IRDR
Integrated Research on Disaster Risk

2010–2020

COMPILATION: A TEN-YEAR SCIENCE QUEST FOR DISASTER RISK REDUCTION

Mobilizing Science for
Disaster Risk Reduction and Development Safety

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Note on cover design: The shadow on the number 2010-2020 implies the global increase of disaster risk. The symbolic world map is filled with the phrase of 'disaster risk reduction' in different languages.

Preface 1

We live in unprecedented times. In the ten years since the establishment of the Integrated Research on Disaster Risk (IRDR) program, disasters such as the 2010 Haiti earthquake, the 2013 Haiyan typhoon and the current COVID-19 pandemic have upended lives and livelihoods. Hazard events are becoming both more frequent and intense because of human-induced climate change, exposing vulnerabilities that undermine resilience building and sustainable development.

The Sendai Framework for Disaster Risk Reduction 2015-2030 sets a clear agenda for global action to reduce disaster risk, and as we near its midway point, stepped up action to achieve its targets is urgently needed. It is increasingly clear that the combined effects of millions of decisions and investments are building risk. And because systems are so intimately connected – health, economies, ecosystems, travel, trade, food and infrastructure- a change in one part of one system has repercussions across many other systems.

Over its ten years of operation, IRDR's research and outreach activities have contributed to demonstrating that scientific and technological knowledge can be put into practice to accelerate action to achieve the Sendai Framework. IRDR's vibrant community of scientists and practitioners from all continents and generations has contributed to a much-needed shift in focus from responding to disasters after they happen to preventing and managing disaster risk more holistically. Promoting and improving dialogue and cooperation among scientific and technological communities, policymakers and all other relevant stakeholders, to facilitate effective decision-making in disaster risk management has been core to these efforts.

This compilation document is testament to, and an apt celebration of, IRDR's achievements since 2010. It reflects the important experiences, progress, and lessons learnt during the past ten years and points toward next steps in global risk reduction in an evidence-based and collaborative manner. We take this opportunity to acknowledge the support of the China Association for Science and Technology (CAST) and the Aerospace Information Research Institute of the Chinese Academy of Sciences (AIRCAS) to the program and the commitment and contributions of the staff and Scientific Committee members over many years.

Mami Mizutori
Special Representative of the
Secretary General
UNDRR

Dr. Heide Hackmann
Chief Executive Officer
International Science Council

Preface 2

The Integrated Research on Disaster Risk (IRDR) program is a decade-long pioneering initiative in interdisciplinary disaster risk research. IRDR addresses technological and health-related events when these are consequences of natural hazards. The complexity of the task is such that it requires the full integration of research expertise from the natural, socio-economic, health and engineering sciences as well as policy-making, coupled with an understanding of the role of communications, and public and political responses to reduce the risk. The work is guided by A Science Plan for Integrated Research on Disaster Risk published by ICSU in 2008. The Science Plan is the foundation for the IRDR programme, which is guided by three broad research objectives: Characterisation of hazards, vulnerability and risk; Understanding decision-making in complex and changing risk contexts; Reducing risk and curbing losses through knowledge-based actions and the cross-cutting themes of capacity building; case studies and demonstration projects; and assessment, data management, and monitoring.

This Compilation of the work of IRDR 2010-2020 is a major achievement and we would like to sincerely thank the IPO for undertaking the task and coordinating the development of the report from the start to completion. From this new publication, we can see how the program has been evolving over time, and the significant contributions made and actions undertaken by members of the IRDR community along the scientific plans and objectives set a decade ago. As shown by the Compilation, much has been achieved since 2010 in terms of understanding the complexities of disaster risk, the root causes of disaster vulnerabilities, the data needed to support risk reduction, the decision making and policies under diverse and changing contexts, and in putting science knowledge in DRR policy and action. This is also a tribute to the foresight of the program's co-sponsors, who a decade ago set up this program for action, providing overall guidance and support, and connecting research to global policy debates.

IRDR is co-sponsored by the International Science Council (ISC) and the United Nations Office for Disaster Risk Reduction (UNDRR). The IRDR community consists of the scientific committee and its associated working groups, the national committees, the international centres of excellence, the International Project Office (IPO) and the IRDR Young Scientists Programme (YSP). The community has played and continues to play a great role in providing support across the network and most importantly, enabling younger scientists to gain experience.

We express our gratitude to all those involved in the IRDR - all the scientists and researchers who have been involved and contributed, not only to IRDR research and the Compilation as such, but toward the implementation of Sendai Framework globally, regionally, thematically, and nationally. We thank ISC and UNDRR for providing institutional and financial support for IRDR implementation. We further thank the Chinese Association of Science and Technology (CAST) for their generous financial support for hosting IRDR-IPO at the Aerospace Information Research Institute (AIR) of the Chinese Academy of Sciences，that have provided sustained management support.

Much progress has been made in a decade of collaboration. However, the mission of IRDR is far from being accomplished. Rather, there is an even stronger need for integrated DRR research, as clearly indicated by the new Research Agenda for Disaster Risk Science, which re-emphasizes the critical important of transdisciplinary work, and working to implement the Sendai framework, SDGs, the Paris Climate Agreement.

We are confident that, on the basis of IRDR's decade of work, and under the new vision and the priorities set by the Research Agenda, the IRDR Community will find new ways to bring science powers toward a more peaceful, safer, equitable and sustainable world.

Riyanti Djalante (SC Chair 2020 – present)

John Handmer (SC Chair 2019-2020)

Shuaib Lwasa (SC Chair 2016-2019)

David Johnston (SC Chair 2013-2015)

Salvano Briceno (SC Chair 2011-2013)

Gordon McBean (SC Chair 2010-2011)

Content

Chapter 1. IRDR: an evolving science programme

This Integrated Research on Disaster Risk (IRDR) Compilation is made at a critical conjuncture in time. Five years after the Sendai Framework for Disaster Risk Reduction was launched in 2015, and at the beginning of the UN's Decade of Action for Delivering Sustainable Goals, the world's communities expect science to play a stronger, more innovative, and more productive role in the coming years to generate the changes and transformations towards a safer, more inclusive, equitable, and sustainable world.

To move forward, it is important to first look back, to learn from and be inspired by the past. IRDR represents one of the early attempts of international science communities to bring together researchers from their various research areas to work together to tackle disaster risk, a common and complicated challenge facing human societies. Over the course of ten years, much has changed. For example, public health related risk was not marked at the beginning as a priority research area for IRDR except as related to direct impact of natural disasters. Obviously, this is no longer the case. Indeed, even before the Covid-19 pandemic came into the picture, IRDR was increasingly aware of the developing need to consider the risk of public health. Our understanding on hazard, risk, vulnerability, and exposure, in particular as to systemic and cascading nature of risks, is constantly evolving and more comprehensive than 10 years ago. It is important to note, however, that such improvement stemmed and benefitted from the initial design of IRDR mission and programme setting. Many thanks are therefore due to those individuals who helped to craft the IRDR Science Plan during 2007-2009 for their innovative and far-sighted work.

1.1

Initial rationale and programme setting[1]

The International Council of Science (ICSU) Priority Area Assessment on Environment and its Relation to Sustainable Development and the ICSU Foresight Analysis both underlined 'Natural and human-induced hazards' as an important emerging issue. The executive summary of the ICSU Priority Area Assessment on Capacity Building in Science pointed out the widening gap between the advances in science and technology and society's ability to capture and use them. The ICSU Planning Group (established in 2006) concluded that, beyond the then existing or

1 The content of this section is mainly extracted from the original Science Plan (International Council for Science, 2008).

planned work on natural hazards, an integrated research programme on disaster risk reduction, sustained for a decade or more and integrated across hazards, disciplines and geographical regions, was imperative. The Planning Group viewed such a research programme as one whose value would rest with the close coupling of the natural, socio-economic, health and engineering sciences, and recommended that it be named IRDR – addressing the challenge of natural and human-induced environmental hazards (acronym: IRDR).

Looking back today, there is much foresight in the formulation of IRDR's scientific rationale, with the following arguments considered:

- Natural disasters are a global issue and they can result in great loss of human lives, livelihoods and economic assets in both developed and developing countries. Hundreds of thousands of people are killed and millions injured, affected or displaced each year because of disasters, and the amount of property damage has been doubling about every seven years over the past 40 years. Part of the increase in numbers of disasters reported in disaster statistics may be explained by the increasing numbers of smaller and medium-level events that are registered as being related to natural and human-induced or socio-natural phenomena, and by better reporting mechanisms. Nonetheless, the increasing trend make this an increasingly serious issue.

- Natural disasters are capable of cancelling out development gains, and the risk to development stemming from disasters was clearly recognized by UN Member States in the Millennium Declaration (2000), with the growing losses seen as a major constraint towards meeting the Millennium Development Goals.

- In many parts of the world, especially hazard-prone areas, poverty and population growth mean that more people and communities are at risk from natural hazards. The context in which natural hazard events occur is changing rapidly. In examining effective approaches to risk reduction, it is necessary to understand the extent to which the increase in hazard losses can be attributed to the rapid growth in human numbers and the wider spread of human settlements, and how much is contributed by the manner in which the growth and/or development takes place.

- Human interventions in the environment can also increase the numbers and types of hazards and vulnerability to natural hazards. Globalization results in a world more closely interconnected, with changing senses of responsibility towards countries and localities. The movement of people, trade, communications and financial flows are all increasing rapidly. Hazard events, even in remote places, can have repercussions at a great distance. When they occur in the centres of world trade, finance, and communications, the impacts can be global. Hence, environmental disasters, wherever and whenever they occur, have become a common concern of humankind. Indeed, some (though not all) would say, a common responsibility.

- Globalization also impacts the geophysical environment in new ways. The most salient, though not the only, example is climate change. Although the impacts of climate change are highly varied from place to place, there are connections between some of the related events. The acceleration in the pace of scientific and technical advances has occurred in a time-frame that is short compared with the return frequency of the most extreme events, so that society has only a limited experience base with the new emerging vulnerabilities.

- Changes in the global climate will continue to alter the risks associated with natural hazards. According to the Intergovernmental Panel on Climate Change (IPCC), climate change is accelerating. While the linear warming trend over the last 50 years (0.13°C per decade) was nearly twice that of the last 100 years, a warming of about 0.2°C per decade is projected for the next two decades. With that will come, over the 21st Century, more frequent hot extremes, heat waves and heavy precipitation events (very likely), and more areas affected by drought (likely). Widespread changes in extreme temperatures and more intense and longer droughts have been observed over the past few decades. Extra-tropical storm tracks are projected to move poleward, with consequent changes in wind, precipitation and temperature patterns.

- As the tropical sea-surface temperatures increase, it is likely that future tropical cyclones (typhoons and hurricanes) will become more intense, with larger peak wind speeds and more instances of heavy precipitation. Glacier- and permafrost-related hazards such as glacier lake outburst, ice and rock avalanches and impacts on installation foundations are strongly connected to climate change and increasingly threaten human settlements and infrastructure. There is also the possibility of abrupt climate change occurring over relatively short periods of time, leading to increased risks of some hazards. These risks need to be accounted for in the risk analysis.

- Looking at the international context and the Hyogo Framework for Action (HFA) from the World Conference on Disaster Reduction, in particular the agreed expected outcome and strategic goals, the following items are key:

3. Use knowledge, innovation and education to build a culture of safety and resilience at all levels

…

(iii) Research

(n) Develop improved methods for predictive multi-risk assessments and socioeconomic cost–benefit analysis of risk reduction actions at all levels; incorporate these methods into decision-making processes at regional, national and local levels.

(o) Strengthen the technical and scientific capacity to develop and apply methodologies, studies and models to assess vulnerabilities to and the impact of geological, weather, water and climate-related hazards, including the improvement of regional monitoring capacities and assessments.

- Research to identify and analyse successful risk reduction programmes is very important. For the field of disaster risk reduction, there is neither an established and ongoing scientific assessment process, like the IPCC, nor an internationally planned and coordinated scientific research programme. IRDR would fill that latter gap.

It is important to note that at that time, the emphasis of IRDR research was on natural hazard related risks. Echoing the IRDR Science Plan, the programme focused on hazards related to geophysical, oceanographic and hydrometeorological trigger events; earthquakes; volcanoes; flooding; storms (hurricanes, typhoons, etc.); heat waves; droughts and fires; tsunamis; coastal erosion; landslides; aspects of climate change; space weather and impact by near-Earth objects. The effects of human activities on creating or enhancing hazards, including land-use practices, were included. This focus on risk reduction and the understanding of risk patterns and risk-management decisions and promotion thereof at all scales from the local through to the international level. On the other hand, the IRDR Programme would deal with epidemics and other health-related situations only where they were consequences of one or more of the aforementioned events. Further, technical and industrial hazards and warfare and associated activities would not be included per se.

IRDR was also foreseen to leave the legacy of an enhanced capacity around the world to address hazards and make informed decisions on actions to reduce their impacts, such that in ten years, when comparable events occur, there would be a reduction in loss of life, fewer people adversely impacted, and wiser investments and choices made by governments, the private sector and civil society. Comparing such with the much more recent 2015 Sendai Framework 2015-2030 for Disaster Risk Reduction (Sendai Framework) and its priorities, which serves as the document directing international cooperation on DRR till 2030, one has to agree the founders of IRDR were insightful and visionary in crafting the mission of IRDR back in 2006.

IRDR, a decade-long research programme, was established with the co-sponsorship of the International Science Council (itself established from the merger of the International Council for Science (ICSU) and the International Social Science Council (ISSC) in 2018), and the United UNDRR through a 10-year agreement with the CAST, which generously committed funding of equivalent to 300,000 Euro per year for a period of ten years[2] towards programme operations of the international programme office (IPO), and the CAS and its Aerospace Information Research Institute (AIR)[3], which agreed to host the IRDR International Programme Office (IRDR-IPO) for programme execution. IRDR-IPO, located in Beijing, thus became the first office of ICSU Interdisciplinary Body hosted in Asia. In parallel, CAST provided substantial funding per year to enable the Chinese scientists to carry out DRR research through IRDR cooperation.

Scientifically, IRDR is governed by a 14-member Scientific Committee (SC) set up by and on behalf of the Co-Sponsors. Its responsibilities are to define, develop and prioritise plans for the IRDR, guide its programming, budgeting and implementation, establish a mechanism for the oversight of programme activities, and disseminate and publicise its results. The SC is comprised of disaster and risk reduction experts from around the world. Members are chosen based on their standing in the international scientific community and their commitment to the strategic objectives of the Programme. The Committee aims to include a balanced representation of relevant disciplines in the natural, social and engineering sciences, taking into consideration regional and gender balance. A complete list of scientists who have served in the SC is provided in the Annex 8.

IRDR National Committees (NCs) and Regional Committees (RCs) support and supplement IRDR's research initiatives, and help to establish or further develop crucial links between national disaster risk reduction programmes and activities within an international framework. NCs and RCs help foster the much-needed interdisciplinary approach to disaster risk reduction within national scientific and policy-making communities, and serve as important national focal points between disciplinary scientific unions and associations.

IRDR International Centres of Excellence (ICoEs), established by the SC and the relevant NC(s) when applicable, provide regional and research foci for the IRDR programme. ICoE research programmes embody an integrated approach to disaster risk reduction that directly contributes to the ICSU/IRDR Science Plan for IRDR and its objectives, as well as the IRDR Strategic Plan (2013-2017). ICoEs and IRDR projects are collaborative in nature and geared towards global contributions to the intended IRDR legacy. In particular, ICoEs enable regional scientific activities through geographically-focused contributions based on more localised inputs, and act as visible centres of research to motivate participation in the IRDR programme. Figure-1 summarizes the overall functional structure of IRDR.

An important method by which IRDR conducts research is through its IRDR Working Groups (WGs). These WGs are comprised of experts

2 Based on an agreement between the above parties in 2020, the programme and its IPO have been extended to the end of 2021.

3 The host institution was named the Center for Earth Observation and Digital Earth (CEODE) when IRDR IPO was established. In 2012, CEODE merged with other institutes in CAS and became Institute of Remote Sensing and Digital Earth (RADI). In 2019, RADI merged with other institutes in CAS and became Aerospace Information Research Institute (AIR).

from diverse disciplines, and work to formulate new research methodologies, and to address shortcomings and weaknesses of in current disaster risk research. IRDR comprises six WGs, as illustrated in Figure 1-2. They cover a wide range of topics, including: disaster loss data and data systems, underlying drivers and social-environmental factors of disaster risk, risk interpretation, assessments of current integrated risk research, the connections between DRR, climate change and sustainable development goals, and synthesizing national reporting. The detailed specific contributions of these WGs are provided in Chapter II.

In 2016, IRDR further extended its mandate for integrated and trans-disciplinary research through capacity building by creating the IRDR Young Scientists Programme (YSP). IRDR's YSP encourages young researchers to undertake innovative, need-based and cross-cutting studies, and in doing so, to enhance science-policy and science-practice linkages in particular.

Figure 1-1: IRDR functional structure.

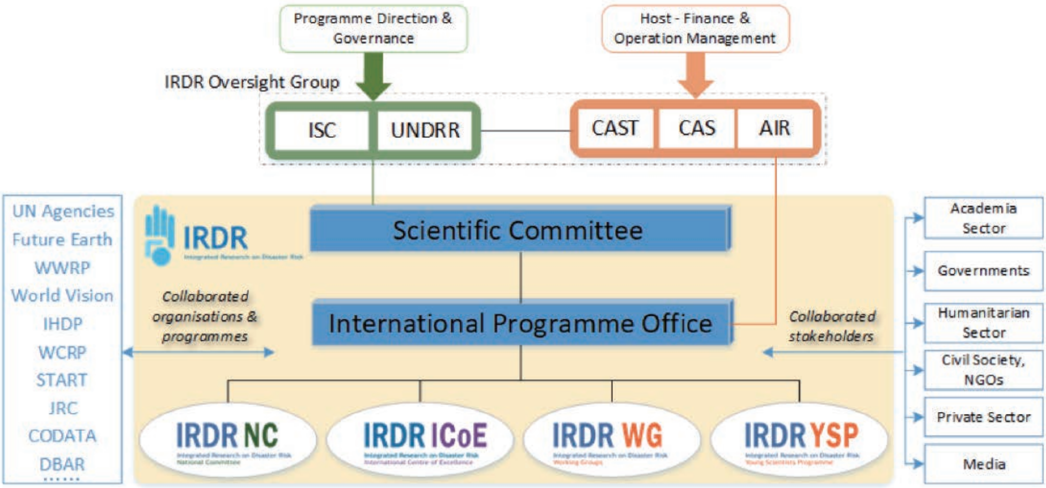


Figure 1-2: Six IRDR Working Groups under IRDR Scientific Committee.

1.2

Mission, Research Objectives and Cross-cutting Themes

IRDR's mission is to develop trans-disciplinary, multi-sectorial alliances for:

- in-depth, practical disaster risk reduction research studies, and
- the implementation of effective evidence-based disaster risk policies and practices.

Research Objectives:

The research objectives of IRDR were proposed to, when projects make successful contributions to them, lead to understanding of hazards and vulnerability and risk and enhanced capacity to model and project risk into the future; to the understanding of the decision-making choices that lead to risk and how they may be influenced; and how this knowledge can better lead to disaster risk reduction.

Objective 1: Characterisation of hazard, vulnerability and risk.

This objective concerns the identification and assessment of risks from natural hazards on global, regional and local scales, and the development of the capability to forecast hazardous events and their consequences. Recognizing that risk depends on hazards, exposure and vulnerability, the research will be of necessity interdisciplinary. Understanding of the natural processes and human activities that contribute to vulnerability and community resilience will be integrated to reduce risk. The objective addresses the gaps in knowledge, methodologies and types of information that are preventing the effective application of science to averting disasters and reducing risk.

The objective can be further broken down into three sub-objectives:

1.1 Identifying hazards and vulnerabilities leading to risks;

1.2 Forecasting hazards and assessing risks; and

1.3 Dynamic modelling of risk.

Objective 2: Effective decision-making in complex and changing risk contexts

This objective focuses on understanding effective decision-making in the context of risk management – what is it and how it can be improved. Closely connected with the other objectives, the emphasis here is on how human decisions and the pragmatic factors that constrain or facilitate such decisions can contribute to hazards becoming disasters and/or may mitigate their effects. The political, institutional, cultural and economic aspects of decision-making and behaviour are important and need to be explored. The salience of strategic societal choices, and of competing rationalities, which cannot be subsumed within the language of risk and risk management, is recognized, a broader context that is addressed by the Programme as the research moves beyond a simple management framework to lay out the complexity of the political and social challenges encountered.

This objective too can be broken down into three specific sub-objectives:

2.1 Identifying relevant decision-making systems and their interactions;

2.2 Understanding decision-making in the context of environmental hazards;

2.3 Improving the quality of decision-making in practice.

Objective 3: Reducing risk and curbing losses through knowledge-based actions.

'Reduction of risk' refers to all the factors that contribute to growing hazards and disaster losses and is generally the overall objective for the IRDR Programme. Objective 3 integrates outputs from Objectives 1 and 2. The central thrust of research under this Objective is therefore to investigate how to combine the understandings from many different fields of expertise into an integrated understanding of the causes of disaster in order to provide practical guidance on the risk reduction and the curbing of losses. Research under Objective 3 develops a new approach to understanding rising risks by bringing to bear and integrating to the extent practicable all existing knowledge of risk factors, hereby providing better diagnoses and laying a scientific basis for more effective policies and actions.

