as economies are decarbonised in response to the climate crisis (IRGC 2021). The process for achieving this vision should be a fair one that should not cost people or communities their health, environment, jobs, or economic assets – in other words, does not increase their vulnerabilities, and works instead to promote the SDGs (linked to Priority 2 on inequalities). Major transitioning has happened many times in history with examples including automation of mining, agriculture and much manufacturing (WRI). Many affected in this way historically have not found new comparable employment.

> "A just transition for all towards an environmentally sustainable economy … needs to be well managed and contribute to the goals of decent work for all, social inclusion and the eradication of poverty." (International Labor Organization 2015).

In this priority the scope of "transition" is broadened to include justice around disaster risk reduction and climate adaptation: how to ensure just and equitable transition to a sustainable less risky world? Issues surrounding just transitions are seen as being particularly urgent in the Global South.

Across the world, there are large informal workforces with low livelihood security, no formal safety nets and who are usually not represented in public discussions about major change. There may also be significant gender dimensions with livelihood insecurity. Negative impacts vary with the circumstances and the type of measure: for example, from low for warning systems through to very high with permanent relocations, and loss of livelihoods and identity. There are also strategies with significant environmental impacts such as major engineering works. Disaster risk reduction can result in major relocations, loss of livelihoods and sense of community, unaffordable housing as a result of new requirements; and in the case of humanitarian aid - unintentional undermining of local economies and livelihoods.

However, the immediate severe disruption to most national and sub-national economies and sectors by Covid-19 provides some good examples of rapid adjustment by government, the private sector and civil society. These are generally seen as temporary, whereas permanent shifts are required to

bring economies into line with climate change adaptation and decarbonisation, to implement the SDGs, and to reduce disaster risk. Unfortunately, there are also cases where authoritarian power has been extended and basic rights as set out in the SDGs ignored or reduced under cover of the Covid-19 pandemic.

There is also some positive action: the European Union has established a Just Transition Mechanism, which will fund projects that are consistent with EU climate and energy goals. This is for the regions most affected by the transition to carbon-neutrality, and is part of the EU crisis response mechanism. Social transfers can be important, but secure livelihoods and implementation of the other SDGs are needed for a sustainable future. This requires more than action by higher level governments. City and local organisations are often key to managing transitions but can lack the necessary power and capacity. Impediments to local organisations and innovative solutions and restrictions on civil society and local community actions need to be removed. Although there is some government and corporate action especially in the Global North, peer networks and learning may be more useful at the local and municipal level.

Potential early result: How can relocations driven by transition, adaptation or disaster risk reduction, be undertaken to minimise the impacts on livelihoods and identity?

5.8 Priority 8: Measurement to help drive progress

What do we need to measure and how can measurement be designed to incentivise improved risk knowledge and progress with risk reduction and development?

Recommendation 5 of the 2020 *Hazards Terminology and Classification* report is to:

> …"operationalise parameters for exposure, vulnerability and capacity, building on the UNGA definitions. … Much work has been done in defining and standardising parameters for exposure in the context of natural or geophysical hazards, and in defining indicators of vulnerability for disaster risk reduction, but no consensus exists in the definition or application of exposure or vulnerability for use in risk assessment across the list of hazards within the broad scope of this report. …"

Measurement is generally undertaken for an assessment purpose such as evaluation or assessing progress towards an objective. This can take place at multiple scales from the individual components of risk through to global processes. It includes evaluation of risk reduction options and their impacts, across systems and sectors, with the aim of helping to determine incremental and transformative strategies to achieve inclusive risk reduction and development imperatives. Measurement, monitoring and evaluation I sonly useful if it feeds into a process for review and improvement.

There are many indicators for the constituents of risk, but they are subject to many shortcomings. A challenge is to develop indictors or measurement tools that incentivize positive change. There is some existing work in this area: for example the development of indicators to drive risk literacy and awareness, and associated behavioural transformations, at a societal scale (see CSER 2021). Measurement is especially an issue in understanding systemic and complex risks, as well as existential risks, where uncertainty is often very large and important aspects of the risk may be unknown. Ultimately, the broader need is to assess progress in meeting risk reduction and development objectives such as those set out in Sendai, the SDGs and other global frameworks. These have their own targets and indicators of progress. However, as with those for the elements of risk, these indicators are often contested.