Specifically, there are two separate sub-objectives:

3.1 Vulnerability assessments;

3.2 Effective approaches to risk reduction

Cross-cutting Themes:

Three cross-cutting themes further support these objectives.

Theme 1: Capacity building

Capacity or capability can be defined as a combination of all the strengths and resources available within a community, nation or region that can reduce the level of risk, or the effects of a disaster. It includes physical, institutional, social or economic means such as financial, political and technological resources, as well as skilled personal or collective attributes such as leadership and management at different levels and sectors of the society. Capacity building aims to develop human skills and societal infrastructures within a community, nation or region in order to reduce the level of risk.

The objectives would be to:

1.1 Map capacity for disaster reduction;

1.2 Build self-sustaining capacity at various levels for different hazards;

1.3 Establish continuity in capacity building.

Theme 2: Case studies and demonstration projects

IRDR SC is to commission and encourage case studies to identify major research needs and gaps at the interface of natural and social sciences, focusing in particular on analysing crises or disasters caused by natural phenomena from which lessons can be learnt. The case studies would involve a wide range of hazards, scales, geographical regions, cultural and economic contexts.

Theme 3: Assessment, data management and monitoring

In order to be able to determine the consequences of environmental hazards and disasters in terms of their impacts and effects, one needs baseline monitoring so as to provide the characteristics of the undisturbed environment and its populations, as well as episodic monitoring to provide the magnitude of the environmental hazard and the severity of the impacts and effects that led to the hazard becoming a disaster. For the disaster prevention and recovery community to be able to use such data it is important that a mechanism be in place to permit timely production and dissemination of easy-to-use, accurate and credible information to the appropriate authorities. To be able to achieve such a goal requires both long-term ground-based and remotely sensed monitoring, pre-determined methodologies for data presentation, and identification of the gaps in our ability to rapidly provide this information to the disaster managers.

Specifically, the objectives would be to:

3.1 Develop Guidelines for consistent data management and assessments of hazards, risk and disasters;

3.2 Apply local assessments globally and global assessments locally.

Through successful work on the aforementioned themes, especially by looking at successful case studies and demonstration projects, and improving data management and monitoring of hazards, risks and disasters, global capacity building and increased recognition of the value of risk reduction activities are likely to be maximized. These are the global benefits the Programme hopes to achieve.

Box 1-1: Comments from SC members

Jane Rovins

First Executive Director (2010-2013)

The IRDR mission was originally and continues to be important and relevant. The idea of bringing together social and natural sciences and research to inform policy and practice is as relevant today as it was 10 years ago when we opened the IPO. The Science Plan was a good starting point but needed clearer goals especially as it was several years old (i.e. a little out of date) by the time the IPO was opened and the IRDR programme got started. It needed to be reviewed and updated once the Sendai Framework was released.

Sálvano Briceño

IRDR Scientific Committee Chair (2011-2013), Member (2013 – 2017)

The IRDR Programme was established in 2008 as an international scientific complement to the UNDRR (formerly UNISDR), an international policy programme that followed the IDNDR (1990-1999) programme, which itself had a strong scientific component. Once the UNISDR was established in 2001, it was clear that its work required scientific guidance and advice. In this regard, it was evident that ICSU (now ISC) was the relevant organization with whom to partner in such an effort. Close collaboration was initiated on behalf of ICSU by Robert Hamilton (US NAS and former Director of IDNDR). He was followed by Gordon McBean, who led the establishment of the IRDR programme in collaboration with the UNISDR in 2008. IRDR and its Science Plan have informed the DRR international policy frameworks including both the 2005 HFA and its follow-up, the 2015 Sendai Framework. An earlier framework, the Yokohama Strategy and Plan of Action, which was formulated during the IDNDR process, provided IDNDR with relevant initial policy recommendations. The initial question that motivated the launching of the IRDR, remains as relevant in 2020, and indeed has taken on even greater urgency: *Why, despite advances in the natural and social science of hazards and disasters, do losses continue to increase?*

J.Richard Eiser

IRDR SC member (2009-2016). Previously, member of ICSU Planning Group (2006-2009) which lead to IRDR

In my opinion, the main achievement of the IRDR programme during the time of my involvement was the establishment of a truly interdisciplinary agenda for disaster risk research. Within the programme, I was particularly involved in the Risk Interpretation and Action (RIA) working group, the main output of which was the following article: *Eiser, J.R., Bostrom, A., Burton, I., Johnston, D.M., McClure, J., Paton, D., van der Pligt, J. & White, M.P. (2012). Risk Interpretation and action: A* *conceptual framework for responses to natural hazards. International Journal of Disaster Risk Reduction, 1, 5-16.*

Although we made a major conceptual contribution in terms of agenda-setting, the fact that IRDR did not directly fund primary research meant that we all had to rely on funding agencies that were typically less international and interdisciplinary in their focus. Plus, I don't recall any serious discussion of the potential disaster risk of a pandemic like we are now experiencing.

Rajib Shaw

Executive Director (2016-2017), Member (2017-onwards)

Disaster Risk Reduction (DRR) is a fast-growing subject, and the context changes rapidly. One of the key aspects for the duration of the Science Plan was the formulation of the Sendai Framework and a few other important global frameworks like the Sustainable Development Goals (SDGs), the Paris Agreement, the New Urban Agenda etc. All these are inter-connected, and the relevance to IRDR mission and Science Plan is also very important. The Science Plan was formed at an early stage of HFA, and that's why it is aligned with HFA. The Science Plan hence focused significantly on hazard research. However, the trend has now moved towards resilience related research, and focuses more on socio-economic contexts. Complex, cascading disasters, climate risks become more prominent in recent years, and policy research on these have become increasingly important. Thus, I find the IRDR Science Plan to have been relevant and a good guide for directing research in the first half of the decade, but faced with new challenges had to reorient itself in the later part of the decade.

Shuaib Lwasa

IRDR SC Member (2013-2018), Vice-Chair (2014-2016), Chair (2016-2018)

My reflections on the science plan is twofold. First the science plan was quite ambitious and novel in mapping out the hazards, their interactions and possible outcomes thus framing an integrated approach to disaster risk. This framework has enabled a discussion that transcends single disaster events and stand alone responses to disasters. This has shaped some of the global and local discussions as well as actions recognizing that are constructed and not natural. This discussion has found its way into the Global Assessment Report on Disaster Risk Reduction (GAR) process of the UNDRR and a growth of a network of DRR professionals coming together as academics, researchers, humanitariansist, private sector and funders that are now organized under a global alliance. Second the science pan laid foundation for breaking new ground in conceptual and methodological approach to disaster risk management. By highlighting disasters as part of the core of development, methodological framings including forensic investigation of disasters (FORIN), risk interpretation and action, risk communication and multi-hazard risk analysis, systemic risk and risk and disaster data management that have influenced a discourse of on risk governance and investments.

1.3

From Hyogo to Sendai: IRDR contribution

The Hyogo Framework for Action 2005-2015 (HFA): Building the Resilience of Nations and Communities to Disasters provided critical guidance in efforts to reduce disaster risk and has contributed to the progress towards the achievement of the Millennium Development Goals. However, the implementation of HFA highlighted a number of gaps in addressing the underlying disaster risk factors, in the formulation of goals and priorities for action, in the need to foster disaster resilience at all levels, and in ensuring adequate means of implementation. Ten years after the adoption of the HFA, disasters continue to undermine efforts to achieve sustainable development. Against this background, and in order to reduce disaster risk, the Sendai Framework for Disaster Risk Reduction 2015–2030 was adopted at the 3rd United Nations World Conference on Disaster Risk Reduction (WCDRR).

IRDR actively contributed to and was integrally involved in the efforts to develop the Sendai Framework. IRDR, in partnership with China Association for Science and Technology (CAST) hosted the 2nd IRDR Conference from 7 – 9 June 2014 in Beijing, China on the theme "Integrated Disaster Risk Science: A Tool for Sustainability". The conference emphasised the importance of science as a tool to address hazard risks, integration and partnership. A key cross-sessional discussion considered the influence of science in HFA and preparations for a new DRR framework which developed into the Sendai Framework. The outcomes of the Conference covered issues on DRR research, education, implementation and practice, and policy implementation for the Sendai Framework[4].

IRDR and ICSU acted as the Organizing Partners for the Scientific and Technological Community Major Group (STMG) for the 3rd WCDRR, starting from the First Preparatory Committee Meeting (PrepCom1) in July 2014. IRDR provided an independent collective response to the pre-zero draft, which identified three specific needs, namely to: 1) Develop, on the basis of state-of-the-art prospective knowledge, a forward-looking agenda, notably in terms of linking disaster risk reduction science with the SDGs targets; 2) Emphasise the need for stronger support for science as the foundation for action-oriented cutting-edge knowledge, including necessary monitoring activities; 3) Emphasise the need to better connect national and local levels for the collection and analysis of the necessary vulnerability and loss data as prerequisite for both responsive and preventive planning and investment[5].

Meanwhile, IRDR proposed a '4+2' formula, which it issued as a STMG statement, to support the implantation of Sendai Framework at the 3rd WCDRR[6]. The four lines of action are:

- Assessment. Provide analytical tools to advance a comprehensive knowledge of hazards, risks, and underlying risk drivers → deliver regular, independent, policy-relevant international assessment of available science on DRR,

4 More details on the outcomes of 2014 IRDR Conference can be found on the IRDR website at the below link: http://www.irdrinternational.org/2014/08/21/planetrisk-irdrconference2014/

5 The detailed contribution from IRDR towards the Sendai Framework could be referred to the IRDR Annual Report (2014): https://www.wcdrr.org/wcdrr-data/uploads/579/IRDR%20Annual%20Report%202014.pdf

6 The detailed contributions from IRDR to the 3rd WCDRR can be found in IRDR Newsletter Vol. 6: http://www.irdrinternational.org/wp-content/uploads/2015/05/IRDR-Newsletter_Vol6-No2-April-2015.pdf

resilience and transformations.

- Synthesis. Facilitate the uptake of scientific evidence in policy-making → synthesize relevant knowledge in a timely, accessible and policy-relevant manner.
- Scientific advice. Translate knowledge into solutions → provide advisory capabilities, integrating all S&T fields in collaboration with practitioners and policy-makers.
- Monitoring and review. Support the development of science-based indicators, common methodologies and processes → harness / make use of data & information at different scales.

These are underpinned by efforts in two cross-cutting domains:

- Communication and engagement. Develop closer partnerships between policy-makers, scientists and society as well as between researchers → improve the communication of scientific knowledge to facilitate evidence-based decision-making (at all levels of government and across society).
- Capacity building. Promote risk literacy through curricular reform, professional training and life-long learning across all sectors of society.

Box 1-2: Priorities and Targets of Sendai Framework

The Sendai Framework[7] proposed four priority areas for sectors to take actions:

Priority 1: Understanding disaster risk.

Priority 2: Strengthening disaster risk governance to manage disaster risk.

Priority 3: Investing in disaster risk reduction for resilience.

Priority 4: Enhancing disaster preparedness for effective response and to "Build Back Better" in recovery, rehabilitation and reconstruction.

Seven targets were agreed upon, to be measured at the global level, and are to be complemented by work to develop appropriate indicators:

(A) Substantially reduce global disaster mortality by 2030, aiming to lower the average per 100,000 global mortality rate between 2020-2030 compared to 2005-2015;

(B) Substantially reduce the number of people affected [by disasters] globally b 2030, aiming to lower the average global figure per 100,000 between 2020- 2030 compared to 2005-2015;

(C) Reduce direct disaster economic loss in relation to global gross domestic product (GDP) by 2030;

(D) Substantially reduce disaster damage to critical infrastructure and disruption of basic services, among them health and educational facilities, including through developing their resilience by 2030;

(E) Substantially increase the number of countries with national and local disaster risk reduction strategies by 2030;

(F) Substantially enhance international cooperation to developing countries through adequate and sustainable support to complement their national actions for implementation of the framework by 2030;

(G) Substantially increase the availability of and access to multi-hazard early warning systems and disaster risk information and assessments to the people by 2030.

7 https://www.undrr.org/publication/sendai-framework-disaster-risk-reduction-2015-2030

1.4

Responding to the changing DRR landscape/contexts

1.4.1

IRDR Strategic Plan 2013 – 2017

The IRDR Science Plan originally published in 2008 was the fundamental document for the programme operations. After the establishment of IRDR programme, the strategic goals and activities to guide the operation of IRDR were further articulated through the *IRDR Strategic Plan 2013 – 2017*[8]. The original three research objectives and three cross-cutting themes were framed into six concrete goals. Attainment of these goals will lead to a better understanding of hazards, vulnerability and risk; the enhanced capacity to model and project risk into the future; greater understanding of the decision-making choices that lead to risk and how they may be influenced; and how this knowledge can effectively lead to disaster risk reduction.

The overall global benefits of the IRDR programme are dependent on the recognition of the value of risk reduction activities, which are likely to be brought about by concrete evidence arising from case studies and successful demonstration projects; assessments, data management and monitoring of hazards, risks and disasters; and capacity building, including mapping capacity for disaster risk reduction and building self-sustaining capacity at various levels for different hazards.

1. Promote integrated research, advocacy and awareness-raising.
This goal is concerned with developing and promoting integration and collaboration within the disaster risk reduction community to avoid unnecessary duplication and to maximise research outcomes.
2. Characterisation of hazards, vulnerability, and risk.
This goal looks at identifying hazards and vulnerability leading to risks from natural hazards on global, regional and local scales; the development of the capability to forecast hazard events and assess risks; and dynamic modelling of risk. It also addresses the gaps in knowledge, methodologies and types of information that are preventing the effective application of science to averting disasters and reducing risk.
3. Understanding decision-making in complex and changing risk contexts.
This goal focuses on understanding effective decision-making in the context of risk management – what it is and how it can be improved. It looks at identifying relevant decision-making systems and their interactions; understanding decision-making in the context of environmental hazards; and improving the quality of decision-making practices.

8 http://www.irdrinternational.org/2013/04/15/irdr-strategic-plan-2013-2017/

4. Reducing risk and curbing losses through knowledge-based actions.	
This goal brings together the outcomes of Goals 2 and 3. It will be accomplished through the implementation of vulnerability assessments and effective approaches to risk reduction.	
5. Networking and network building.	
This goal focuses on the development, strengthening of and collaboration within the IRDR network at global, regional and national levels.	
6. Research Support	
This goal focuses on enhancing the support for research and the utilisation of findings.	

1.4.2

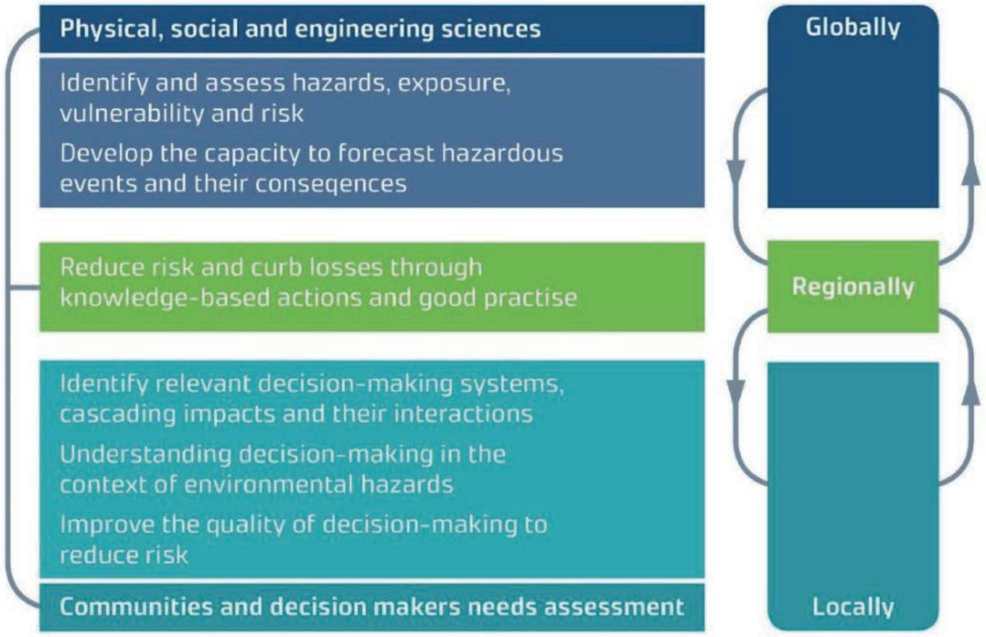
IRDR Action Plan 2018-2020

In early 2016, the three co-sponsors of IRDR commissioned an independent, forward-looking mid-term Review covering the first six years of the ten-year programme. The Review Report suggested "rethinking, reforming or reshaping IRDR's strategy" and "operating IRDR as an 'action network' towards collective impact". In response to these suggestions, the IRDR Scientific Committee presented a draft IRDR Strategic Plan of Action for 2017-2020 at the 16th IRDR Scientific Committee meeting. This document was designed to guide the IPO as well as other entities within the IRDR network in implementing specific actions towards scientific advice in disaster risk reduction. The document was further amended to take into account the SC meeting's decision to incorporate critical findings of the review committees, and place additional emphasis on more forward-looking strategic actions which arise from evidence and science-based decision making at a crucial time for the implementation of the Sendai Framework. A total of 23 actions on activities and deliverables were proposed on areas including 1) Science Advocacy at global, regional and national scales; 2) Sendai Framework indicators and strengthening national reporting system; 3) Thematic contribution by Working Groups; 4) Facilitating Associated Projects; 5) Strategic partnership with International Centres of Excellence (ICoEs); 6) Science capacity development: Young Scientists Program; 7) Science outreach by communication strategy and products.

Undergoing further edits, the document was further shaped into the IRDR Action Plan 2018-2020[9], which was adopted at 18th IRDR Scientific Committee Meeting. The new Plan does put forth the aforementioned more forward-looking strategic actions, specifically puts forth 22 actions grouped into three categories: 1) Improving the Governance of IRDR (2 actions); 2) Expanding the IRDR Network and Scientific Outputs (16 actions); and 3) Improving the visibility of IRDR (4 actions). Each action included detailed description, deliverables, lead group, and outcomes & impact. In the SC meetings following the adoption of the new Plan, IPO reported IRDR updates according to the implementation of these actions. Figure 1-3 illustrated the science behind IRDR.

9 http://www.irdrinternational.org/what-we-do/action-plan-2018-2020/

Figure 1-3: **Science behind IRDR: the foundational multi-hazard framework of IRDR to understand and characterize risk, risk production processes and governance, and damage and losses (Fakhruddin & Bostrom, 2019).**



1.5

Coherence with other UN 2030 agreements

In 2015, a number of landmark international agreements were reached at the United Nations. Apart from the Sendai Framework, the world community agreed on Transforming our World: the 2030 Agenda for Sustainable Development (2030 Agenda), the Paris Agreement, the Addis Ababa Action Agenda (AAAA) and the New Urban Agenda (NUA)[10]. Each of these agreements has interconnections with the Sendai Framework. It is therefore natural that there have been calls for coherence and synergy to realize the goals and targets of the post-2015 agreements (Figure 1-4) and update current approaches to risk assessment accordingly.

The Sendai Framework was the first of the world's best-known policy agendas. It set out the case for development to be risk-informed in order to be sustainable. In both the Sendai Framework and the SDGs, outcomes are a product of interconnected social and economic processes. As such, there is a lot of synergy between the two policy instruments. In fact, Sendai Framework monitoring is intended to complement monitoring of 11 SDG indicators (Figure 1-5).

10 The UN Global Assessment Report on Disaster Risk Reduction (GAR): https://gar.undrr.org/

Figure 1-4: Risk Reduction – a journey through time and space.

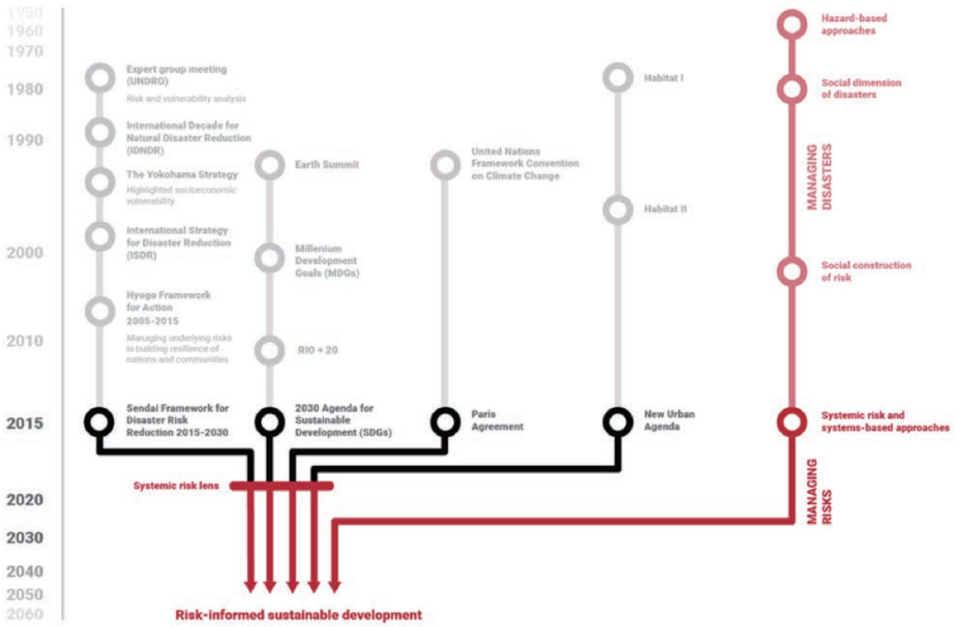
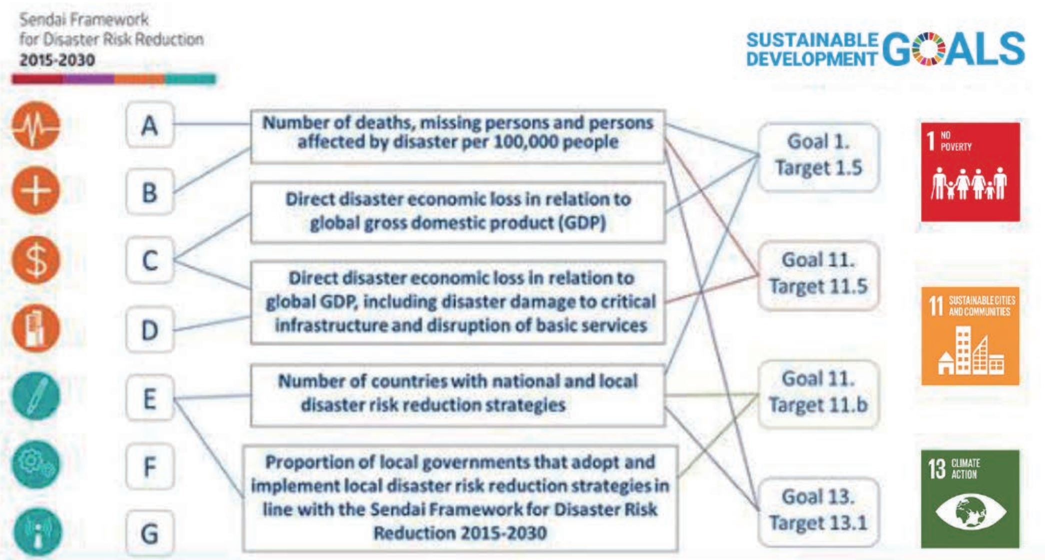


Figure 1-5: The coherence between Sendai Targets and SDGs indicators.

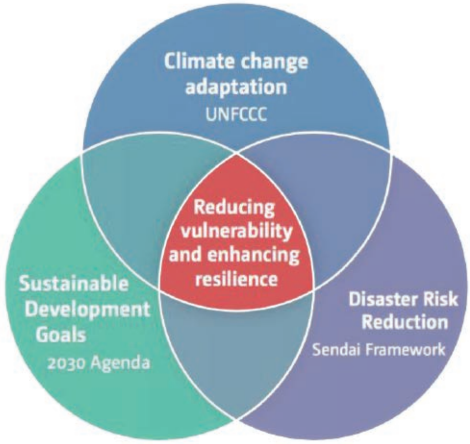


IRDR has started moving in this direction. In 2018, IRDR established a new Working Group (WG) on DRR-CCA[11]-SDG under its Scientific Committee, whose role is specifically to look into the Sendai Framework connections with the Paris Agreement, with SDG 11 on cities and with SDG 13 on climate change (Figure 1-6). Through research activities and strengthening of scientific networks, the WG aims to reduce vulnerability and enhance resilience.

Also in 2018, to further build the connections between the IRDR research objectives, Sendai Targets, Paris Agreement and SDGs, IRDR initiated its working paper series. It is the hope of the authors of the working papers and IRDR as a whole that the papers will not only bring new knowledge, experience and information toward disaster risk reduction, but also help build better coherence of DRR with the mainstream UN agenda of moving towards more inclusive, resilient and sustainable human societies. The following chapters will provide more details on the IRDR working papers.

Discussions and exchanges at IRDR related meetings are increasingly focusing on new risks, particularly daunting multi-dimensional, systemic, cascading and transboundary risks and disasters, as exemplified recently so starkly by the Covid-19 pandemic. It is clear that the inherent vulnerabilities of our environment and human societies will have to be addressed in transformative ways. In all of these IRDR will have roles to play and contributions to make.

Figure 1-6: The concept behind DRR-CCA-SDGs.



11 CCA: Climate Change Adaption

Reference

Fakhruddin, B., & Bostrom, A. (2019). Integrated Research on Disaster Risk (*IRDR*). Retrieved from Contributing Paper to GAR 2019:

International Council for Science. (2008). A science Plan for Integrated Research on Disaster Risk: Addressing the challenge of natural and human-induced environmental hazards.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Chapter 2.
IRDR Research Objectives and IRDR in actions

The IRDR Science Plan (2008) and Strategic Plan (2013-2017) are the 2 fundamental documents upon which programme operations are based. The programmes by the IRDR National Committee (NC) and International Centres of Excellence (ICoE) hence adopt an integrated approach to disaster risk reduction which the Science Plan set forth. In addition, to meet the research goals of the Strategic Plan, IRDR established Working Groups (WGs) to formulate new methods in addressing the shortcomings of current disaster risk research. And IRDR Young Scientists Programme (YSP) gathered young professionals, who were encouraged to undertake innovative and needs based research, hereby strengthening the bonds between science and policy as well as science and practice. The following achievements from WG/NC/ICoE/YSP/flagship projects and IRDR program partners were mainly submitted by the principal of each communities. The editorial committee also collected some achievements via their websites. Actions are under the support of resources from their host institutions. Ownership of the deliverables are shared among host institutions and IRDR. These achievements are grouped and summarized based on the 3 objectives and cross-cutting themes in Science Plan.

Highlights of key results and impact of IRDR work, per the three main Research Objectives and eight Sub-objectives.

Obj. 1: Characterization of Hazards, Vulnerability and Risk

This objective concerns the identification and assessment of risks from natural hazards on global, regional and local scales, and the development of the capability to forecast hazardous events and their consequences. This includes projects in response to Goal 4 of the IRDR Strategic Plan. Key questions that are tried to be addressed under this objective are list as below. NCs and ICoEs from Asia (China, Iran, Malaysia and Pakistan), Europe (France and Netherlands), Oceania (New Zealand) and South America (Colombia), including the Forensic Investigations of Disasters (FORIN) WG contributed greatly to this objective.

Key questions:

- What are the places at risk, and what is the source of this risk?
- Who are the people most at risk?
- What is the level of risk?
- How may risk change with time?
- How can natural hazards be forecast confidently?
- What factors contribute to future risk and related uncertainties?
- How can uncertainties be reduced?
- How can forecasts, their limitations and uncertainty be communicated effectively?

Under this objective, the root, long-term effects, and chains relation of risk and disasters have been studied. A plenty of researches have been done to characterize the risk, hazard, vulnerability, exposure. Models were published to forecast and simulate different disasters individually including earthquake, volcano, typhoon, and so on. Based on the achievements submitted, most communities focused on the questions that what is the source of risk, how may risk change with time and how to forecast the risk and disasters.

O1.1 Identifying Hazards and Vulnerability leading to Risks

◆ Gaining insight into Root Causes of Risk and Risk production—Forensic Investigations of Disasters (FORIN)

The **Forensic Investigations of Disasters (FORIN) project**[12] proposed an approach that aims to uncover the root causes of disasters through in-depth investigations that go beyond the typical reports and case studies that are conducted post-disaster. Thoroughly analysing both successful and failed cases, the project helped build an understanding of how natural hazards do—or do not—become disasters. This is in furtherance of IRDR Strategic Plan's Goal 4 (Reducing risk and curbing losses through knowledge-based actions.) with which FORIN's activities are aligned.

The methodology is built around case studies, which, in keeping with IRDR research objectives, are integrated. The FORIN case studies not only assemble but further combine a variety of different disciplinary approaches.

The project's wide range of objectives are listed below:

1. Policy: conduct analyses with inputs from multiple disciplines, stakeholders, and policy makers in order to guide policy and encourage coherence across all key disciplines.

2. Management: focus attention on the link between research findings and improved policy formulation and application in practice, and develop and maintain a bank of high-quality case studies publicly available through the IRDR website.

3. Scientific research: advance methodological diversity and implement science-based results, and build a strong interdisciplinary capacity in young researchers.

4. Development: substantiate the notion that generic causes have local manifestations, promote a 'learning culture' among all stakeholders, and foster wider dialogue between analytical researchers and implementing practitioners, building a common discourse in the process.

5. Disaster risk reduction: promote sustainable risk management and risk reduction through

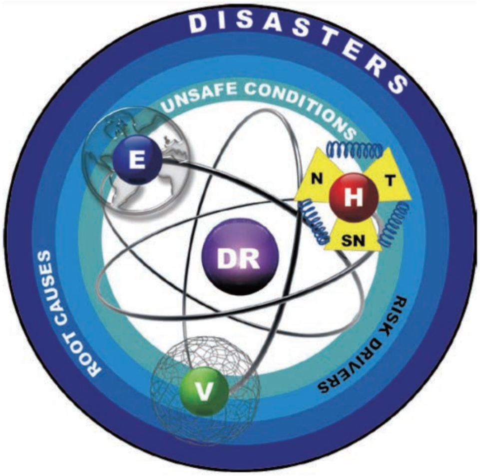
12 http://www.irdrinternational.org/wp-content/uploads/2016/01/FORIN-2-29022016.pdf

science-based research, relate the research to the HFA, place stronger emphasis on reducing human consequences, and develop case studies that illustrate 'risk-drivers.'

FORIN aims to enhance the societal capacity to address hazards around the world, by informing decisions on actions to reduce their impacts. This includes shifting away from a response-recovery focus towards prevention-mitigation strategies and the integration of disaster risk reduction into development policy and practice. A willingness to learn systematically from experience will help this shift towards, avoiding the social construction of risk, reducing risk from hazards, and building resilience there to.

Figure 2-1 below illustrates the key relationships and processes in the social construction of risk. E stands for exposure; V stands for vulnerability; H stands for hazard with the categories N (natural), T (technological) and SN (socio-natural); DR stands for disaster risk.

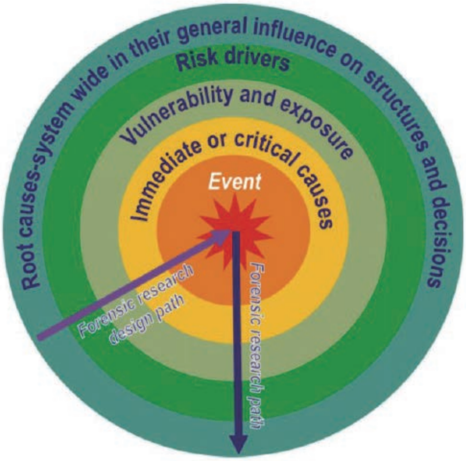
Figure 2-1: The key relationships and processes in the social construction of risk.



Developed initially from the pressure-and-release model (Blaikie et al., 1994), FORIN examine how root causes relate to risk drivers, which then lead to the occurrence of disasters. FORIN employed a systematic approach for examining the root causes and dynamics of disaster risks, including assessment of: (a) triggering events, which may include cascading events (e.g., earthquakes followed by landslides or tsunamis); (b) exposure of social and environmental elements, including not only people and infrastructure, but also means of production, natural resources and wealth; (c) the social and economic structure of exposed communities, their resilience and vulnerabilities; and (d) institutional and governance elements, including legislation, insurance, authority and participation in decision making, and education and research capacity for disaster risk management (Oliver-Smith et al., 2016). To investigate these elements, four research strategies were proposed: retrospective longitudinal (historical) analysis, FORIN disaster scenario building, comparative case studies, and meta-analyses (Oliver-Smith et al., 2016). Each of these strategies recognizes the value of thick description, but also of causal analysis and systematic assessment of commonalities across studies. Fundamentally, FORIN employed a transdisciplinary approach that requires multiple methods, disciplines, and participatory research (Hadorn et al., 2008; Oliver-Smith et al., 2016).

Figure 2-2 below displays both the design path of forensic disaster research and the actual path through which forensic research proceeds. The design path of forensic disaster research starts with the immediate causes affecting impacts and moving through risk drivers, vulnerability and exposure factors toward root causes in explaining the disaster event. The research path starts with the disaster event and moves outward through immediate causes to risk drivers, vulnerability and exposure toward root causes.

Figure 2-2: The design path of forensic disaster research and the actual path through which it proceeds.



Little progress on learning systematically from disaster risk research was previously evident under the HFA (Oliver-Smith et al., 2017). FORIN provides a strategy for progress, is at the heart of the IRDR scientific programme, and is essential to achieving the goals of the Sendai Framework for Disaster Risk Reduction. A brief summary of each research strategy follows below:

Retrospective longitudinal analysis (RLA) is concerned with the temporal development of the processes that have produced disasters in the past. For the 2010 earthquake in Haiti, RLA reveals that some aspects of risk and vulnerability have very deep roots in colonial history (Oliver-Smith et al., 2016).

FORIN disaster scenario building (FDSB) attempts to “look into the future”, modelling the future based on selecting a known hazard and analysing what factors may affect the possibly inevitable future event. Scenario building is a well-known strategy to produce alternative images of how the future might unfold, and is used in a wide variety of situations ranging from commercial ventures to policy and military contexts (Oliver-Smith et al., 2016).

Comparative case analysis is an event-based analysis that seeks to identify underlying causes of disasters by comparing disaster impacts or contexts in different social contexts. An example where comparative study has been useful is the case of Hurricane Luis impacts on the distinct French and Dutch parts of the NE Caribbean island of St Maarten in September 1995. Despite there being more intense winds and rainfall on the French side of the island, damage and loss was considerably less than on the Dutch side (Oliver-Smith et al., 2016).

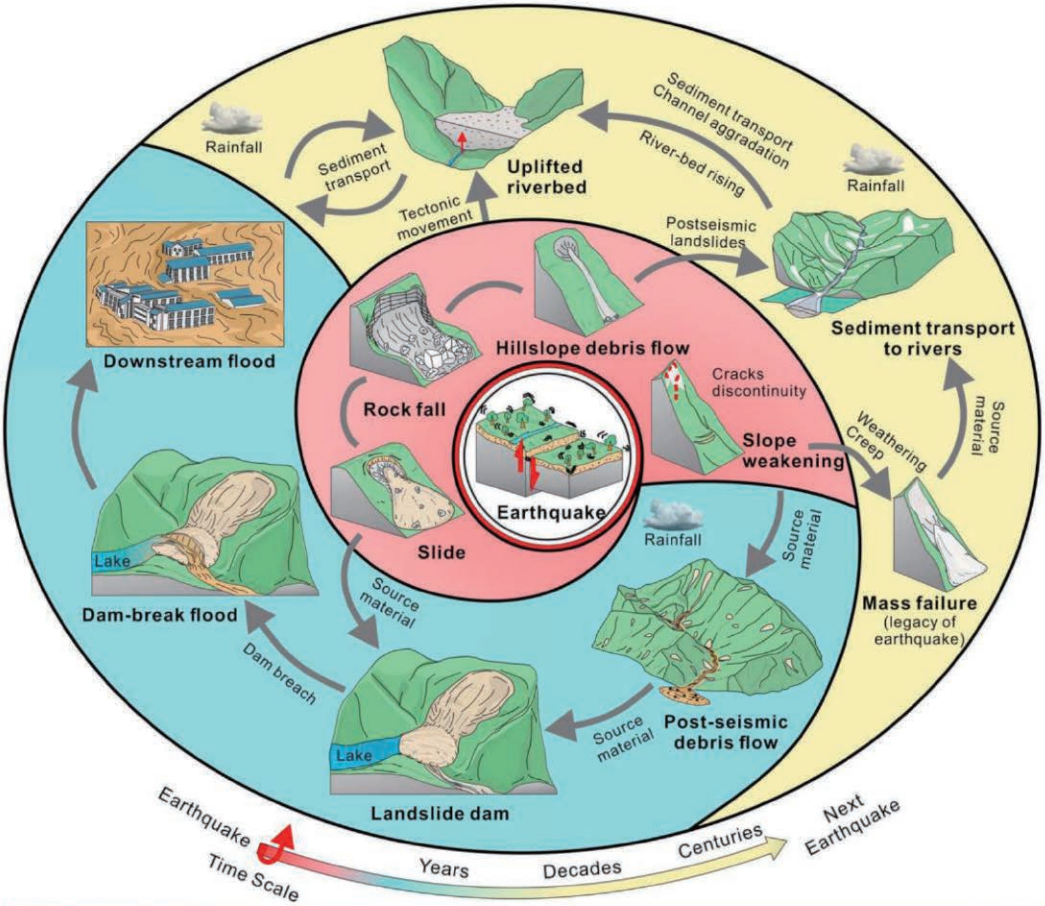
Meta-analysis is an event- or system-based review of the available literature carried out to identify and assess consistent and contrasting findings across diverse studies. The research led by the Study Group on the Disaster Vulnerability of Megacities of the International Geographical Union and the subsequent book “Crucibles of hazards: mega-cities and disasters in transition” (Mitchell, 2000) is informed by a meta-analytical perspective.

The concept, methodology and case studies of FORIN group has been published in English, Spanish, French, and Chinese and has been used for different training courses.

◆ Long-term effects of Disaster Chains triggered by Mega-earthquake

Earthquakes are one of the disasters which cause the most serious economic losses and casualties in the world. Meanwhile, China, with its massive population, is at the same time one of the nations with the most concentrated and active continental earthquakes. Thus, naturally, earthquake disasters have a huge economic and social impact in China. **IRDR NC-China** conducted a continuous tracking study on geological disasters in earthquake areas for more than ten years and obtained several important research results.

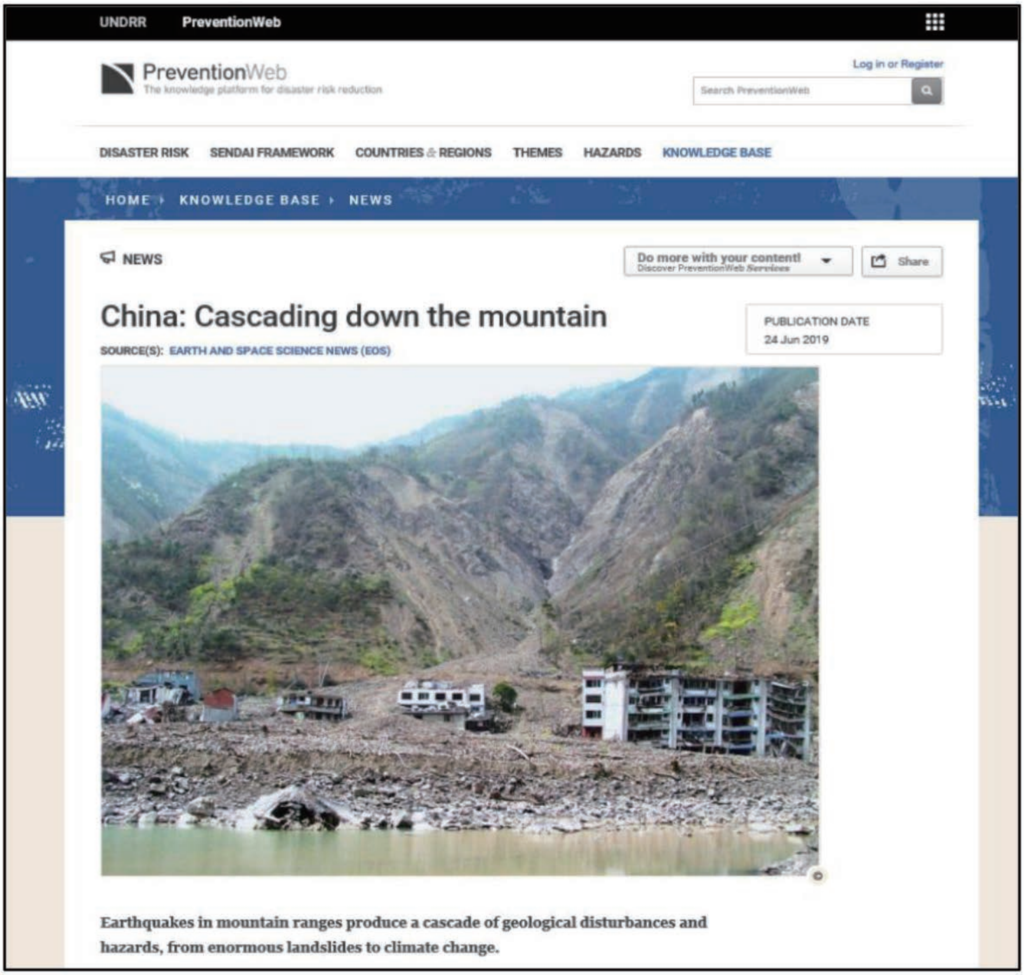
Figure 2-3: Chains of geologic hazards triggered by a strong continental earthquake and reviewed in this work. Causal relations between hazards are indicated. Red background shows different types of coseismic landslides; blue background indicates the post-seismic cascade of hazards (days to years later); and yellow background represents the long-term impact of an earthquake (years to decades and perhaps longer).