Potential rapid impact: how can we best measure progress with reducing risk in development through addressing Priority Theme 2 drawing on current knowledge and experience?

5.9 Priority 9: Foster trans-disciplinarity and multi-stakeholder collaboration for solutions to risk challenges

Researchers and knowledge holders across DRR and risk science frequently observe that there is much in the way of research results and other knowledge which appears useful, actionable, and pertinent to the policy or practice issue in question, yet lies unused (Albris et al 2020; ISC 2020) – well articulated in the European Environment Agency's reports on "Late Lessons from Early Warnings". This issue was raised directly or indirectly in most of our consultations, and affects policy and practice across public, private and non-profit sectors.

However, there are many exceptions where research does inform policy and practice. These include, for example, the information and communications sector, finance including transactions, reinsurers, aviation safety and in the public domain much of the health sector, surveillance and some service provision. There is also extensive knowledge held by practitioners in the form of experience and practice, and traditional knowledge held by indigenous and local communities. Unlike modern science which is codified and published, this knowledge is often documented in other ways and less recognised globally. This Agenda emphasises the need to provide legitimacy and mainstreaming to all sources of knowledge.

Why are research, discussions and policy debates seemingly often not influencing change? For a start, knowledge needs to be in actionable form to be useful for the risk reduction task. And the challenge is to develop effective ways of ensuring it informs policy and practice, in an environment of competing personal, institutional and political priorities, and which can be hostile to science and technical expertise. The transdisciplinary nature of risk science and knowledge, bridging sectors and stakeholders may be central to finding solutions.

For this to happen, science and scientists need to change. The transdisciplinary nature of risk needs to be reflected in the way knowledge is developed, organised, communicated and applied. We need a substantial shift towards a more inclusive integrated approach if major risk problems are to be addressed. The responsibility for this shift should be shared among all knowledge holders and users. A starting point could be provided by the many existing international, national and sub-national networks of interest, however most are weak at integrating research and practice. The many active networks of the Global South could be better connected with the North for mutual support. Mapping these networks could be a useful exercise to improve collaboration and sharing of expertise and resources (also see Section 6). An important limitation of (most likely all) these networks and the associated mapping is that they represent formal arrangements and rarely include local communities, the private sector or representatives of the often more creative and innovative arts and humanities. The scope for more informal networks and arrangements is large and they could be more effective.

Potential early result: what are the most effective ways of developing and supporting networks of practice and knowledge to enable exchange and development of ideas and interaction with policy and practitioners?

6 Pathways to impact and transformative change

> *We need to make the "last mile our first mile". We need to be more responsive to the heterogeneity of the community and its needs. We need more grassroot and social innovation in the field of DRR, and there needs to be a platform for social innovation in DRR, leading to entrepreneurship development (Prof. Rajib Shaw, from Agenda Engagement Process).*

Framing research priorities is one thing but pursuing them and achieving the desired impact and transformative change alluded to throughout this agenda is a separate challenge altogether. Ultimately, our vision is for risk science to support risk reduction in terms of both what is known (i.e. understanding risk) and how various forms of knowledge are put into action (i.e. disaster risk action and governance and the governance of how 'science' is done in the future in relation to equity within decision-making and practice, implementation and funding). There is a great deal to unpack within this, and this section outlines some pathways and considerations in implementing the risk science agenda and its priorities. We acknowledge the broad and general nature of these pathways, and stress the need for each to be evaluated, discussed and applied appropriately according to context and local realities to create a diversity of pathways and approaches to implementation.

As Bauer and Kirchner (2020) note the apparent effectiveness and attractiveness of change does not by itself ensure implementation, which depends on a wide range of contextual, incidental and deliberate impediments and enablers. Similar sentiments are being echoed in various COVID 19 pandemic implementation efforts globally https://www.un.org/en/pdfs/UNCOVID19ResearchRoadmap.pdf; with the pandemic (on the back of many armed conflicts, the disastrous 2019-2020 bushfires in Australia and the Western US; among other major disasters) threatening progress on the SDGs and providing a rich lens to shine into the deep corners of complex risk and vulnerability. Given that the global risk landscape is increasingly diverse and complex, we need to inspire increasingly diverse and inclusive approaches to coping with risk and vulnerability in equitable ways.