Triggering and controls on coseismic geo-hazards	Triggering and controls on post-seismic debris flows	Post-seismic landslides and their hazard	Long-term impact of strong earthquakes
• Mapping, spatial distribution patterns • Initiation and failure mechanism analyses • Evaluation of runout characteristics • Controls on formation and failure of coseismic landslide dams	• Case studies and inventory • Initiation and runout: mechanisms and modelling • Observations and modelling of changing rainfall thresholds • Structural and non structural risk management and mitigation	• Distribution patterns and spatio-temporal evolution • Controls on the post-earthquake geo-hazards evolution • Susceptibility and hazard assessment • Risk assessment and reconstruction strategies	• Weathering-related post-seismic landsliding • Sediment cascade and yield after a strong earthquake • Long-term landscape evolution: the mass balance problem • Tectonic control on landslide occurrence

With funding from both China and the UK, the Earthquake WG of NC-China collaborated with the Cardiff University (UK) research team to study the dynamic response of slope surface to mega earthquakes, the gestation and formation mechanism of large landslides, and the temporal and spatial evolution law of geological disasters after earthquakes and their long-term effects. The study not only reveals the starting mechanism of large-scale co-earthquake landslides from a new perspective, but also strengthens the research on the evolution of post-earthquake geological disasters and its geological environmental effect. This study is also the first time geological disaster research has been combined with sociological research to deeply analyse the impact of geological disasters on social and economic losses, as well as post-disaster resilience of people in the disaster-stricken area, including in emergency response, post-disaster reconstruction, and recovery stages. Based upon the study, the basic principles of potential geological disaster identification and risk prevention and control in mega-earthquake situations were formed (Fan et al., 2019). The research results are of great significance to the prevention and control of geological disasters in both China and Britain. Indeed, the work was reported as important research progress by the UNDRR in 2019.

Figure 2-4: Official report of the United Nations Disaster Prevention and Reduction Agency (UNDRR).



◆ Characterisation of Hazard, Vulnerability and Exposure

The IRDR research objectives are given consideration in all major projects of **IRDR ICoE for Disaster Risk and Climate Extremes (IRDR ICoE-SEADPRI-UKM, Malaysia)**. Working at the local scale, a characterisation of hazard, vulnerability and exposure (which constitute risk in the context of both climate variability and climate change) was completed for several specific local geographic areas in the region. A project funded by the Asia-Pacific Network for Global Change Research (APN), has enabled the identification of hazards, vulnerabilities and exposure leading to risks for local areas in Cambodia, Malaysia, The Philippines and Vietnam (Pereira, Pulhin, et al., 2019). This is further advanced in the project supported by the Newton Ungku Omar Fund, where hazards, vulnerabilities and exposure identified in Kuala Lumpur are visualised in a Multi-hazard Platform (Pereira, Muhamad, et al., 2019).

The **ICoE-UR&S** and **IRDR ICoE on in Disaster and Climatic Extremes (IRDR ICoE-DCE, Pakistan)** support the first IRDR objective related to the characterization of risk-including, hazards, vulnerability, and resilience-through theoretical and empirical approaches. Such approaches

Table 2-1. Examples of probabilistic hazard and risk modelling

Examples of achievements	IRDR WG related
Development of a Global Drought Probabilistic Hazard and Risk Model in the framework of the CAPRA platform improvement for UNISDR Risk Knowledge Section	RIA
Participation on the Risk Nexus Initiative: Risk modelling and metrics, Indicators and knowledge for sustainability and resilience, and enhancing risk governance	RIA, DATA
Development of the UN Atlas-GAR: Unveiling Global Disaster Risk (200+ countries based on the GAR's Global Multi-hazard Risk Assessment. Launched during the 2017 Global Platform on DRR, May 2017	RIA, DATA
Development of the Holistic Evaluation of Disaster Risk at global level using physical/economic risk metrics and indicators of social fragility and lack of resilience of the countries	DATA
Implementation of the Index of Disaster Risk Implications for Development based on the average annual loss and economic flow indicators of the countries such as capital stock, social expenditure, capital formation, savings and reserves	RIA, DATA
Development of Brief Risk Profiles for 200+ countries based on the update of the Global Multi-hazard Risk Assessment for the UNISDR GAR15. Presentation of the results in the 3WCDRR: Working session on global risk trends	RIA, DATA
Development of The Global Risk Model for GAR13. Outputs: Fully probabilistic earthquake and tropical cyclone (wind + storm surge) hazard and risk assessment at global level; Computing the Loss Exceedance Curve and other probabilistic risk metrics using the Comprehensive Approach to Probabilistic Risk Assessment (CAPRA) Platform; Calculation of Hybrid Loss Exceedance Curves to reflect extensive and intensive risk; Provision of specific examples of risk evaluations at local level for earthquakes, tropical cyclones, floods and volcanoes; Descriptions of a Country's risk profile based on coarse-grain information for risk awareness and comparison among countries; and Development of a good-enough risk assessment methodology to replicate the global approach at the local level. We note that this is the first time that a Loss Exceedance Curve is calculated for 215 countries using the same arithmetic and base information	RIA, DATA
Hydro-probabilistic model	IRDR ICoE-DCE

include actuarial/statistical and analytical/ engineering models that link social and economic vulnerability, natural hazards and exposure on a variety of spatial scales for probabilistic hazard and risk modelling to obtain risk metrics useful for risk transfer, macroeconomic valuations, contingent fiscal liabilities, sovereign risk, and land-use decision-making, among other actions. Examples of these efforts are listed in the following table.

Table 2-2. Examples of ICoE-UR&S's efforts in Understanding, Evaluating and Modelling Risk and Safety

Examples of achievements	IRDR WG related
Drought Risk Assessment for Crops Insurance in Colombia, FINAGRO	RIA
Development of the Disaster Risk Atlas of Uruguay, SINAE	RIA, DATA
Development of the Disaster Risk Atlas of Colombia, UNGRD	RIA, DATA
Evaluation of risk using the Drought Risk Model in Central America (Honduras, Guatemala, El Salvador; Trifinio Region) and Uruguay	FORIN, RIA
Evaluation of risk using the Drought Risk Model in Central America and Northeast of Brazil for collective review during the workshop convened by NOAA in Boulder, February 2017	RIA
Development of the Drought Probabilistic Hazard and Risk Model and integration to New Generation CAPRA Robot platform	RIA
Country's Disaster Risk Profile for Argentina and Chile (RIA); Country's risk evaluation and profiles for Argentina, Chile, Bolivia, Peru, Ecuador, Venezuela, Colombia, Guyana, Nicaragua, Costa Rica, El Salvador, Honduras, Guatemala, Belize, Mexico, Jamaica, Dominican Republic, Trinidad and Tobago, Nepal	RIA
Hybrid Loss Exceedance Curve methodology to reflect the extensive and intensive risk for Colombia, Mexico, Nepal, Ecuador, Venezuela, Guatemala, Bolivia, El Salvador, Jamaica, Peru, Mauritius, Seychelles, Madagascar	RIA
Comprehensive Approach to Probabilistic Risk Assessments: CAPRA and Global Risk Model Suite: CAPRA-GRM (risk evaluation and capacity building in 19 countries)	RIA
The multi-hazard risk evaluation CAPRA platform and the hybrid loss exceedance curve (based on DesInventar database and CAPRA), used in several countries from the Americas, Europe and Southeast Asia, and in the framework of the Global Risk Model (GRM) of the UNISDR GAR.	RIA, DATA

◆ Hazard-centred Territorial Management

For several years now, **IRDR NC-France** along with other French organizations have implemented territorial management approaches based on risk. These approaches are often "hazard-centred", i.e., they characterize, according to the threatening phenomena (e.g., earthquake, flood, ground movement, explosion, etc.), the territorial envelopes exposed to hazards and characterize the vulnerabilities on the said exposed territories. Thus, both hazards and prevention maps are drawn up. These are made available and shared with relevant stakeholders as regulatory documents on open data and information sharing zones of the Ministry of the Environment's website.

In addition to these actions, "territory-centric" approaches help give a more complete characterizing of risk and vulnerability. In other words, it is not the hazard that defines the territories at risk, but rather the different spatial, historical, decision-making ability and experience of the actors that make it possible to fully understand and grasp the risk.

The issue of people's exposure to risk has been addressed in different ways. A flagship initiative was set up to enable collaboration between public and private players, including insurance companies through the establishment of the ONRN[13]. However, this initiative of opening up to data seems to have regressed since 2014, possibly as a result of reluctance integrating security issues since the terrorist attacks.

The issue of territorial inequalities has also given rise to several research and expert initiatives as well as regulation (e.g., Health-Environment Plan). There are, however, still a number of major challenges that should be taken into account, particularly with regard to multi-risk issues and cumulative (cocktail) effects.

Finally, the issue of new and emerging risks has been the subject of several research projects. Recently, the issue of transitions and taking into account global changes has been the subject of increased focus. In addition to these themes, new dynamic modelling approaches have been taken into account. Thus, a novel graph and network based approach makes it possible to rethink the question of risk no longer as a question of potential but rather as a question of flows transferring from one system to another. This approach still needs to be tested and confirmed.

What is Risk?

It should be noted in this respect that the Natural and Technological Risk Law of 30 July 2003 (passed after the Toulouse ammonium nitrate explosion and floods in southern France) has made it possible to take into account the dimensions of hazards, the vulnerability of targets as well as risk management and reduction measures in the definition of risks. This 2003 definition (and the associated regulation instrument, the risk prevention plans for natural hazards, since then applied to technological risks) was a shift as it integrated benefits from territorial approaches of natural hazards vulnerability and transferred it to technological risks. However, this definition has since been subject of many difficulties following the adoption by France, in certain sectors of activity, of the ISO 31000 standard, which changed the definition of risks within the prevention community from "Risk is the combination of a hazard and vulnerable issues" to "Risk is the effect of uncertainty on objectives", which in effect shifts from a spatial vision of risks to an entrepreneurial vision of risks.

--By **IRDR NC-France**

13 Observatoire National des Risques Naturels. https://www.georisques.gouv.fr/risques/observatoire-national-des-risques-naturels

O1.2 Forecasting Hazards and Assessing Risks

◆ Typhoon monitoring and forecasting

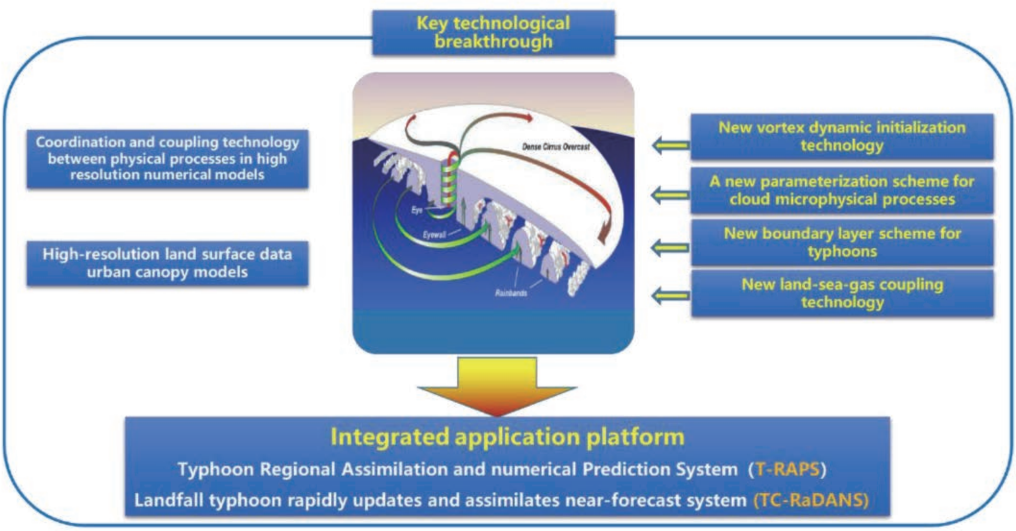
Typhoons trigger a number of natural disasters in China as well as causes serious disaster losses. Till now, how to accurately monitor and forecast the intensity thereof, as well as the typhoon's associated gale and rainstorms have not been completely addressed. In order to meet the requirements of national typhoon prevention and disaster mitigation, **IRDR NC-China** conducted numerous scientific investigations. The progress therefrom are summarized below.

A. High-resolution Typhoon Monitoring and Forecasting System

Key technologies of high-resolution typhoon monitoring and forecasting system are developed in integration with the dynamical initialization scheme (Liu et al., 2018), and data assimilation and coupled atmospheric and ocean models. Of those, the Turbulence Kinetic Energy (TKE) and TKE dissipation rate based 1.5-order closure planetary boundary layer parameterization scheme, and the Chinese Academy of Meteorological Sciences cloud microphysics parameterization scheme suitable for TC condition parameterization schemes of the turbulence kinetic energy-turbulence kinetic energy dissipation rate closed boundary layer under typhoon conditions are both better than the commonly used parametric schemes in the world (Gao et al., 2011; Zhang et al., 2020).

Under the framework, which integrates multi-scale observation assimilation and other new technologies, multi-source data such as satellite, radar and aircraft observation are combined, and the fine structure of typhoon analysis field is formed. Based on this framework, the prediction performance of typhoon path and intensity results improved an average of 2.5% (for 12 hr) and 5.9% (for 72 hr); with the path prediction results improving 10.1%, and the intensity prediction results improving up to 25.3% and 32.6% (Duan et al., 2019). The typhoon assimilation forecast system developed has realized operational operation, which can provide strong technical support for national disaster prevention and reduction. This achievement won second prize at the 2018 National Science and Technology Progress Awards.

Figure 2-5: **Key technological breakthrough of the T-RAPS.**



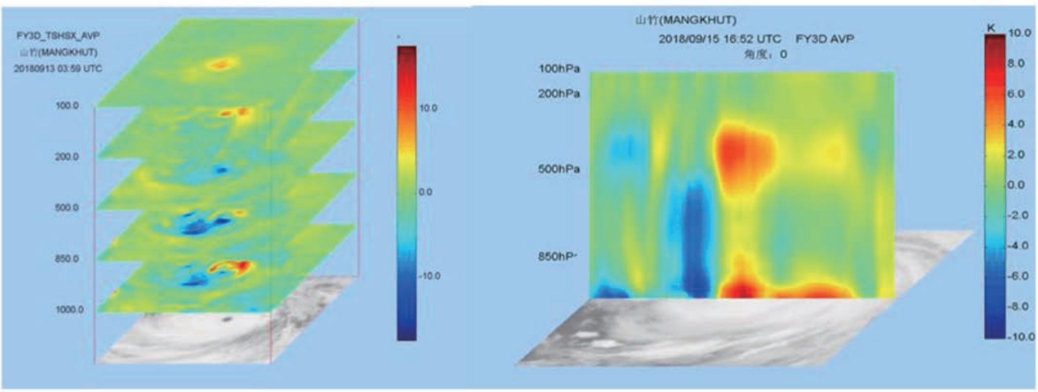
B. Typhoon Vertical Structure Monitoring based on Fengyun Satellite

A new method for vertical structure monitoring of typhoon through Fengyun meteorological satellite is developed. Based on the vertical microwave detection data of Fengyun satellite, taking the typhoon eye, eyewall, as well as spiral rainbands as the main monitoring objects, the position and shape changes of the structure of the typhoon can be accurately monitored. From this monitoring, changes in the three-dimensional temperature structure characteristics of the typhoon can be analyzed. In other words, the typhoon structure, typhoon intensity and their changes were analyzed from the perspective of energy (Figure 2-6). Finally, parameters calculation and research results complete the quantitative description of the three-dimensional structure characteristics of the tropical cyclone. Altogether these accurately express the intensity and variation trend of the tropical cyclone, and provide basic reference information for tropical cyclone monitoring and forecasting.

◆ Improving Multihazard Risk Assessment

IRDR ICoE in Spatial Decision Support for Integrated Disaster Risk Reduction (IRDR ICoE-SDS IDRR, Netherlands): A single extreme weather event such as a tropical cyclone or monsoon can compound hazard effects, domino effects of hazard chains. Research projects were done in the Caribbean, looking at risk assessment of small island states (funding GFDRR[14]). Very often when we look at these situations, we use models for each hazard separately but this is not what stakeholders' experience. Tropical cyclones cause seas surges, wind damage, flash floods, landslides and debris flows. All of these occur all at the same time and there is no safe area on an island. For instance, research on the Island of Dominica shows that what we call "flash floods" as a result of Hurricane Maria (2017) are in fact fast debris flows from runoff and landslides with heavy sediment loads and massive amounts of trees that have much more destructive power than water alone. Hence, one major area of work is the development of a multi-hazard model that can simulate a number of these processes simultaneously, whereby the landscape can change during the event. This model (openLISEM[15]) is free and open source and

Figure 2-6: The vertical heart-warming structure of the super typhoon Mangkhut monitored by the FY-3 D-star.



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15 https://blog.utwente.nl/lisem/

is constantly under development as new areas are simulated (Van Den Bout et al., 2020). Such a model is hard to calibrate but at the time it gives a more realistic perspective on impact of hazard processes.

Hazard "chains" and domino effects were also studied in a research cooperation the Chengdu University of Technology (CDUT), after the Wenchuan earthquake in 2008 in China. Apart from direct damage, the earthquake caused approximately 85,000 landslides, of which hundreds blocked rivers and had to be cleared to prevent flooding (Fan et al., 2012). Landslide triggering by earthquake wave propagation is in the process of being added to the model. The strength of openLISEM is that it can use globally available data sources (GPM for weather, SOILGRIDS for soil info, various DEM and land use sources, open street map) although local data will improve results. Tutorials and lecture material for courses are available and are being put online.

Monitoring an area for several years shows that risk is not a static quantity that you have to calculate only once, it changes constantly because of human actions, changing landscapes and changing climate. After each disaster risk has to be re-assessed. To help with this, a spatial decision support system (SDSS) was developed in 2014-2018 funded by the EU FP7 Marie Curie called 'RiskChanges' (Van Westen et al., 2014). The web-based system calculates physical risk using detailed spatial input of hazards and elements at risk, and the user is able to simulate

Figure 2-7: Example of domino effects simulated with openLISEM in Honchun (China): First come the slope failures (1st stage), which develop into debris flows (2nd stage), which then accumulate as a debris flow dam in the river (3rd stage), eventually causing a flash flood (4th stage), (Van Den Bout et al., 2020).

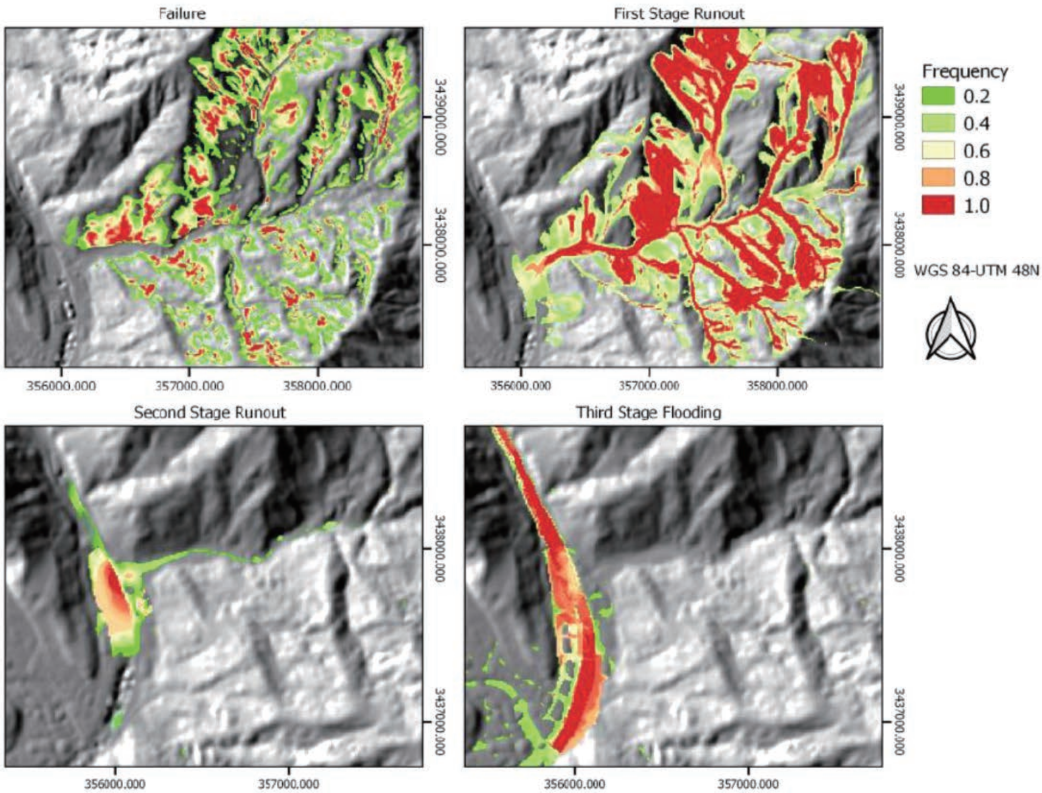
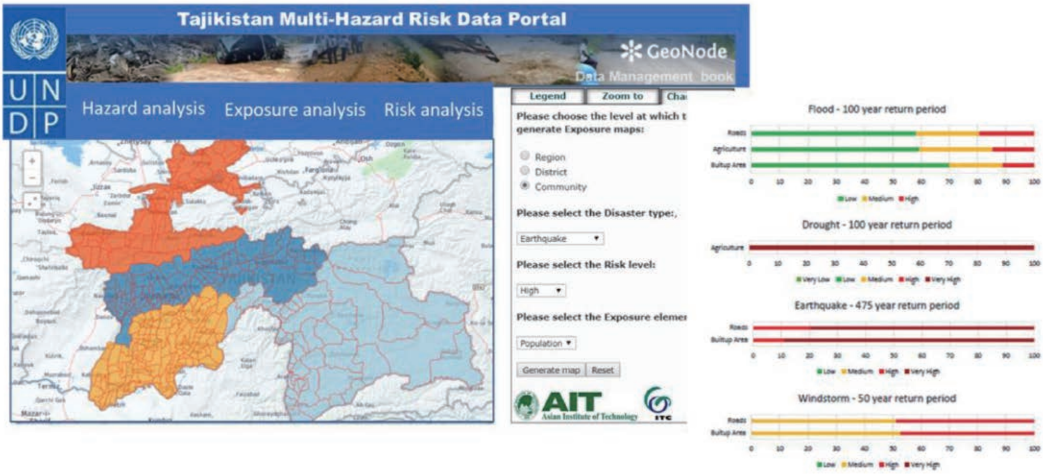


Figure 2-8: Tajikistan data portal with exposure and risk data for multiple hazards, with links to a Geonode for spatial information (for UNDP, 2020).



the effect of scenarios from "business as usual", to different planning and mitigation strategies, or the effects of climate change for instance. RiskChanges is in a prototype stage that is now further developed in cooperation with the Asian Institute of Technology and integrated with openLISEM as one package. This process should be completed in the next 4 years. Currently available for research purposes, once it is out of a beta/testing phase RiskChanges will be freely available to the wider IRDR community.

Apart from detailed local assessments, methods have also been developed for national scale assessments of hazard, vulnerability, exposure and risk. National scale assessments have different stakeholders (as they are more policy and national planning oriented), and the information is usually in relatively scaled indicators rather than direct quantitative impact. An example is the UNDP funded project for Tajikistan where the vulnerability of communities and infrastructure to earthquake, landslides, floods, mudflows, snow avalanches, windstorms and drought was assessed. Risk profiles as a basis for development planning processes were created for all districts of Tajikistan (Van Westen, 2019). The project included local expert training sessions.

◆ National Hazard Forecasting Models in New Zealand

A. National Volcanic Hazard Model

Since the 2012 Te Maari eruption, IRDR NC-New Zealand has continued to make advances, including a 'NZ Inc' approach towards establishing a National Volcanic Hazard Model (NVHM) for New Zealand (Bebbington, 2015). The Goals of this NVHM for New Zealand:

1. Identifying and achieving the minimum data requirements for NVHM development;
2. Gaining the support and acceptance of the NVHM from peers in the scientific and end-user communities;
3. Establishing the NVHM as a versatile open-source model
4. Ability to apply the NVHM to multi-hazard analysis
5. Ability to the NVHM to directly inform risk assessment

NC-New Zealand carried out an expert elicitation approach to estimate future eruption potential for 12 volcanoes of interest in New Zealand. A total of

28 New Zealand experts provided estimates that were combined using Cooke's classical method to arrive at a hazard estimate. In 11 of the 12 cases, the elicited eruption duration increased with Volcanic Explosivity Index (VEI, used as a measure of eruption intensity), and was correlated with expected repose, differing little between volcanoes. Most of the andesitic volcanoes had very similar elicited distributions for the VEI of a future eruption, except that Taranaki was expected to produce a larger eruption, due to the current long repose. Elicited future vent locations for Tongariro and Okataina reflect strongly the most recent eruptions. In the poorly studied Bay of Islands volcanic field, the estimated vent location distribution was centred on the centroid of the previous vent locations, while in the Auckland field, it was focused on regions within the field without past eruptions.

B. Coastal Hazard Forecasting

The 2016 Kaikōura earthquake generated a tsunami that inundated and badly damaged a cottage on Banks Peninsula, and towns south of Kaikōura experienced a near-miss as the tsunami ran-up 6-7 metres on embankments between them and the sea. New Zealand researchers were instrumental in gathering the data on this tsunami, providing the only clear picture of how far this earthquake extended offshore. Significantly within the last 10 years, the host of NC-New Zealand funded researches to develop the first model of tsunami hazard for all New Zealand coasts, and progress with the techniques that have enabled much of the country to have tsunami evacuation zones mapped.

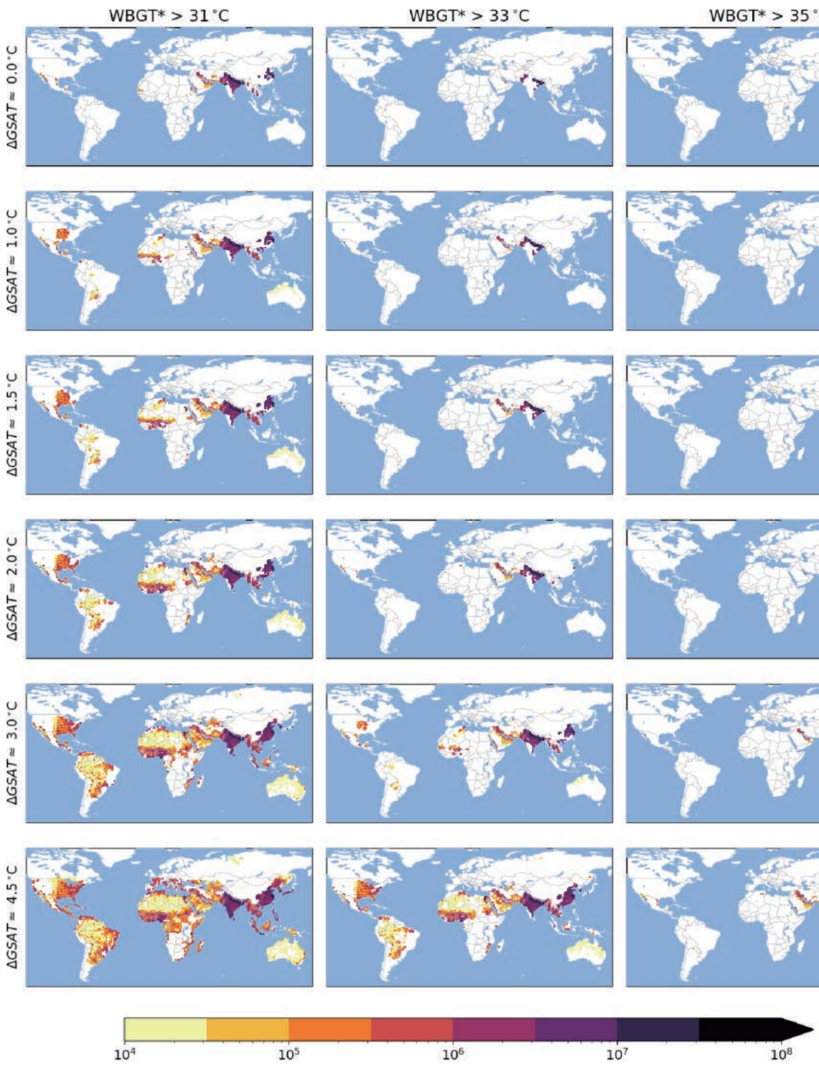
Another exciting project nearing completion is the 'Enhanced probabilistic flood forecasting' which will generate high-resolution, probabilistic two day ahead flood (catchment) forecasts for all of New Zealand. The forecasts are produced by using a complex Bayesian statistical method to create an unbiased spread (or ensemble) of forecasted hourly rainfall rates at grid points over a catchment that feed into a river flow model. These unbiased ensembles are calculated on a fine spatial grid of 1.5 km and forecasts are updated every six hours and extend to 48 hours. The development of this method will enable the production of next generation forecasts as high-resolution weather ensemble forecasts become available in New Zealand. This will allow for more realistic uncertainty (probabilistic) estimates (providing a range of outcomes) to be made in flood situations.

Climate change is a critical issue. Coastal hazard researchers hence have developed a free storm surge & coastal hazard tool for end-users. Researchers of the University of Auckland have further modelled and assessed coastal inundation due to tide, wave and storm surge conditions for current and future storms that impact New Zealand and impressive visualization tools have been developed to demonstrate the changing risk over the next century (Coco & Bryan, 2018).

◆ Health impact of weather/climate extremes

Heatwaves harms human health, especially for older persons and those with chronic conditions. Older patients with chronic conditions may be at heightened risk for heat-related hospitalization due to the use of heat-sensitizing medications throughout the summer months (Layton et al., 2020). In the context of global warming, exposure to heatwaves is increasing. While most studies assessing future heat stress have focused on surface air temperature, compound extremes of heat and humidity are key drivers of heat stress. The scientists at the Fudan University, which is the host of **IRDR ICoE on Risk Interconnectivity and Governance on Weather/Climate Extremes Impact and Public Health (ICoE-RIG-WECEIPHE, China)**, developed a statistical model based on quantile regression approach to capture the joint distribution of temperature and humidity (Yuan et al., 2020). They found that despite a modest decrease in median relative humidity, heat stress measured by metrics considering both humidity and temperature in a warming climate will increase faster than that measured by temperatures alone would indicate. Furthermore, the intensity of heat stress in a day at a given maximum daily temperature will increase in a warming climate due to the increase of humidity. Li et al. (2020) evaluated future changes in daily compound heat-humidity extremes as a function of increasing global-mean surface air temperature (GSAT). The historical ~1°C of GSAT increase above preindustrial levels has already increased the population annually exposed to at least one day with WBGT exceeding 33°C (the reference safety value for humans at rest per the ISO-7243 standard) from 97 million to 275 million. Maintaining the current population distribution, this exposure is projected to increase to 508 million with 1.5°C of warming, 789 million with 2.0°C of warming, and 1.22 billion with 3.0°C of warming (similar to late-century warming projected based on current mitigation policies).

Figure 2-9: Maps of population affected by at least 1 day per decade of WBGT*max greater than 31°C (left column), 33°C (middle), and 35°C (right). Colours represent population in each nominal 1 degree grid cell. WBGT* statistics is based on output from 40-member CESM-LE RCP8.5 simulations. (Li et al. 2020).

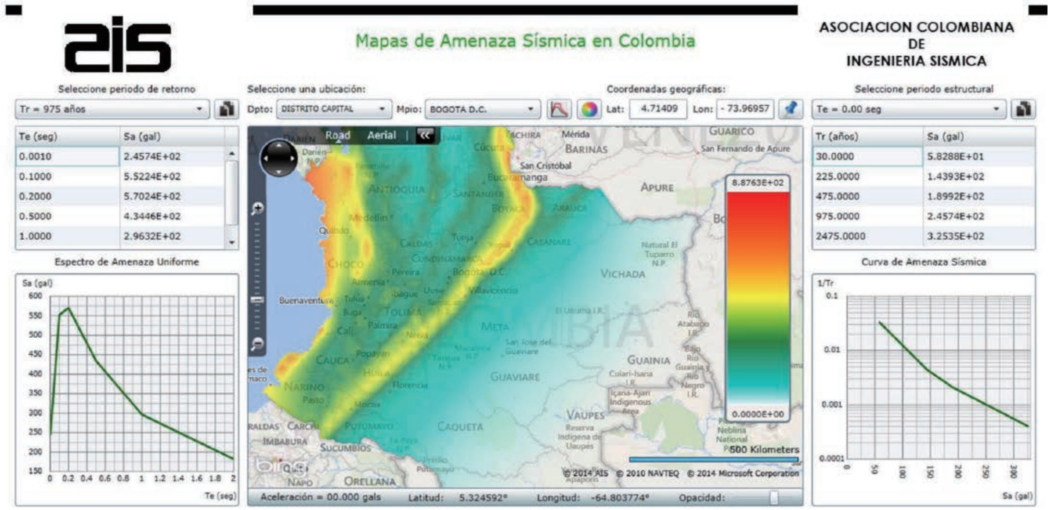


◆ Evaluation of the seismic hazard of Colombia

The availability of more refined models and calculation techniques for evaluating seismic hazards and the existence of a greater number of seismic event records allow for an update of seismic hazard studies nationwide. **IRDR NC-Colombia** describes a new methodology used to estimate different expected seismic intensities for designing and constructing earthquake-resistant buildings in Colombian territory. The intensity results obtained for different return periods and spectral ordinates for buildings of different structural periods are presented, which is a necessary input for seismic go within the national territory of the Republic of Colombia[16].

Concerning the general seismic hazard study, the Committee in Colombia (named as AIS-300) has evaluated the seismic hazard at the national level using updated information in the framework of the update of the Colombian Seismic Design Code of Bridges. In terms of the catalog used, five more years of information and strong motion attenuation ratios calibrated from local records. This update evaluated the seismic hazard with a probabilistic and spectral approach to establish the values of the seismic design coefficients associated, with a probability of exceedance of 7% in 75 years, which is roughly equivalent to an average recurrence period of 975 years[17].

Figure 2-10: **AIS platform to obtain the parameters of the country's seismic threat.**



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17 https://repositorio.gestiondelriesgo.gov.co/handle/20.500.11762/19790

How to better forecasting hazard and risk?

The issue of hazard prediction cannot be separated from the issue of liability and enforceability in disaster risk prevention and management. Thus, beyond the question of hazard prediction, there is the question of predicting areas of vulnerability. Similarly, the issue of forecasting raises the difficult link between risk and resilience as well as between safety, security and adaptation.

This question has been taken into account in three ways. The first is the question of the characterization of hazards in territories according to their nature, their probability, their kinetics, their territorial amplitude and the different potential effects (e.g. lethal effect). The second is the question of taking into account the historical dimension and the memory of territories and actors. Thus, the loss of information induced by the change of administrative and territorial protocols for hazard mapping and the evolution of impacted perimeters can be curbed by maintaining a memory of disasters and improving the quality of data and knowledge sharing between stakeholders, especially useful for keeping alive risk perception and action repertoires. The third is related to the detection of early warning signs, weak signals and tangential breaks.
The increasing research deployment of historical, physical and analytical approaches to hazards has highlighted that the failure to forecast was often due to a lack of analysis of major historical events.

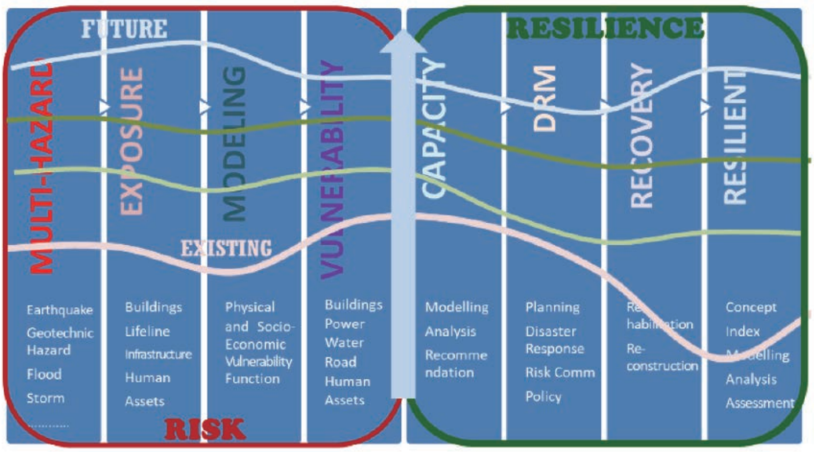
--By **IRDR NC-France**

O1.3 Dynamic modelling of risk

◆ Integrated Iran Natural Hazards Risk and Resilient Model/Toolbob (IRRM)

Although many comprehensive studies have been carried out and various models have been developed to assess earthquake risk in Iran, the lack of a multi-hazard approach can be clearly seen. **IRDR NC-Iran** published the Integrated and Comprehensive Natural Hazards Risk and Resilience Model of Iran, which is under development, targeting the quantification of actual risk (physical, social and economic loss); as well as definition of the acceptable level of risk and the target resilience with the emphasis on the main urban settlements (Atrachali et al., 2019).

Figure 2-11: Integrated and comprehensive Hazard, Vulnerability, Risk and Resilience Model.



Key Guiding Principles of IRRM are:

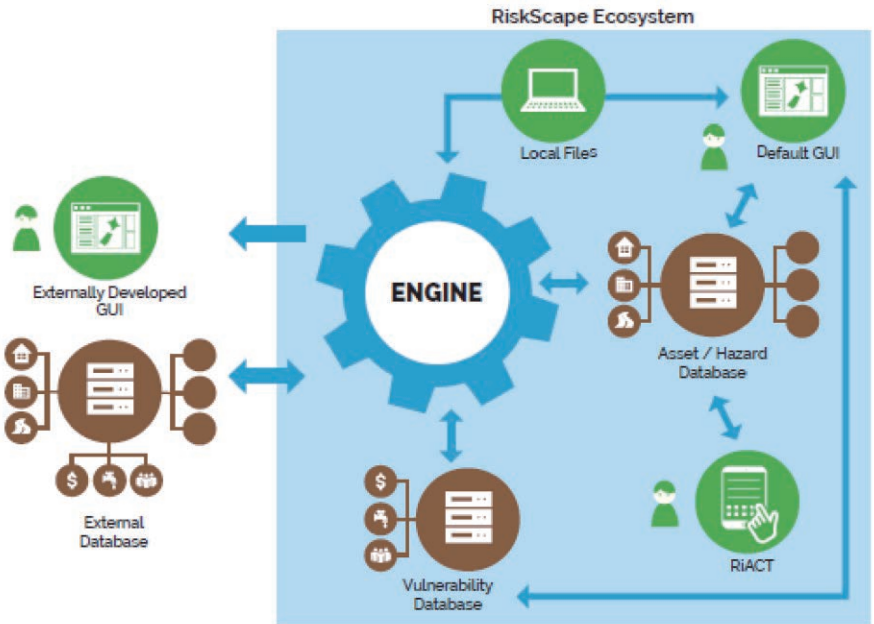
1. Integrated and comprehensive resilience approach;
2. Multi-hazard approach;
3. Consideration of urban and regional interdependency;
4. Tangible, implementable and feasible actions;
5. Joint collaboration and partnership;
6. Creation of added values and incentives for all partners;
7. Avoidance of possible duplications using gap analysis

◆ RiskScape + MERIT Modeling Tools for Resilience Investment

RiskScape is a risk modelling software developed jointly since 2004 by the National Institute of Water and Atmospheric Research (NIWA), Geological and Nuclear Sciences (GNS) Science and **IRDR NC-New Zealand**. The software quantitatively estimates the impacts of natural hazard events, identifying where the highest risks to people, buildings and infrastructure damage may occur. It's a valuable tool for land-use planners, emergency managers, engineers and insurers.

A new collaboration with the Earthquake Commission (EQC) will see RiskScape 2.0 replace the Commission's current risk modelling software. It will be used to produce earthquake loss and impact estimates and will inform EQC's annual reinsurance negotiations. The aforementioned organizations will continue to develop RiskScape 2.0, including assessing other geological and weather-related hazards. Starting in May 2018, RiskScape has been under redevelopment using open-source technology to build a new modular adaptive platform. The work program for RiskScape includes continuing to develop its core engine, with a focus on workflow functionality,

Figure 2-12: **RISKSCAPE Version 2.0.**



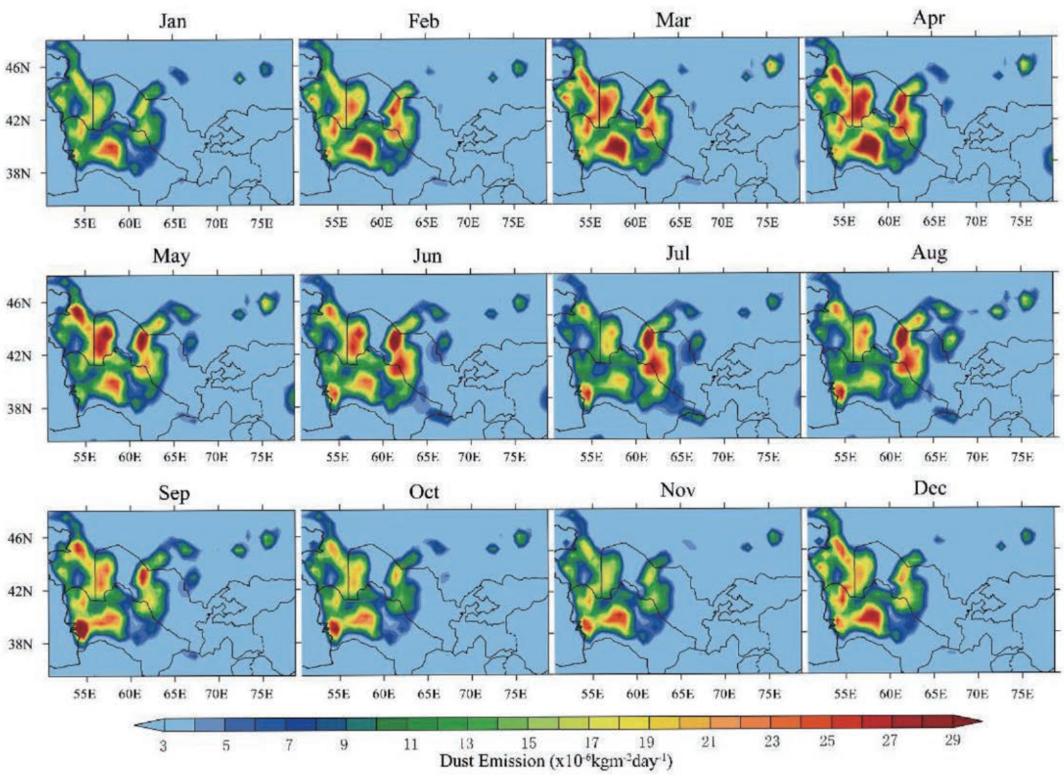
optimization and performance enhancements. Finally, starting in late 2019 and still ongoing is RiskScape's work on building a customized user interface to respond to the specific requirements from the vast array of users.