The knowledge-to-action challenge

To achieve transformative change at a societal scale, the transfer of knowledge from all sources to policy and practice (i.e. 'action') needs to be much more effective. This transfer should be in the form of a dialogue between all those involved. While significant bodies of knowledge and evidence on risk and DRR exist within an array of scientific disciplines and stakeholder and local groups, they can be fragmented, inaccessible, and not applicable to risk reduction decision-making, practice and implementation. This may be due to a number of factors, such as ineffective knowledge production, limited multi-stakeholder collaboration especially of those bearing the risks, uncertainties and a perceived lack of legitimacy of scientific evidence, limited capacity, cognitive and political biases, power imbalances, and social inequalities. This challenge partly explains the limited progress towards international goals and national priorities, and the need for science and action to work more closely together to address growing challenges and meet transformative goals.

Box: The knowledge-to-action challenge

It is our intention that this Agenda actively addresses this science-to-action challenge through its implementation across a range of ways in which DRR knowledge is framed, contested and carried by and across various geographies, cultures, sectors, and spatial and temporal scales. Implementation

approaches need to be conscious of these implications and challenge and make space for different forms of knowledge in governance and decision-making to drive progress. More than ever before, the confluence of rapidly increasing risk trends and slow DRR progress demands more meaningful and inclusive collaboration across scales, geographies, disciplines and sectors, and more progressive governance approaches to risk reduction.

The ways in which the disaster risk reduction challenges are framed and more importantly by whom remain key challenges in creating a just and fair DRR agenda. Such vital considerations encourage the collective questioning of the ethics and openness of the current science system. The science-to-action focus highlights the need to examine the legitimacy of current scientific knowledge creation and validation processes, and the equity and inclusion of wider groups within this multi-scaled dialogue.

In this vein, engagement on this with the global caucus of indigenous scientists organised as part of the development process for the agenda, emphasised that achieving impact and transformative change will require more open approaches to judging the scope and validity of what counts as 'relevant knowledge' (where such scope and validity in general continues to be framed by orthodox, largely western hegemonic spaces of 'science' knowledge (Menzies and Butler, 2019; Cash et al., 2003; Cash and Moser, 2000)). The democratisation of science also requires a more pluralist and equitable framework (Jacobson and Stephens, 2009). There is a strong aspiration for respectful integration, where the legitimacy of, and trust in, science will be enhanced with more active attention to respecting differently situated knowledge cultures – recognising that legitimate knowledge is derived and tested in diverse ways and not solely contingent on what are considered scientific methods (Whyte, 2018; Sarkki et al., 2014).

In line with the vision of this agenda, science working across disciplines, sectors, groups and with communities and other sources of knowledge, is actively encouraged as fundamental to achieving transformative change. Open science prepared to work in a trans-disciplinary manner is integral to this vision, playing a generally supporting role with fields of science and practice, communities, informal networks and collectives working together, and it is important to underscore that generic approaches do not fit all contexts.

This is the key reason why the operationalisation of the research priorities outlined in the agenda is challenging, and solutions need to be designed for the unique circumstances of each location and community by those involved. This section does not seek to be prescriptive, but instead inspire innovation and enable diverse viewpoints (from Indigenous communities, local and informal groups) to have visibility within future dialogue on risk. With the Agenda's vision of risk science's contribution to transformations to a lower risk, more sustainable world in mind, the following pathways have emerged out of Agenda development processes.

Insert Figure here - The following graphic will outline various pathways to action, e.g. one pathway relating to enhanced vulnerability (in all its dimensions mapped out); data pathways and the ethics of this; capacity and other needs development etc.

6.1 Pursue trans-disciplinary science and multi-stakeholder knowledge co-production

As highlighted at various points, the trans-disciplinary and multi-stakeholder emphasis of this agenda

is reflected in engagement on the agenda's development, which drew on diverse perspectives (from Indigenous scholars, community perspectives, through to private sector and broad stakeholders).[2] See also Priority 9 in Section 5 above. From the outset this agenda has strongly promoted the empowerment of plural knowledge frameworks, and acknowledgment of plural solutions. Risk science alone, while of significant value with regard to deepening society's understanding and engagement with risk and vulnerability, will not facilitate the required transitions to enable global society to cope better with escalating risk. Risk science needs to be much more collaborative, trans-disciplinary, accepting of, framing of the issues at hand and working with other sources of knowledge, and with those who fund and implement the evidence generated by science. This will require a multi-scalar, persistent and inclusive project of iterative and constructive dialogue between diverse knowledge disciplines/cultures that accounts for diverse, place-based ways of knowing across spatial and temporal scales.[3]

6.2 Enhanced emphasis on multiple contexts in which the roots and expressions of vulnerability to disaster risk may be located.