Since its initial development, RiskScape has been used domestically and overseas to learn more about natural hazards and evaluate potential mitigation options. Beginning with pilot studies in Westport, Hawkes Bay and Christchurch, RiskScape is now being used by the Samoa and Vanuatu governments through the Pacific Risk Tool for Resilience (PARTneR) project, and in some Indonesian universities. The New Zealand Treasury and the insurance sector are also using the tool for major projects to forecast future losses and impacts. Interest is not restricted to New Zealand shores, with the World Bank Group and National Aeronautics and Space Administration (NASA) also showing keen interest in RiskScape. In New Zealand, RiskScape has underpinned loss estimates for the AF8 research program and has evaluated the impacts of a large Wellington earthquake, in partnership with the MeRit (Measuring the Economics of Resilient Infrastructure) Tool (Woods, 2018).

◆ Factors and temporal variation of emissions from dust sources in Central Asia over the past 40 years

The shrinkage of the Aral Sea and the development of abundant irrigation systems have increased the sources of dust aerosol. Understanding the variation trend of dust emissions over Central Asia and their linkages to climate is crucial for the regional economy and dust storm management.

Figure 2-13: Average annual variation of dust emissions (1980 to 2019).



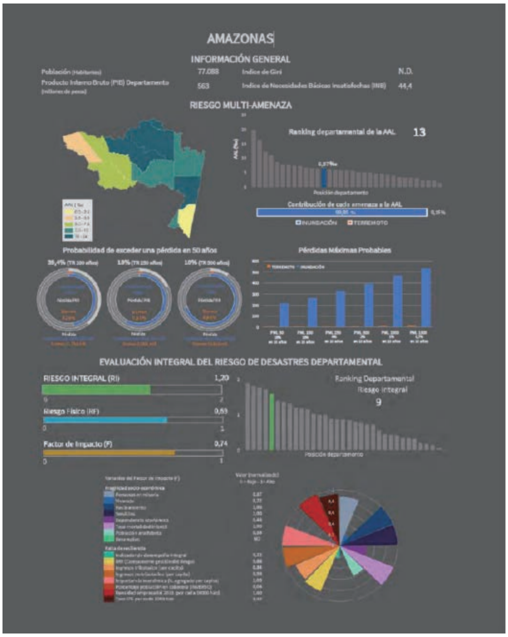
IRDR NC-China use monthly dust aerosol data and meteorological data to analyze the variation trend of dust storm events over Central Asia from 1980 to 2019, and to explore events' association with surface conditions, temperature, and climate indices based on multiple long-term datasets. Main findings are as follows: 1. Dust emissions over dust sources in Central Asia exhibited two maximum value intervals, one from 1980 to 1986, another from 1993 to 2003. 2. Dust emissions over the eastern shore of the southern Caspian and the central Karakum desert from 2015 to 2019 increased to the level of the maximum value intervals due to the extreme drought and gales (at the 0.99 confidence level).

◆ Colombia's Risk Atlas: Revealing Latent Disasters

The regional action plan for implementing the Sendai Framework for risk reduction of 2015-2030 disasters in the Americas, raises a first priority: understanding disaster risk. In response to this, it is essential that the countries of the region advance in strengthening the information systems, the monitoring and registration of potential and existing risks, and the exchange of knowledge of disaster reduction and management.

The Risk Atlas of Colombia[18] has been prepared by the National Unit for Disaster Risk Management, which is the host of **IRDR NC-Colombia**, and by INGENIAR Risk Intelligence, a leading company in the country in risk management. This product arises given the need to advance in the knowledge of risk at the national and regional level, taking into account that the entity's mission is to improve people's quality of life and contribute to sustainable development. The Atlas provides a better understanding of disaster risk in its dimensions of hazard, vulnerability, degree of exposure, and characteristics of the environment in the country.

Figure 2-14: Cover of Colombia's Risk Atlas: Revealing Latent Disasters and a case of Amazon Area.



This publication compiles advances made in the analysis of the different hazards and presents new results of the risk in Colombia at the province (departmental) level. Additionally, it is the result of an inter-institutional effort, with information from the leading institutions in the field such as the OSSO Corporation, the General Maritime Directorate (DIMAR), the Colombian Geological Service (SGC), the Institute of Hydrology, Meteorology and Environmental Studies (IDEAM), and the Agustín Codazzi Geographical Institute (IGAC).

It is expected that this type of initiative will become an incentive for interrelated work among the different national, territorial and operational institutions. Further, the Atlas also generates and shares information to understand the importance

18 https://repositorio.gestiondelriesgo.gov.co/handle/20.500.11762/27179

of risk knowledge and the positive impact that this step can have on the country's socio-economic development. The knowledge generated in this Atlas can be used for risk analysis and evaluation, and it becomes a fundamental tool to generate risk reduction and disaster management strategies. The National Unit for Disaster Risk Management will generate new knowledge that informs decisions to produce a less vulnerable Colombia with more resilient communities.

◆ Impact of COVID-19 and its association with meteorology and air quality (MAQ)

ICoE-RIG-WECEIPHE did quite a few investigations regarding the impact of MAQ to COVID-19 and several papers were included by the WMO in the Review[19] on Meteorological and Air Quality Factors Affecting the COVID-19 Pandemic published on 18 March, 2021. Liu et al. (2020) found that some medical staff areas initially had high concentrations of viral RNA with aerosol size distributions that showed peaks in the submicrometre and/or supermicrometre regions. This study findings suggest that SARS-CoV-2 may have the potential to be transmitted through aerosols. Yao, Pan, Wang, et al. (2020) reported positive associations between PM pollution and COVID-19 death risks in cities both inside and outside Hubei Province. Yao, Pan, Liu, et al. (2020) investigated the associations of meteorological factors (including temperature, relative humidity and UV radiation) with the spread ability of COVID-19 in 224 Chinese cities. They found that high temperature and UV radiation could not reduce the transmission of COVID-19 and thus it might be premature to count on warmer weather to control COVID-19. Pan et al. (2021) examined the possible association between meteorological conditions and basic reproductive number (R0) of COVID-19 in 202 locations in 8 countries and revealed that meteorological conditions did not have statistically significant associations with the R0 of COVID-19. This study indicated that warmer weather alone seems unlikely to reduce the COVID-19 transmission. Wang and Zhang (2020) analyzed air quality variations before and after lockdown period and effect of meteorological factors. Results showed that provinces with the significant air quality variations are the hardest hit by COVID-19, demonstrating the link between disease prevention and control measures and air quality. Yet pollution concentrations in Beijing and surrounding areas almost show the same level with historical average, possibly due to the unfavorable atmospheric horizontal and vertical diffusion conditions combined with the relatively high humidity. Wang et al. (2020) assessed the benefits of lockdown measures from containing the spread of COVID-19. They estimate that swift action in China is effective in limiting the number of COVID-19 cases, whereas a one-week delay would have required greater containment and a doubling of the emission reduction to meet the same goal. They also find an unprecedentedly high cost of maintaining activities and CO_2 emissions during the COVID-19 pandemic and stress substantial benefits of containment in public health by taking early actions to reduce activities during the outbreak of COVID-19.

Obj. 2: Understanding decision-making in complex and changing risk contexts

This objective is focused on understanding effective decision-making in the context of risk management. These include actions undertaken in furtherance of Goal 1 (promote integrated research, advocacy and awareness-raising) and Goal 3 (understanding decision-making in complex and changing risk contexts) of IRDR's Strategic Plan. Key questions that are tried to be addressed under this objective are list as below.

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The largest number of achievements fall under this objective, with a number of NCs and ICoEs from America (Canada, Colombia and USA), Asia (China, Malaysia, India and Iran), Europe (France, German, and Netherlands), Oceania (Australia and New Zealand) and the global Stockholm Environment Institute all making great contributions. This also includes WGs Assessment of Integrated Research on Disaster Risk (AIRDR; aligned with Goal 1) and Risk Interpretation and Action (RIA; aligned with Goal 3).

Key questions:

- Whose decisions make most impact on level of risk?
- How much, and what kinds of, authority do different decision-makers have?
- How do different decision-makers and agencies interact?
- How do decisions made at local and at national or international levels impact on each other?
- How do actors/decision-makers perceive the level of risk associated with any given hazard considered singly and/or in comparison to other hazards they are facing?
- What options do they believe are open to them when faced with such hazards?
- What do they perceive to be the likely consequences of these different options?
- How are disaster risks perceived in relation to more chronic risks such as unemployment, lack of income, threats to cultural and personal identity?
- What is the quality of information available to decision-makers at all levels?
- What factors influence whether or not such information will be used?
- What factors influence whether risk communications are trusted?
- What governance structures may facilitate better decision-making practice?
- How to adapt the decision-making systems to the different levels of decision makers?

Researches and their achievements under this objective take more attention to human and human behavior, social and policy strategy. Interview and literature review are mostly used methods to understand decision-making; indicators, platforms and simulation systems are established to help decision-making; the results were managed into plans, reports, guidelines, and so on. Climate Change Adaptation (CCA) were also taken into account by most community at the same time. According to the achievements submitted, researches all focused on making the decision more effective.

O2.1 Identifying relevant decision-making systems and their interactions

◆ Understanding how mainstream community/cultural processes influence resilience

The **IRDR ICoE in Community Resilience (IRDR ICoE-CR, New Zealand)'s** work supports the IRDR objectives of characterizing resilience through empirical measurements, based upon the principle that resilience affords many benefits to societies and their members. This involves understanding how mainstream community/cultural processes influence resilience (based on the premise that people's capacities derive primarily from their everyday life experiences). That is, understanding how 'everyday' community competencies and characteristics influence risk, consequences, and the choices people make about how to manage their risk. This affords opportunities to implement resilience programmes in ways that integrate risk management and community development through community engagement (Kwok et al., 2019; Kwok et al., 2016). This process increases the likelihood of sustained benefit as a result of its focus on developing social capital that can have benefits in everyday life, and not just when disaster strikes. More details on the outcomes and outputs of the ICoE-CR can be found in their "Summary report of activities 2014 to 2019". These activities both contributed to and build off the activities of IRDR as well as the broader work around the Sendai Framework and New Zealand's National Resilience Strategy. The activities ICoE have shown us a number of insights. Practitioners charged with integrating scientific findings into community interventions and improvements while juggling various policy requirements and operational goals frequently continue to neglect to include appropriate scientific information. Likewise, researchers often struggle to comprehend the views of the user when they are not involved in the operationalisation of their theory-driven concepts and neglect to include end user needs when conducting research (Kwok et al., 2016). Therefore, it is important to recognize that as science informs practice, practice can equally inform science. The work at the ICoE is an example of scientific co-production of knowledge, a collaborative process between multiple stakeholders, to ensure knowledge is useful, useable, and used (Doyle et al., 2015).

◆ Association of State Floodplain Managers

In the United States, flooding causes more losses than all other natural hazards combined. Given the damage and destruction generated by floods, unsustainable development, and population growth in hazardous regions, it is critical to periodically assess the status of state floodplain management programs.

The Association of State Floodplain Managers (ASFPM) periodically conducts a national assessment of state floodplain managers to learn more about the practices by which state and local governments manage floodplains. In 2017, ASFPM, with funding from the Federal Emergency Management Agency (FEMA), commenced a one-year project with the Natural Hazards Center,

Figure 2-15: An ICoE workshop at Wellington Region Emergency Management Office (WREMO) on Knowledge Sharing between communities, practitioners, and researchers. The findings from this workshop have been published as Doyle et al. (2015).

which is the host of **IRDR NC-USA**, to update its ongoing state-wide survey of state floodplain managers.

The central objective of this project was to assess and make public, by way of the report, the then current status of state level floodplain management in the United States, with the material contained therein meant to serve as a useful reference for policy advocates and those in the floodplain management community who are interested in understanding more about the identification and assessment of flood risks and the actions that are being taken to reduce those risks. The report assessed funding and staffing trends and highlighted best practices for sound floodplain management, and is organized around the 10 guiding principles for floodplain management, as was established in prior ASFPM reports[20]. Finally, the sharing of the information provides an evidence base to help states build stronger floodplain management programs.

Table 2-3. Ten Guiding Principles for Floodplain Management

Principle 1	Principle 2	Principle 3	Principle 4	Principle 5
• State floodplain management programs need strong, clear authority.	• State floodplain management programs should be comprehensive and integrated with other state functions.	• Flood hazards within the state must be identified and associated risks must be assessed.	• Natural floodplain functions and resources throughout the state need to be respected.	• Development within the state must be guided away from flood-prone areas; adverse impacts of development inside and outside the floodplain must be minimized.

Principle 6	Principle 7	Principle 8	Principle 9	Principle 10
• Flood mitigation and recovery strategies should be in place throughout the state.	• The state's people need to be informed about flood hazards and mitigation options.	• Training and technical assistance in floodplain management need to be available to the state's communities.	• The levels of funding and staffing for floodplain management should meet the demand within each state.	• Evaluation of the effectiveness of state floodplain management programs is essential and successes should be documented.

20 https://www.floodsciencecenter.org/projects/floodplain-management-state-programsupdate-2017/

◆ Formulation of Earthquake Disaster Management Master Plans

To date, many projects have been implemented to reduce earthquake risk and improve disaster management, each addressing specific issues of DRR. However, the experiences gained during recent years depicted that individual measures cannot sufficiently improve existing conditions to achieve main goals of sustainable development. Therefore, **IRDR NC-Iran** devised the integrated Disaster Risk Management Master Plans (DRMMP). Accordingly, since 2010, many disaster management master plans have been prepared for major cities in Iran, in which the following subjects have been addressed and their links and interconnections clearly established (Ghafory-Ashtiany, 2014):

1. Mitigation and Prevention: In this section many measures have been introduced, specifically on risk assessment (earthquake and geological hazards, vulnerability of built environment, exposures, etc.). In addition, necessary guidelines and standards were developed and enacted to carry out such assessments and implementation of DRR.

2. Preparedness: Risk mapping and risk communication are the main objectives of this sector in DRMMP, including demonstrating the status quo of existing risks to individuals and provide knowledge and trainings on DRR to different target groups. In addition, developing disaster risk transfer and finance mechanisms and designing community-based disaster management activities are examples of the components of this sector that have been addressed in the DRMMP.

3. Emergency Response: Improving disaster management legislations and organizations, establishing Emergency Operation Centers (EOC) as well as Incident Command Systems (ICS), making emergency response plans (in different areas including search, rescue and relief, emergency medical care, emergency communication, evacuation and emergency shelters, etc.), and developing necessary tools and technology for facilitation of emergency response are among the key elements of Emergency Response included in the DRMMP.

4. Recovery and Reconstruction: Preparing appropriate plans for post-disaster needs assessment, recovery and reconstruction based on international and domestic experiences, local conditions, and devising programs for enhancing urban areas have been also taken into consideration in the preparation of the DRMMPmaster plans.

The current situation in decision making

The issue of disaster risk regulation and management and the distribution of roles and prerogatives among institutes, agencies and research centers has received much attention. To date, the prerogatives of these organizations have been divided by major state bodies, by theme or by scientific or even territorial approaches.

Assessing the validity and legitimacy of disaster risk decisions remains a topical issue. Indeed, although different forms of evaluation of public policies take place (e.g. evaluation by objective, evaluation by means, economic evaluation, stakeholder consultation...) the articulation of the fields of relevance and the limits of the current system remains a central research topic and a thorny object of national and territorial regulation. Thus, the questions of indicators, of inspection and of opposability remain at the center of technical and political concerns.

--By **IRDR NC-France**

O2.2 Understanding decision-making in the context of environmental hazards

◆ Risk Interpretation and Action (RIA)

The focus of the **Risk Interpretation and Action (RIA)** project is on the question of how people — both decision-makers and ordinary citizens — make decisions, individually and collectively, in the face of risk. The project is in furtherance of Goal 3 (understanding decision-making in complex and changing risk contexts) of the IRDR's Strategic Plan with which RIA's activities are aligned.

RIA focuses on four priority areas:

1. Decision-making in uncertainty;
2. Early warning systems;
3. Adaptive management and resilience; and
4. Individual perceptions and risk behaviour.

Understanding decision-making in complex and changing risk contexts, risk governance and institutional development are the goals as figuring out how people interpret risks and choose actions based on their interpretations is vital to any strategy for disaster reduction. Decision-making under conditions of uncertainty is inadequately described by traditional models of 'rational choice'. Instead, attention needs to be paid to how people's interpretations of risks are shaped by their own experiences, personal feelings, values, cultural beliefs and interpersonal and societal dynamics. Furthermore, access to information and capacity for self-protection are typically distributed unevenly within populations. Hence trust is a critical moderator of the effectiveness of any policy for risk communication and public engagement.

RIA WG aims to make these concepts and theories more accessible to practitioners in a range of disciplines and to promote better integration of behavioural and social sciences in disaster risk research, especially in regard to decision-making.

The main objective of the RIA project is to build a community with hands-on practical advice with regards to risk perception, communication and decision-making. It is in response to both the mushrooming supply of scientific approaches to risk perception and communication and to three specific demands from the policy and science communities (which also map onto the four above-mentioned areas):

1. The shift from deterministic to probabilistic risk forecasting requires close working between scientists and policy makers to improve interpretation of modelled risk, communication and action.
2. Unresolved challenges of communicating risk through early warning efforts including science-society communication and emergency response planning.
3. Resilience capacity and action rest upon knowledge production, management and learning. Approaches are needed to better identify, understand, and model knowledge environments for those managing and living with disaster risk.

Strong scientific communities as well as communities of practice including in psychology, institutional economics, organisational sociology and risk communication largely operate in parallel. These rich, independent knowledge resources offer a great opportunity for learning and synthesis, which helps reduce the duplication of research and overcome barriers to integrated risk management rooted in a multiplicity of disciplinary languages.

RIA's four areas of interest are cross-cut by three work priorities:

1. *Integrating new science with policy planning*: Facilitating the interaction of science with research-users. This includes workshops to bring humanitarians or development professionals together with climate science experts to explore how best information can be exchanged, bringing risk managers together to consider risk communication strategies in

different country and organisational contexts, working with local stakeholders to examine science and other knowledge interactions and its effect on action.

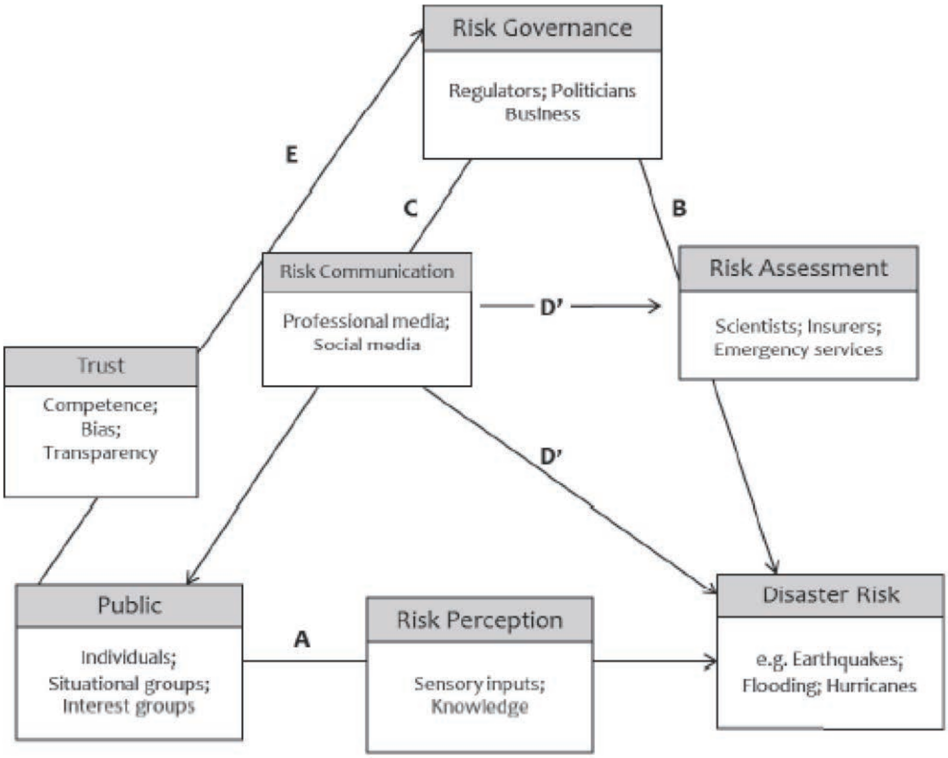
2. *Community building*: Providing an international focal point for pure and applied research, and building a community for risk management professionals working on risk perception, communication and governance including professionals working in resilience building and assessment. Activities include maintenance of an open access online portal as part of the IRDR's website, and workshops (focusing in particular on those that can piggyback on existing international and national conferences)

3. *Research leadership*: Championing risk perception, communication and governance concerns through the research process. This includes providing expertise for integrated research activities and grant submissions and providing guidance to research funders.

A. The RIA framework

In 2011, RIA published a report to provide an integrated perspective on research on risk and decision-making and offer pointers to how this can be applied to natural hazards, as well as outline practical implications[21]. The report looked at and summarized the basic concepts involved

Figure 2-16: A schematic representation of the hazard management system for disaster risk from the perspective of the public.



21 https://www.preventionweb.net/files/globalplatform/51946bd57f1512._RIA_Project_Report_No._1_2011.pdf

in research on risk interpretation and action including following items:

1. Definition of risk
2. Characterizing previous research on risk interpretation and decision-making
3. Individual decision-making under uncertainty: Beyond ‘rational choice’
4. Heuristics
5. Decisions from experience
6. Trust in others
7. Complexity, scale and social context
8. From risk interpretation to action

Reviewing the RIA framework, Doyle et al.(2014) made three observations: 1) Risk interpretation and action is not just psychological, but also social and cultural; 2) effective communication of risks is relevant for numerous policy domains, especially with regard to the goal of effectively informing individual decision-making, but there is an ongoing need to shift from risk communication to risk engagement across these domains; and 3) there is a continued need for collective, multiscale, multi-actor, multi- and transdisciplinary exploration of risk interpretation and action, in addition to the need to further explore risk interpretation and action at the individual, psychological scale. These echo themes that have been important in disaster risk research, both historically as well as in more recent developments.

B. Impact based early warning systems

RIA WG’s main objective is to build a community of practice with respect to risk perception, communication and decision-making. Understanding how people interpret risks and choose actions based on their interpretations is vital to any disaster risk reduction strategy. To improve on this understanding, one of RIA’s top priorities is to enhance impact based early warning systems for countries vulnerable to multi-hazards. This is the WG’s flagship project.

Early warning systems exist for natural geophysical and hydro-meteorological hazards, biological hazards, complex socio-political emergencies, industrial hazards, personal health risks and many other related risks. With the exception of earthquakes, it has become technically possible to anticipate the occurrence of most disasters arising from natural hazards, although the time of forewarning and the range of appropriate responses to the risk vary with the individual hazard. Devastating hazard events and subsequent research highlighted the need to communicate warning messages in terms of likely impact, to enhance awareness of risk and uncertainty, and to increase preparedness prior to an emergency. Early warning systems are a major component in disaster risk reduction through the emphasis on disaster preparedness for global to local risk assessment (Fakharuddin et al., 2019). IRDR, the World Meteorological Organization, the International Science Council (ISC) and Tonkin and Taylor International together promote a guideline based end-to-end early warning system consisting of ten essential elements that work together to create a single, cohesive and robust warning system (Figure 2-17). Like the links on a chain, the overall system is only as strong as its weakest link. The failure of any one of these individual elements will lead to the failure of the entire early warning system (*WMO, 2015*).

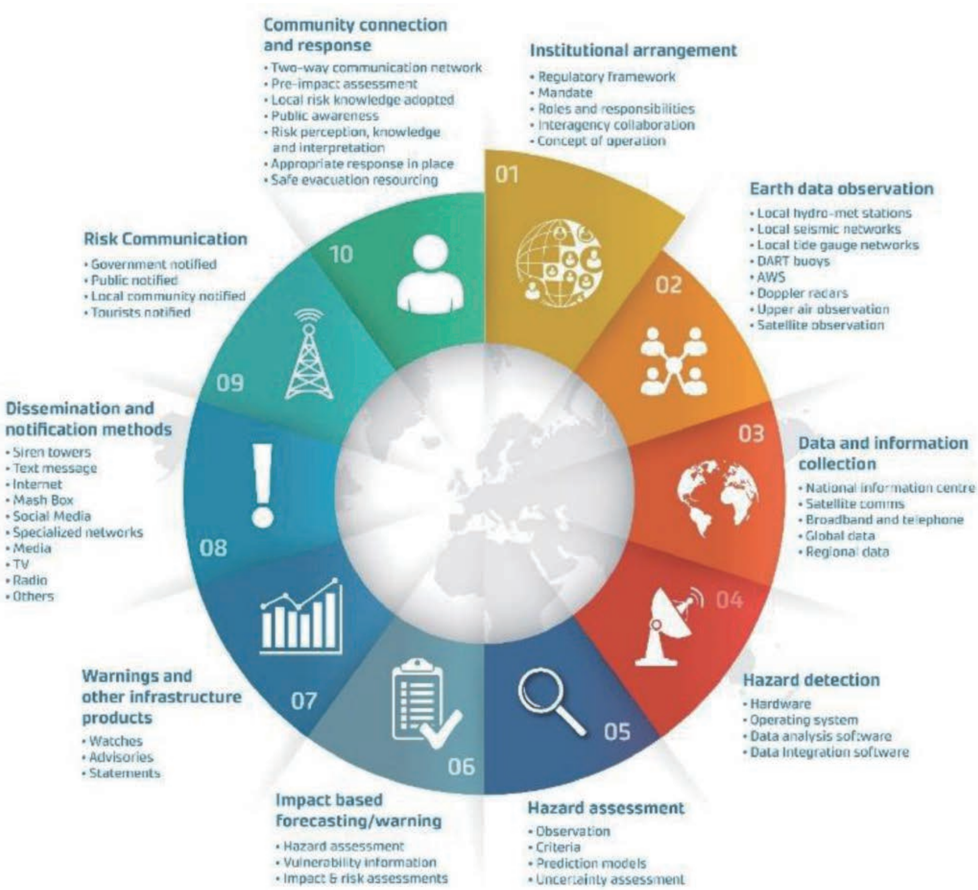
An effective early warning system not only enables timely responses to natural hazards and extreme events but also development planning that can take risk reduction into account. Furthermore, beyond the application in emergency situations, early warnings also apply to changing climatic trends and the early warning component allows for reliable predictions of possible impacts.

It is not surprising hence that IRDR promotes an early warnings system which could lead to early action by providing sufficient notice of an imminent event to allow communities to make informed risk-based decisions in response to emergency warnings (Anderson-Berry et al., 2018). It is acknowledged that early warning systems are most effective in countries where government have invested in building a strong regulatory framework and a clear mandate for agencies involved in preparedness and the system as a whole (Golnaraghi, 2012). Complimentary to effective governance is interagency collaboration, which is critical in ensuring data sharing, timely communication, and coordination of disaster response (Moe & Pathranarakul, 2006). Many governments utilize a concept of operations to outline the characteristics of the early warning system, hereby enabling clearer communication of the complex system of procedures and networks that form a multi-hazard early warning system (Fakhruddin & Chivakidakarn, 2014).

In support of the Sendai Framework for Disaster Risk Reduction 2015-2030, countries are encouraged to increase their resilience to future hazard events through reinforcing interventions such as:

1. risk assessment and communication,
2. inclusive risk governance,
3. national-local level risk management,
4. preparedness and early warning,
5. resilient recovery.

Figure 2-17: End to end impact based early warning system (Fakharuddin et al., 2019).



Indeed, this echoes one of the seven targets of the Sendai Framework, namely to 'substantially increase the availability of and access to multi-hazard early warning systems and disaster risk information and assessment to people by 2030'.

B.1 Achievements and tangible results of RIA

Globally, significant effort and investment has been made towards the development and practical implementation of technologies for accurately forecasting natural hazard events. With increased recognition of the need to support the most vulnerable countries, large scale funding provided by many supporting countries and implementing partners (such as the World Meteorological Organization, The World Bank, the Global Facility for Disaster Reduction and Recovery, and the United Nations Office for Disaster Risk Reduction) has helped communities better understand the risks they face, accurately monitor hazards, efficiently issue simple warning messages that reach all populations at risk and increase preparedness on how to respond. In addition to the RIA project, initiatives including the 'Climate Risk & Early Warning System Initiative' (CREWS), IFRC's 'forecast based financing' and the 'Pacific Resilience Programme' have contributed to the success of global implementation of early warning systems.

Since 2004 and the establishment of RIA, multi-hazard early warning system projects have been commissioned for more than 25 countries including nations in the Caribbean, Africa, South-east Asia, and the Pacific. Table 2-4 highlights an example of handful of nations that have successfully implemented or improved their EWS using this philosophy.

Table 2-4. Some examples about the EWS projects

Region/Country	Project(s)	Description of early warning system (EWS)
Caribbean Antigua, Barbuda, Dominica, Dominica Republic, Saint Lucia, Saint Vincent and the Grenadines	Strengthen Integrated Early Warning Systems for more effective disaster risk reduction in the Caribbean though knowledge and tool transfer	Many Caribbean countries have set out to improve their EWS due to the increasing risk of climate change and hazards. The project seeks to strengthen EWS components and close priority gaps at a national level, contributing to the integration of national and community EWS, and addressing sustainability and national ownership of EWS. Many of these countries have taken more of a community-centred approach which has ensured knowledge transfer and communication leading to a greater sense of ownership and understanding of EWS and preparedness at national and community levels. These countries have now more advanced policy-making and programming for early warning systems and have more awareness of their strengths and gaps.
Africa Burkina Faso, Niger	Climate Risk and Early Warning System Initiative (CREWS)	In Burkina Faso, CREWS is supporting the improvement of operational hydro-meteorological forecasts and early warning services, with an emphasis on flood and drought related hazard risk. A special focus has been towards improving early warning systems for agriculture, food security and civil protection. This project has taken a people centric approach which has included rural women contributing their knowledge to the design of early warning systems, addressing the gap of unequal access to early warnings and limited information about real-time weather forecasts. Focus is placed on ensuring the system is practical and responsive to local women's needs to help them take appropriate actions. Niger being frequently exposed to floods, the CREW project has supported local efforts to improve early warnings and link meteorological services with a disaster management system to inform communities of flood risk and prepare them to take appropriate actions. The project has helped provide accurate and timely warnings as well as high-priority equipment to at-risk populations, strengthen civil protection capacities, and open an additional effective communication channel.
Asia Cambodia	People in Need (PIN) and United Nations Development Programme	The frequent nature of flooding is a continual risk for Cambodia. Until recently, at risk communities had little to no warning, however, the implementation of an early warning system using sophisticated hazard-detection technology, data-storage and warning dissemination software now delivers advance warnings to people in areas susceptible to flooding. The EWS 1294 sends voice-based alerts and instructions to registered users when water levels rise. The system is currently operating in 21 out the 24 provinces and is used by 93,000 people. There is continued investment towards further enhancing Cambodia's early warning system, focusing on both increasing the institutional capacity to assimilate and forecast hydrological, climate and environmental information, as well as to straightforward increasing the capacity to operate and maintain EWS and continue to monitor water levels.

Region/Country	Project(s)	Description of early warning system (EWS)
The Pacific Region Tonga, Samoa, Fiji, Cook Islands, Kiribati Niue and Tuvalu, Palau, Nauru, Marshall Islands Tokelau, Honiara, Papua New Guinea	The Pacific Resilience Program – Multi Hazard Early Warning System in Tonga and Samoa Risk Interpretation and Application Program of IRDR Climate Risk and Early Warning System Initiative (CREWS) Coastal Inundation Forecasting Demonstration Project (CIFDP-Fiji) United National Development Project	Robust early warning systems are of recognised importance to Pacific Island nations, who need to improve resilience to cope with increasingly frequent extreme events and hazards such as cyclones, floods, tsunami, droughts, and storm surges. The economic benefit of a robust early warning system was quantified using a cost benefit analysis in Samoa following Cyclone Evan. This analysis found that for every $1 USD invested in early warning, there is a return of $6 USD (Fakhruddin & Schick, 2019). This clear endorsement of effective early warning systems was developed by measuring the magnitude of losses and damages experienced during Cyclone Evan, which occurred prior to the implementation of a EWS. These losses were compared against an estimate of the losses that would have been experienced had the EWS been in place, while allowing for the costs of providing an early warning system. The value that communities place on reliable early warning services was evaluated in south-west communities of Bangladesh, which found that at-risk households were willing to pay on average US$5.5 per year for such services (Ahsan et al., 2020). In the Pacific, projects are strengthening hydro-meteorological and early warning services for many island countries. The CREWS project aim is to enhance ad upgrade facilities at the Regional Specialised Meteorological Centre (Nadi) within the Fiji Meteorological Service to support other Pacific Islands and enhance the capacity to provide impact-based forecasts. This includes installation of new automated weather facilities with a high-performance computer to improve weather predictions. Only a few months after the completion of CIFDP (Fiji), the system was tested by the Category 4 TC Harold when it hit Fiji on 7 April 2020. The newly implemented coastal flooding early warning system enabled accurate prediction of extreme storm surge heights in exposed locations, and formed the basis of successful evacuation warnings to vulnerable communities. Honiara, capital of the Solomon Islands, is significantly prone to flooding and cyclone events. A EWS was put in place to alert the city of rising water levels in order for them to prepare accordingly. Improvements in this particular EWS include the installation of rain and tide gauges, building up the staff capacity building and providing services to other stakeholders. Significant investment has also gone into the 'Weather and Climate Early Warning System for Papua New Guinea project' which aims to improve control and maintenance of the existing drought and flood monitoring networks. This EWS tailors early warnings for the agriculture sector and disaster managers.

B.2 Lessons learnt through implementation of early warning systems

In recent years, science and technology have provided improvements to the tools available for multi-hazard early warning systems. Additionally, there is growing momentum towards adoption of early warning systems by vulnerable communities. However, recent events related to the Covid-19 pandemic have highlighted the importance of understanding not only expected disasters, but also wider risks, such as those related to unexpected uncontrolled events.

Although many countries continue to invest in and improve their early warning systems, more work is still needed in further addressing preparedness capacities, reinforcing early warning systems for developing countries and fostering exchanges and linkages between countries. The following 'lessons learned' embody some of the most important issues that we see facing disaster risk reduction in our complex world:

Collaboration, not fragmentation: As global challenges become more integrated and multi-faceted, numerous agencies, organisations and groups responsible for preparing against and responding to these challenges may be involved. There is hence an urgent need for enhanced collaboration. Agencies, sectors and authorities need to coordinate on both local and international levels to understand specific roles and responsibilities across all phases of a EWS. Continued investments towards capacity building and cross-sector trainings are needed to ensure a cohesive and robust EWS.

Transition from managing disasters to managing risk: The additional complexity that the Covid-19 pandemic brought to the response and recovery from Cyclone Harold is an example of the importance of understanding how all types of risks can occur. It highlights the necessity of focusing on preparing for the dynamic and systemic nature of risks. The recent creation of the Global Risk Assessment Framework (GRAF) is an acknowledgement of this new challenge.

Have a clear direction: As early warning systems become more integrated across a variety of sectors, it is important that there is alignment in policies, planning and coordination from the national all the way down to local levels. This includes better integration of early warning systems in disaster risk reduction strategies and other related policy decision-making.

Protect the weakest links in the 'early warning chain': Population groups with minimal or no access to technical support (e.g. cell phones, internet, education, support groups) are likely to be the most vulnerable. The consequences of these limitations, both in terms of their ability to receive warnings, and in their ability to respond once warned, must be taken into account when designing local warning systems.

Build resilience into the system through multiple communication pathways: False actions, bias, and non-confidence may be embedded in public perceptions of the forecasts and warning they receive. This lowers the resilience of the individuals in response to hazard warnings, as they doubt the severity of the warnings. This is why we encourage the use of the EWS framework in order to strengthen and build individuals capacity, as it incorporates alternative pathways for raising community awareness.

Community-centred early warning systems are strongly encouraged: Top-down approaches have proven to be insufficient in providing the community with appropriate information that allows them to respond and minimise risk and impacts (WMO, 2015). A community-centred EWS involves community members across all elements of the design, implementation, and use of the early warning system. All sectors, including government agencies, civil societies including NGOs and private organisations, and the public coordinate their roles and responsibilities. Note that this should include embedding indigenous traditions and knowledge into EWS.

Prioritise clear warning communication: The effectiveness of warning systems is increased when user are clearly identified and their needs properly specified. Thorough understanding should be given to individuals needs across sectors, to ensure all are equipped with relevant and valuable information. To give one example, using appropriate language depending on the audience in the dissemination of warnings, hereby ensuring maximum clarity. IRDR also promotes rapid alert notification systems to allow for fast warning of rapid onset disasters such as tsunamis.

New technology can strengthen our response: There is an increasing demand for hazard event monitoring through social media platforms. The idea is to incorporate the public's updates to create situational awareness of the event impacts as they occur. This will help strengthen the credibility of warnings and updates.

◆ Disaster Risk Reduction and Climate Change Adaptation

The Synthesis Report on Disaster Risk Reduction (DRR) and Climate Change Adaptation (CCA) in Germany (Marx et al., 2017), published by **IRDR NC-Germany** and its hosts, contains data from produce reports on specific national approaches to policy, legislation and research frameworks for natural hazards and adaptation to climate change. Part of a larger project to collect such data from six European Union countries, these national reports form part of a larger synthesis of such approaches at both European Union and global levels.

The report consists of three main sections: research methodology, data collection and analysis, though it starts first by presenting the institutions in DRR and CAA in Germany, and introducing the legal and institutional framework in relation to DRR and CAA (including the different ministries and agencies on national, federal state and municipal levels, as well the non-governmental organizations). Basing itself on both interviews and literature reviews, challenges were identified in Germany in terms of:

1. Governance, resulting from institutional barriers, funding arrangements and political will/motivation
2. Risk Perception and assessments
3. Gaps related to scientific frameworks
4. Communications, in particular as related to existing legal policy

Due to these fundamental institutional complexities and because both fields face many different tasks, interviews and literature alike conclude that DRR and CCA in Germany cannot and should not be integrated as such on the federal level but rather through be through cooperation, with defined collaboration responsibilities especially for the overlapping policy areas. While both vertical and horizontal cooperation can still be further improved, the German adaptation strategy to climate change, has served as a model a substantial number of such collaborative initiatives (Marx et al., 2017).

IRDR ICoE for Disaster Resilient Homes, Buildings and Public Infrastructure (IRDR ICoE-DRHBPI, Canada) also focuses on integrating climate change adaptation and disaster risk reduction. To give but one example of its work, Kovacs (2020) examined the implications of climate risks for the insurance industry in Canada. A related cross-cutting issue the Center has focused on is multi-level governance and the interplay between municipalities and higher levels of governance (Bednar et al., 2019; Raikes & McBean, 2017; Dan Sandink et al., 2016; Vogel et al., 2020).

◆ Composite indicators reflecting disaster risk and risk management

The **ICoE UR&S** has developed composite social, environment, and development indicators to reflect both disaster risk and risk management, so as to allow for comparison over time and among countries, sub-national areas and urban centres.

Table 2-5. Examples of ICoE UR&S's efforts in developing indicators to reflect disaster risk and risk management

Examples of achievements	IRDR WG related
Contribution to the Ibero-American report on climate change adaptation for the IPCC-AR6, project RIOCCADPAT (2017-2019)	RIA
Flood hazard and risk evaluation for the Action Plan of Integrated Risk Management and Climate Change Adaptation of La Mojana Region, for the Adaptation Fund and National Department of Planning, Colombia	RIA, FORIN
Resettlement and relocation case studies at Asia, Africa and LAC, in coordination with University College of London (Bartlett, DPU), Indian Institute of Human Settlements and FLACSO, for CDKN	FORIN
Implementation of the automated Disaster Risk Modelling System of the city of Bogota. Seismic (shakemaps) and landslide hazard and risk warning system, based on online earthquake and rainfall monitoring	RIA
Disaster risk management program of Manizales, Colombia. Risk knowledge and information systems (5 projects); Instrumentation, monitoring and early warning systems (6 projects); Using risk for planning and awareness (5 projects)	RIA, DATA, FORIN
Holistic risk evaluation (Applied at city level to Barcelona, Metro-Manila, Bogota, Santo Domingo, Port of Spain, Medellin, Manizales, and at subnational level in Nicaragua and Costa Rica.	RIA, DATA
Seismic hazard assessment for the building code of Colombia; seismic micro-zonation, flood, hurricane and landslides hazard evaluation, and lifelines risk evaluation at local level in Quito, Lima, Bogota, Caracas, Santo Domingo, Santiago de los Caballeros, Belize, Georgetown, David and Manizales	RIA

◆ Understanding Decision-Making through Interviews

A report from **IRDR NC-USA** focuses on identifying and understanding stakeholder values in the context of Hurricane Michael. Semi-structured interviews were conducted to understand what public and private stakeholders valued in different phases of the hurricane. Based on the preliminary interview results, ten stakeholder values were identified and analysed, including: safety, resource efficiency, natural resource preservation, culture preservation, community growth, community adaptability, community cohesion, social welfare improvement, personal achievement, and business development. This research advances knowledge in the area of disasters by empirically investigating public and private stakeholder values across different phases. Such knowledge will help practitioners implement disaster-resilient strategies in ways that account for diverse stakeholder needs and priorities, thus facilitating human-centered decision-making aimed at building more resilient communities (Zhang et al., 2019).

Another research used Hurricane Irma as a case study. This research investigates evacuation decisions, specifically the influence of social connections on that decision. A survey of those who evacuated and those who did not evacuate was conducted to assess individual social connections by examining three dimensions: dependability, density, and diversity. These variables, together with socioeconomic variables (e.g., race/ethnicity, age, education), were looked at to better explain the influences on evacuation decision making. The surveys of those who evacuated were completed during the evacuation. Those who did not evacuate were surveyed shortly after the hurricane had passed. Such real time and near real time data collection, as opposed to collecting the data sometime after the event, allows for more accurate information since people can better recall the intricacies involved in their decision making. Through statistical analyses, we found that evacuees had significantly more dense and diverse relationships. However, no significant relationship was found between the perceived dependability of a person's social connections (i.e., their perceived access to resources and support) and the decision to evacuate or not. This study has important implications for adding to the knowledge base on community-based sustainable disaster preparedness and resilience (Collins et al., 2017).