There is no 'one' single view of what a disaster is. It is therefore critical to recognise different ontologies in understanding disasters as well as diverse approaches and epistemologies in researching them. One pathway for DRR science-led research agenda should therefore be more locally-led (ground-up), national, regional and international agendas for effective risk reduction, as the recent COVID-19 pandemic has shown us in stark consequence at an international scale. As part of this we need enhanced emphasis on the constructions and measures of vulnerability (as per Priority Area 2, Section 5).

There is an overwhelming need to also better frame and understand what is meant by vulnerability, how and what is to be effectively measured (e.g. dynamic vulnerability) particularly in the context of systemic risk, tipping points of intersecting vulnerabilities, and various other parameters "to strengthen human vulnerability reduction and more clearly determine incremental and transformative strategies to achieve inclusive and sustainable resilience" (Pelling, 2021).

6.3 Enhanced data acquisition, management and implementation

Linked to the issues of the initial framings of risks as outlined above, there is also the need to carefully consider the ethical and justice dimensions of what and whose data counts. Often the need for technical data, while essential, can overwhelm and preclude the necessary debates and critical thinking on the role of more tacit and local data that may also be required to effectively reduce disaster risk. Creating spaces for this form of engagement, by local practitioners and various knowledge holders, including greater participation by social scientists (e.g. anthropologists, philosophers, ethicists and political scientists), can help expand the discourse on data. Priority guidance and governance guidelines or frameworks, for example, providing guidance on appropriate mechanisms for engaging with and integrating diverse forms of data and knowledge (traditional and indigenous science, policy ready and actionable knowledge) will be needed.

Depending on the issue at hand, data infrastructure is increasingly seen as central to the implementation and monitoring of policy. The infrastructure includes the organizational structures,

[2] Integration between disciplines and sectors is also recognised in Priority 9 (Section 5), which outlines the need to develop formalised channels for dialogue and outcome focused information sharing.

systems and technologies involved in all aspects of data collection, protection and use. Such infrastructure can help integrate and make accessible ideas and information form diverse sources. This would assist risk science, as it is inherently an integrating domain that draws from, and contributes to, a wide range of disciplines, forms of knowledge and professions. See also Priority 5 (Section 5).

6.4 Rapid social learning systems that are mindful of various knowledges, values and belief systems

An issue in much implementation is the need to adjust and adapt as implementation proceeds. Rapid learning systems use the best available evidence and local data to inform decisions and commit to learn from their experiences as quickly as possible to enable continuous improvements and to contribute to the global evidence base:

> "… to rethink how to address the present need for more knowledge in disaster risk reduction constructively—as one thing seems certain: we will not need less knowledge going forward" (Albris, Lauta and Raju, 2020: pp. 10).

In addition, this relates specifically to this Agenda, which needs to remain flexible and adaptable as needs for and priorities of risk and risk reduction 'science' change. This will require a process for regular monitoring of the global risk landscape, and review and updating of the agenda as needed. Importantly, evolving priorities need to be seen as desirable in a highly uncertain environment and necessary to ensure the currency of the Agenda. Change in these circumstances is in no way a criticism of the original Agenda. Rather it is an acknowledgement that it is designed to evolve. To do this we need to better identify knowledge needs and gaps, and build in the flexibility to address new priorities as they emerge. This also indicates a need for a mechanism for renewal and updating of priorities to ensure that priorities written in 2021 are not static and redundant by 2030 (and beyond). We suggest that as part of the implementation of the Agenda that a regular review and updating process for the Agenda is agreed.

6.5 Collective and concerted efforts on capacity enhancement to reduce risks

The ever-changing disaster risk landscape is also prompting a change in capacity, training needs including the long-standing issues of building an inclusive risk awareness and risk literacy,[4] as well as risk management capability. Here once again the need for a more expanded recognition of the types of knowledge is needed – how this knowledge is framed, understood and gathered. The ability to 'make sense' of the types of knowledge gathered and then how to interpret and assess risk, science-policy-practice,[5] and then derive management linkages is also critical. Training in networking and negotiation skills is likely to become more important in terms of working in and developing a trans-disciplinary and cross sectoral approach.[6] Enhanced governance and organisational structures – including those led and informed by community perspectives to understand and act on reducing

[4] For example, innovative tools such as using comics and scientific literature to promote risk awareness: https://www.weforum.org/agenda/2020/12/3-scenarios-for-how-bioengineering-could-change-our-world-in-10-years/

[5] See: Submission of Evidence to The House of Lords Select Committee on Risk Assessment and Risk Planning (UK) https://www.repository.cam.ac.uk/handle/1810/317467

[6] As an example: https://www.cser.ac.uk/news/new-report-pathways-linking-science-and-policy-fie/

risks (integrative governance and action for DRR) are needed.

6.6 Open science

> *… for me as a scientist, sort of stepping back a little bit … we're really just providers of tools and other ways of doing things that can be led by others in the community … as scientists and practitioners, we provide tools that can help society deal with rapid change at all kinds of scales ... [these] tools can only be improved by opening them up and sharing them [beyond the science community]" (from the Indigenous consultation)*

Open science is about building on epistemological, institutional and strategic gaps as well as building capacity and resources that limit the transfer of knowledge from science to policy and practice and from practice-policy and back to science - and thereby enhancing risk awareness (and informed decision making) in society (Albris, Lauta and Raju, 2020).

The Epistemological Gap refers to the fact that science and policy, and subdomains within each of these, have different interests and worldviews when it comes to the very conception and framing of knowledge, and what it is to be used for. Some of the differences between these worlds make it inherently difficult to integrate the results of research into disaster risk reduction practices. Improving upon ways in which practitioners, policy makers, scientists and researchers can better engage and communicate complicated material around the pressing matters inherent in risk reduction and awareness in a collaborative manner is needed.

The integration of science and policy for risk reduction is not only a matter of dealing with different types of knowledge and the management of uncertainty. It is equally about governance and institutional building. Current weaknesses and impediments to building institutional and governance capacity in diverse contexts and scales can be described as **Institutional Gaps**. In order to effectively contribute, the risk science community's role must be clearly identified in relation to the government system in question (municipalities, agencies, ministries, and so on).[7]

The Strategic Gap refers to the lack of common vision on how to progress. One of the key issues for the strategic gap is that of communication. There are few outlets for scientists and related policy-makers to debate and discuss issues of relevance and strategic long-term outlooks.

- On the global stage, standards and international frameworks such as the Sendai Framework (UNISDR 2015) have proposed trajectories for the involvement of science in disaster risk-reduction policies at the local level, integration and knowledge transfer tends to take place in a sectorial fashion rather than in a cross- or multi-sectoral fashion.
- Although international frameworks such as Sendai place great emphasis on risk reduction and capacity development, including educating and nurturing of disaster expertise, there has not been a similar level of focus on such aims at the national and local levels.

  Scientists for their part need to understand cultural and institutional nuances in order to create knowledge inputs for sustainable, holistic policies, while policymakers need to develop and embrace more nuanced ideas of innovative knowledge production for disaster

7 The connection between science and policy is considered to be a priority in implementing the Sendai Framework (Pearson and Pelling 2015), the central issue at stake is how to set up the most effective and useful institutional arrangements that allow the scientific community and scientists employed in government entities to contribute to disaster risk reduction.

risk reduction. However, these two dimensions also sit within complex localised contexts that need to be part of the discussion.

6.7 An action plan for Implementing the Agenda

To achieve such an action plan a number of enabling contexts and factors will need attention. Some of these are outlined below. Across all these factors transitions to lower risk and greater sustainability need to be just and equitable as set out in Priority 7 above in Section 5.

6.8 Networks and communities of practice

One of this Agenda's research priorities concerns the need for interdisciplinary knowledge including experience, working with those in policy and practice. This would include a wide range of existing networks, both led and concentrating on a range of 'networks' e.g. grassroots communities, business communities as well as those led and hosted by scientists the ISC, UNDRR, GAR, IPCC, Future Earth, GAUDRI, IRDR, La Red, Periperi U, private sector and non-profits, WEF, and various research organisations and think-tanks including Global Future Council on Frontier Risks, the Centre for the Study of Existential Risk, Future of Humanity Institute, and Future of Life Institute.

There are also many faith-based networks active in risk reduction and supporting affected people – the international connections of such groups can be particularly effective in mobilising support and expertise. There are some connections across these groups, but they need strengthening and linking with networks of practice and policy. Often these are in the form of professional associations for all types of work and interests, local government groupings and higher-level intergovernmental forums. [please add specific examples] A wide embrace of the 'network of networks' thinking to bridge between actors, paradigms and approaches, across various scales (as explained in section 5.3) is needed.

There are incentives for these existing networks and hopefully new networks and communities of practice to take an active role in promoting and implementing the agenda. The main incentive is to reduce the chance that disasters will affect the people and communities, their livelihoods and businesses as well as co-dependencies on environment and ecosystem services. An incentive would also be to lessen the impact of disasters on the security of food, water and supply chains. Another incentive for some groups is to develop positions on common interests as a step in influencing policy and practice. [The indigenous caucus organised as part of the development of this Agenda is an example of that could continue as a higher-level international/transnational policy discussion on disaster risk.]

This Agenda aims to contribute and complement other Global science processes and activities; is focused on 2030 in line with the UN Agenda for 2030, and beyond; and needs to develop a range of collaborative implementation approaches with [stakeholders, actors] in industry, finance, health and other sectors to ensure relevance and uptake of research progress and possible solutions by society and in the mechanisms of risk governance, policy and decision making.

A potential action pathway

A major issue facing the interface between science, policy and practice in disaster risk reduction is the lack of platforms and structures that not only enable sharing of knowledge between researchers and government institutions, but also enables the application of knowledge in policies and being

informed by effective social practice (Amaratunga et al. 2017b). (See also Priority 9 above in Section 5.) Risk web-platforms and related online repositories for knowledge sharing, such as the United Nations Prevention Web, also indicate that the tide is changing with respect to the perceived relevance of scientific knowledge in policy (Antofie et al. 2018). Many national examples of such arrangements also exist. The German Climate Consortium has brought together several scientific institutions since 2008 to synthetize scientific findings on climate change (Marx et al. 2017). In Switzerland, the recognition of the issue of knowledge transfer and sharing has given rise to the creation of The Mobiliar Lab for Natural Risks in 2013, a private/public partnership hosted at Universita¨t Bern to bridge the interdisciplinary gap between science and disaster risk management practice (Booth et al. 2017). A recent positive initiative comes from DEFRA (UK) which has launched a catastrophic risk project and the UK Parliament is advocating legislation for the well-being of future generations.[8] Significant challenges still prevail in allowing scientific research and technological innovations to have a real impact in the domains of governance and policy.

While efforts are being made (especially in the EU[9] and XX) structural mechanisms are lacking for bringing diverse knowledges together to inform and enrich the multi-scalar, trans-disciplinary (and trans-boundary) dialogue on risk and vulnerability.

A specific example of what could be done

For example, scientists working with local communities asked how a platform could be created for dialoguing with diversity in equitable and respectful ways, and whether current global science mechanisms (led by organisations such as the ISC and the UN) can support this as a strategic objective.

Additionally, commentary from ISC stakeholders, ERG and Core Group members raised the need for developing improved forums for knowledge sharing (between science, policy and practice communities, public and private sector interests, government and academic institutions situated in developed and developing contexts); and, for raising the visibility and enhancing the legitimacy of alternative knowledge holders, such as informal groups, as well as activist and advocacy groups.

6.9 The need for actionable knowledge

Refocusing and augmenting the existing risk science ecosystem so that new and pre-existing knowledge is available in forms that are actionable, is a key priority in implementing this agenda. This means supporting progress towards enhanced integration between science and other sources of knowledge, with communities of practice and policy. The aim being to improve the accessibility and inclusion of risk science at the forefront of wider discussions beyond the DRR realm, including societal risk, sustainability and development.

This means working with those expected to implement the agenda, at whatever level from international organisations through to communities and households. Extending the ethos that grounds this Agenda, this means a greater emphasis on co-production of knowledge with all stakeholders and a deepening or relationships between the science community and wider knowledge and implementation communities. This approach will ensure all have ownership and see

[8] Refer: https://bills.parliament.uk/bills/2477

[9] https://ec.europa.eu/info/research-and-innovation/strategy/goals-research-and-innovation-policy/open-science_en

the risk-based knowledge developed by diverse processes of co-production as their own, as useable and informative, and hence it should be better implemented.

Overall, the success of this agenda will rely on the relationships built during the process of design and implementation and the buy-in achieved and invested in across disciplines and sectors.
[input required – are their other approaches to achieving actionable knowledge?]

6.10 Funders/donors are a critical part of this process

[See also Chapter 4 of the 2021 UN Report on Covid-19 recovery research discusses this issue under "Science of science".]

Implementation of the priority areas requires funding. Funders and donors are part of the development process of the agenda research priorities, to encourage investment in the identified areas and can either enhance or reduce DRR vulnerabilities (Eriksen et al., 2021).

Ideally, research funding would contain incentives to help promote the aims of the agenda, DRR, climate change adaptation and the SDGs: this would mean funding and research that is more inclusive and more focused on practical impacts. The best way to achieve these aims is itself a research question. Some major funders of research provide at best limited support for the type of use inspired science called for in this agenda science. For example, in the United States, the National Science Foundation prefers to fund less applied work, even on transformation). Other sources of funding exist from the various agencies but their research programs are relatively small. [Input on gaps/limitations in current funding and funding mechanisms, especially outside of major events.]

6.11 Caveats and challenges to implementation – The precautionary principle

[can this be moved up in this section? Or expanded with examples?]

The precautionary principle emphasises caution and the need for pausing and review before implementing innovations that may prove disastrous. As such, the precautionary principle is of practical relevance as much to risk assessment as to risk management. Precaution also calls for deliberate and comprehensive attention to contending policy or technology pathways (Stirling, 2007). Far from being in tension with science, precaution offers a way to be more measured and rational about uncertainty and ambiguity, acknowledging that attempts to assert a single aggregated picture of risk are neither rational nor 'science-based'.

7 List of abbreviations and acronyms

Abbreviations and Acronyms	Definition
AAAA	Addis-Ababa Action Agenda
Agenda for Humanity	Annex to the Report of the Secretary-General for the World Humanitarian Summit (2 February 2016)
AI	Artificial Intelligence
ASEAN	Association of Southeast Asian Nations
DRM	Disaster Risk Management
DRR	Disaster Risk Reduction
Ex-ante	Before a disaster event
Ex-post	After a disaster event
GAR	Global Assessment Report on Disaster Risk Reduction
ICoEs	International Centers of Excellence
IoT	Internet of Things

IPCC	Intergovernmental Panel on Climate Change
IRDR	Integrated Research on Disaster Risk
IRDR ED	Integrated Research on Disaster Risk: Education
IRDR SC	Integrated Research on Disaster Risk: Scientific Committee
IRDR Science Plan	A Science Plan for Integrated Research on Disaster Risk
ISC	International Science Council
NCs	National Committees
The New Urban Agenda	
The Paris Agreement	The Paris Agreement on Climate Change
Post-2020 Global Biodiversity Framework	Convention on Biodiversity Post-2020 Global Biodiversity Framework
PPMW systems.	Public Participatory Monitoring and Warning systems.
STAGs	Science and Technology Advisory Groups
SDGs	Sustainable Development Goals

Sendai Agreement	Sendai Framework for Disaster Risk Reduction (2015 – 2030)
UN	United Nations
UNDRR	United Nations Office fro Disaster Risk Reduction
WEF	World Economic Forum
2021 Horizon Europe	Horizon Europe Strategic Plan (2021-2024)

8 References

[References for work cited in the literature reviews are found in the relevant appendices]

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9 Appendices

[see separate document]

[The appendices are under development]

List of Appendices

Appendix 1.0: **Agenda Consultation and Development Process (as of April 2021)**

Appendix 2.0: **Members of the Leadership, Core and Expert Review Groups**

Appendix 3.0: **Global Risk Science Landscape Overview.**

Appendix 4.0: **Research agenda background literature review paper.**

Appendix 5.0: **Details of research priority areas from Section 5.**

Appendix 6.0: **The IRDR 2008 Science Plan summary**