◆ Australian Natural Hazards Management Conference

The 12th Australasian Natural Hazards Management Conference hosted by **IRDR NC-Australia** started with questions and worked through to a strategic view on whether we have the best knowledge to deal with the extreme hazards of our future that are of a nature and scale beyond our current experience. The conference concludes in particular that as natural hazards continue to increase in frequency and severity, it is more important than ever to provide decision-makers with the evidence, information and tools to make the necessary critical decisions. With changing demographics, cities expand further into the bush, leading to more dependence on technology increases, increasing exposure to risk. Indeed, the economic, social and environmental costs are forecasted to rise in a way that is unprecedented and unsustainable. These challenges are complex, and one should be wary of quick fix solutions.
This conference was an opportunity to explore the decisions available that can be made to reduce the impacts of these inevitable natural hazards. A diverse cross-section of industries that deal with natural hazards came together and provided with opportunities to stretch thinking beyond current experiences. NC-Australia invited them to contribute to the development of new pathways of research, knowledge, and lessons for policy and practice, navigating the challenges of the changing risk profile in the region by making use of new knowledge and relationships cultivated at the conference. NC-Australia further encourages decision-makers at all levels to make courageous and creative choices to improve Australia's resilience. Finally, the Bushfire and Natural Hazards CRC, which is the host of NC-Australia, drew together all of Australia and New Zealand's fire and emergency service authorities with the leading experts across a range of scientific fields to explore the causes, consequences and mitigation of natural disasters and, ultimately, contribute to a more disaster resilient Australia (Bates, 2020).

◆ Multi-Risk perception barometers and territorial observatories

The dichotomy between the different forms of risk (acute, chronic, accidental, diffuse, etc.) makes the evaluation of public and private action delicate. Thus, acute and accidental risks continue to monopolize attention to the detriment of chronic and diffuse risks. This must be balanced by the different actions undertaken by the State both in the creation of Health-Environment Plans and, more broadly, the focus on the theme of territorial inequalities and low doses. Multi-Risk perception barometers (e.g., IRSN by **IRDR NC-France**) have been set up and territorial observatories (e.g. Nice) make it possible to report on changes in risk perception.

O2.3 Improving the quality of decision-making practice

◆ Assessment of Integrated Research on Disaster Risk (AIRDR)

The WG **AIRDR** is designed to undertake the first systematic and critical global assessment of IRDR. The project is in furtherance of Goal 1 (promote integrated research, advocacy and awareness-raising) of the Strategic Plan, with which AIRDR's activities are aligned. For the purposes of this assessment, integrated disaster research involves two or more researchers from diverse disciplines and specialties—including both academic experts and practitioners —actively cooperating to produce novel concepts, theories and methods that leads to new knowledge. It includes a community of researchers spanning traditional academic boundaries (natural sciences, social sciences, humanities, health, engineering, law, arts, education and business), methodological approaches (quantitative, qualitative, analytical, interpretive, expressive, and performance), and real-world, hands-on experiences. Integrated research is problem-focused, socially driven, examining questions that cannot be adequately addressed by one or a few research disciplines, or without collaborative problem solving and real-world engagement of non-academics.

IRDR ICoE in Vulnerability and Resilience Metrics (IRDR ICoE-VaRM, USA) conceived and implemented the initial AIRDR project and developed the bibliometric approach and methodology for assessing the need for and the assessment of integrated research. Through a practical methodological guide (IRDR, 2014), and a critical assessment (Gall et al., 2015), this approach led to greater understanding and global advocacy of the integrated approach to disaster risk science, all culminating in an oft-cited article in *Nature* (Cutter et al., 2015), and *Natural Hazards* (Ismail-Zadeh et al., 2017). Susan Cutter lead most of the efforts for the initiative until 2016, along with others prominent researchers. Virginia Jiménez and Shuaib Lwasa took over the Co-Chairs of this working group.

The goals of AIRDR are:

1. To provide a baseline of the current state of the science in IRDR to measure the effectiveness of multiple programmes.
2. To identify and support a longer-term science agenda for the research community and funding entities.
3. To provide the scientific basis to support policy and practice.

There are two primary elements in the approach:

1. Document and critically assess the existing published scientific literature on integrated disaster risk. Questions to be considered include:

   a. How has integrated research been constituted and organised?

   b. What kinds of research qualify as IRDR?

2. Identify the strengths, weaknesses, gaps, and opportunities for new knowledge and investments. Questions to be considered include:

   a. What is well-known within the research community in terms of capacity, technology, tools, methodologies, and translation of findings to actions?

   b. What evidence is there to support such strength in understanding?

   c. What is less well-known in the research?

   d. Where do the shortcomings come from, e.g. perils studied, regional understanding, spatial or temporal coverage of topics?

   e. Where are the gaps in our empirical understanding of disaster risk where strategic investments could be made?

   f. How do we identify through our research what is not now known but needs to be known?

   g. What new opportunities are available for learning from the co-production of knowledge to further enhance integrative research?

h. What barriers impede integrative research and how might these be overcome?

A. Guide to Assessing IRDR

A preliminary assessment of the landscape of integrated disaster risk research (Gall et al., 2015) provided a template for a methodological approach for systematic reviews. This methodology highlighted the limitations of focusing solely on English-language literature. The guide hence was developed to facilitate a broader and more inclusive review of IRDR. The idea is to promote systematic reviews of local and regional research contributions in other publication outlets and in native languages that, when viewed collectively, produce a global synthesis.

The guide offers a step-by-step procedure for conducting systematic reviews. It documents a methodology (used in the preliminary assessment) of sharing and encouraging locally-based assessments using a common protocol. In this way, the collective inputs can be integrated into a global synthesis of state-of-the-art integrated disaster risk research.

The guide provides two approaches.

1. Content Analysis
    a. Establish Sources for the Review
    b. Criteria for Publication Selection
    c. Storing and Managing References
    d. Reviewing References
    e. Summarising Reviews
    f. Visualising Findings

2. Bibliometric Analysis
    a. Querying Academic Reference and Indexing Services. Example: Web of Science
    b. Use of Bibliometric Software for Temporal Analyses. Example: HistCite
    c. Use of Bibliometric Software for Visual Analysis. Example: VOSviewer

The assessment approach outlined here stops short of evaluating the merits and contributions of the reviewed publications. Such a task is best reserved to the judgment of expert panels. Nevertheless, a descriptive assessment is still valuable since it provides insight into the complexity of disaster risk research by investigating the prevalence of knowledge types, research collaborations, study areas, topics, and methodological approaches.

The analysis of the state of IRDR is facilitated by the use of academic indexing services and bibliometric software. However, relying solely on the use of tools such as Web of Science artificially narrows the analysis to English-language publications and journal outlets that may have global significance but are perhaps locally irrelevant. In order to generate a more comprehensive overview of the state of IRDR, a bottom-up approach is imperative. This applies to the investigation of local research both in regard to content as well as scholarly networks.

Finally, the state of integrated research at the local level, e.g., within African, Asian or Latin American countries, should inform the global assessment. Without such a bottom-up approach, the assessment of global integrated research would be incomplete.

B. Incentives for Disaster Risk Management

Part of the AIRDR project consists of a review of the literature on incentives for disaster risk management: how scientific knowledge of the subject has evolved over the past decades, what we know about incentives, their influence on disaster risk reduction, and where the research gaps in our present knowledge are.

Three key policy questions are addressed in the review:

1. Are disaster risk mitigation and prevention still seen primarily as a cost and not an investment?
2. Are the corrective, prospective, and

compensatory aspects of disaster risk management not well understood and as a result emphasis is still placed on high-cost, corrective and compensatory schemes and approaches as opposed to proactive, lower cost actions thus the cost-benefit calculation more difficult to bear?

3. Can incentives be identified that may constitute tipping points for behavioural change towards prospective disaster risk management and risk-sensitive choices at a significant scale, thereby increasing the political, social and economic saliency of disaster risk management?

This literature review summarises the current state of research based on publications in peer-reviewed journals. This echoes the approach developed by the IRDR AIRDR WG (Gall, Cutter, et al., 2014a, 2014b, 2014c). The original AIRDR database contains 1,069 peer-reviewed, academic, English-language journal articles culled from 39 journals published between 1999 and 2013. For the purpose of this review, a subset of 65 incentive-related articles of the AIRDR database were supplemented with 67 additional articles based on a keyword search (disaster AND incentive) utilising the academic citation indexing and search service Web of Science.

From analysing and synthesizing the articles, five central research themes emerging over the past years are drawn. Summaries of the current state of knowledge and remaining challenges for each theme (Knowledge Cluster) are then provided, which is then followed by an in-depth analysis of the remaining gaps (Knowledge Gaps) in incentives research and research needs.

1. Knowledge Clusters:
    a. Cost-Effectiveness of Investments
    b. Risk Perception and Heuristics
    c. Community-Based Disaster Risk Management
        a) Climate Adaptation through Disaster Risk Management
    d. Disaster Risk Management in Developing Countries

2. Knowledge Gaps
    a. Integrated Disaster Risk Management
    b. Beyond Techno-Centric Solutions
    c. Behavioural Economics
    d. Monitoring Systems
    e. Development and Climate Change Adaptation
    f. Systemic Shortcomings in Incentives Research

The research came to the conclusion that the gap between knowledge and action remains significant, resulting in few success stories. Land use decisions frequently continue to ignore risk assessments despite significant advances in methodology and reliability (Burby, 2006). There exists sound evaluative research on existing policies and programmes, little of which has resulted in programme adjustments or improvements. Finally, while there is sufficient research on how to coerce stakeholders into better decision-making, disaster risk management remains under-prioritised as it is still considered on its own rather than being integrated into economic and social decision-making. In sum, governments and decision-makers are not making more informed decisions despite the abundance of better information.

The added expectations on disaster risk management to facilitate climate adaptation has the potential to foster maladaptation by continuing failed policies, designing inadequate financial products, and focusing on structural solutions. The inability to implement community-based risk management strategies reduces adaptive solutions to discussions about micro-insurance, land use planning, etc. rather than leading towards transformative, long-term risk strategies.

C. Governance in Disaster Risk Management

A review of the pre-Sendai scientific knowledge on the emerging field of disaster governance focuses on the following questions: what do we know about governance and disaster risk management; how it has evolved over the past years; and where the research gaps are in our present knowledge.

Three key policy questions are addressed in this review:

1. What are the principal drivers of changes in disaster risk governance characteristics at national and local scales over the last decade?

2. Is disaster risk governance a separate and autonomous concern/theme or is it a component of sustainable development at local to national scales, and how do international governance frameworks influence it?

3. How is the linkage between climate change adaptation and disaster risk management established and how does this influence the present governance of risk?

The approach adopted in this review follows the Guide to Assessing IRDR and is consistent with all other AIRDR literature review reports. Four knowledge clusters and four knowledge gaps are identified.

1. Knowledge Clusters
   a. Elements of Disaster Governance
   b. Measures of Effectiveness of Disaster Governance
   c. Governance Lessons Learned from Past Disasters
   d. Connections to Climate Adaptation and Sustainability Governance

2. Knowledge Gaps
   a. Evaluation of Performance, Accountability and Effectiveness of Governance
   b. Determinants of Good Disaster Governance
   c. Urban Disaster Governance
   d. Systemic Shortcomings in Incentives Research

The conventional, administrative approach to managing risk focuses on disaster preparedness and response rather than long-term reduction of risk, losses, exposure and vulnerability. What are the benefits of transforming the engrained and institutionalised forms of risk management to disaster governance networks? The research literature identifies two critical benefits: firstly, disaster governance offers an alternative to inadequate (or incapable) governmental efforts when it comes to managing risk; and secondly, the increase in stakeholder participation and representation through governance systems provides a voice to local concerns and previously marginalised groups and actors.

Overall though, disaster governance research is less concerned with investigating the effects—both positive and negative—of governance or how to truly transform existing risk management structures. Instead, most research remains at an abstract level. Although conceptual studies regarding the characteristics of disaster governance are a fundamental necessity, research needs to offer more empirically-based evidence on the risk reducing effects of governance. The promises as well as the limits of disaster governance require more scientific scrutiny. Otherwise, justifying a fundamental shift of risk management structures (i.e. from government to governance bodies) remains a challenge.

Furthermore, accountability for governance failures is and cannot be exercised since questions of accountability "to whom" and "from whom" are not well defined. Without a more systematic approach to disaster governance research (i.e. research that encompasses and holds accountable all stakeholders), blame for failures to adapt will continue to be placed upon governmental entities rather than all governance stakeholders. Indeed, with the inability to penalise failures, there is little incentive to strive for learning and adapting disaster governance networks. Government agencies, which hold power, authority and financial resources, are hence forced to continue to play key roles in risk reduction efforts. This is further exacerbated by weak civil societies that cannot assume active roles and responsibilities in managing local risk, as well as by the continued perception that it is the central government's role to protect its citizens. Consequently, a reconceptualization of disaster risk and a repositioning of disaster risk reduction into and within sustainable economic growth and development have yet to emerge.

D. Transformative Development and Disaster Risk Management

In light of the connection between development and disaster risk reduction, it is important to explore what constitutes transformative disaster risk management. This review summarises our current scientific knowledge on the emerging field of transformative disaster risk management: what we know about the relationship between disaster risk management and development; how it has evolved over the past years; and where the research gaps are in our present knowledge.

Five key policy questions are addressed in this review:

1. How does transformation relate conceptually to research on vulnerability and resilience?
2. What areas of disaster risk reduction have the potential to transform development?
3. Do incremental steps of improved disaster risk management lead to transformed policy and practice?
4. What are concrete development benefits of transformative disaster risk management?
5. How can progress in disaster risk reduction and development be measured?

The approach adopted in this review follows the Guide to AIRDR and is consistent with all other AIRDR literature review reports. Three knowledge clusters and four knowledge gaps are identified.

1. Knowledge Clusters
    a. Transformation Drivers: Vulnerability, Resilience, and Social Learning
    b. Technical and Adaptive Elements of Social Learning: Participation, Representation, and Integration
    c. Case Studies on Transition

2. Knowledge Gaps
    a. Learning Processes
    b. Thresholds and Limits of Disaster Risk Reduction
    c. Incentives, Barriers, and Power Structures
    d. Systemic Shortcomings in Incentives Research

Although knowledge on vulnerability, adaptation and resilience has expanded significantly in recent years, a rift between knowledge and action/change persists. In fact, the combined effects of transformation barriers such as institutional structures that resist learning, lack of accountability, and rising vulnerabilities continue to thwart efforts for new ways to reduce the excessive disaster losses especially among the most vulnerable.

Transformative development and disaster risk reduction need actionable research. However, transforming the status quo of development approaches and objectives is a tall order for disaster risk management, particularly in the absence of any measurable and significant progress toward sustainable development over the past decades (Dittmar, 2014).

In order for transformation not to become the next buzzword, there must be some caution against the diminution of the term transformation in the context of disaster risk management by undermining its "radical potential" (Pelling, 2014). On the other hand, maintaining an idealistic notion of transformation as radical change may exceed practicality and overstate what transformative disaster risk reduction can truly achieve.

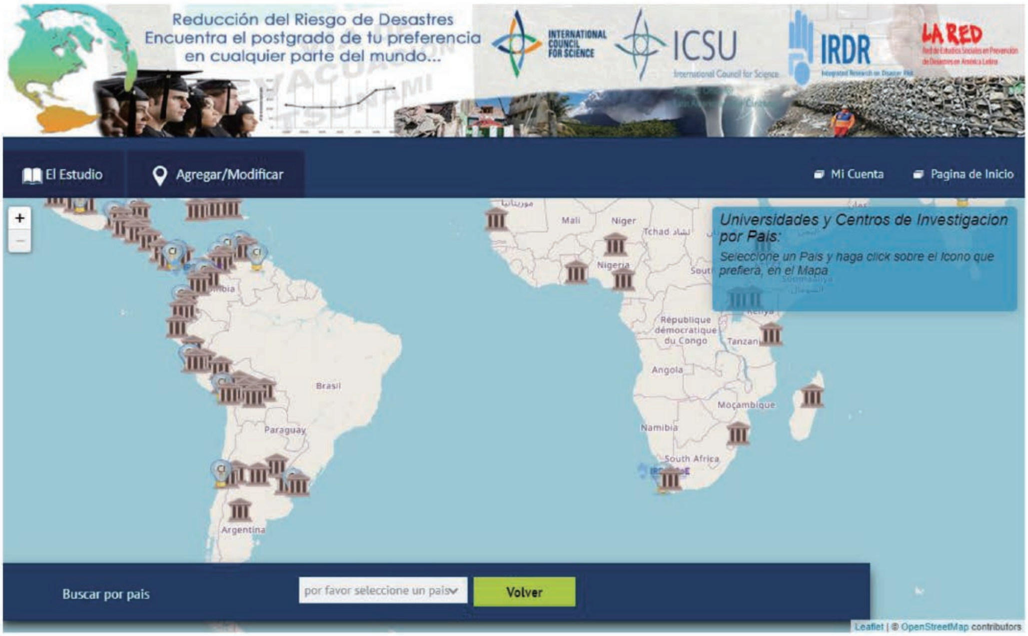
What is needed are honest and comprehensive assessments providing concrete evidence of the capacity and advancements in disaster risk reduction at all scales to determine the current status along the adaptation continuum and whether progress toward "transformation" may be achieved. The necessity is clear, but the barriers may be difficult to overcome.

E. Identification of existing advances and linkages of the scientific and academic community initiatives with Disaster Risk Reduction

AIRDR worked with ICSU ROAP on identifying existing advances and linkages of the scientific and academic community initiatives with Disaster Risk Reduction, especially in Latin America and the Caribbean.

An interactive map[22] was designed to collect the information on DRR research centres and their projects. The template information includes programme name, creation date, services, dependence, related institutions, and related projects. The institute will also be indicated as research centre or university, public or private.

Figure 2-18: Interactive map summarizing information on DRR research centres and their projects.



◆ Digital Belt and Road platform for integrated research on climate change and disaster risk

IRDR NC-China established a platform to integrate multi-source and multi-disciplinary data and research outcomes related to climate change and natural disaster risk along the Belt and Road region. Based on the visual operation of the cloud-based big Earth data platform, the newly built platform can provide scientific support for national level decision-making on climate change and natural disaster risk in the Belt and Road region. Additionally, it provides a highly integrated big Earth data warehouse and analysis-simulation platform for scientific research in related fields, as well as an interactive local data interface and high-level spatial information services for the public.

22 http://www.estudiarrd.org

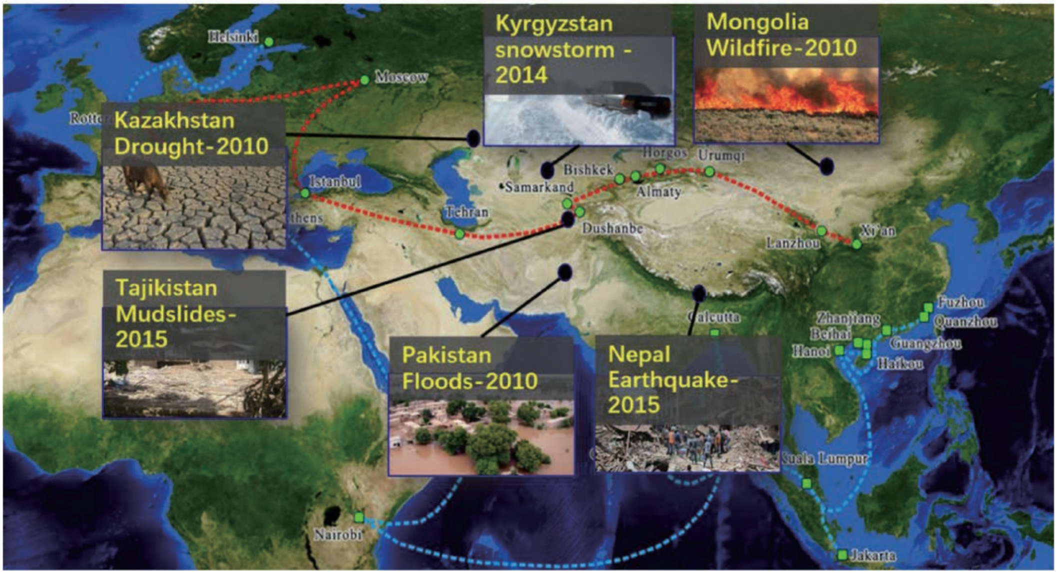
The platform, built specifically to focus on the regional spatial and temporal climate change over entire Belt and Road region and case study areas, aims to reveal the causes and regularity of extreme climate event occurrences, to develop a multi-source earth observation data set and model methodology system suitable for the prediction of regional climate change and extreme events induced disaster risks, and to conduct rapid monitoring of extreme events and natural disaster risk and analysis of cascading effects in the Belt and Road region.

NC-China uses the Emergency Events Database (EM-DAT) from 2015-2019, which is integrated in the platform, to evaluate SDG 13.1.1 (number of deaths, missing persons and directly affected persons attributed to disasters per 100,000 population) status among countries in the Belt and Road region (using trend change instead of raw numbers to more easily evaluate the change in SDG 13.1.1). Using remote sensing technology to cross-check the EM-DAT statistical dataset, NC-China found that: 1. From 2015 to 2019, Asia and Africa were most severely affected by natural disasters—Africa had the most deaths (5,435) and Asia had the most affected people (600 million) and most property losses ($194.64 billion). 2. Changes in the calculated values of SDG 13.1.1 for countries along the Belt and Road during the study period improved little, and several countries increased slightly because of frequent natural disasters. 3. Comparing national-scale Earth observation products for natural disasters (floods, landslides and debris flows, fires, etc.) to statistical database products, the two are quite consistent in overall disaster trend estimation, but the Earth observation products can provide more accurate and timely disaster area assessments. Key findings were included in the UN Disaster Reduction Report “Global Assessment Report on Disaster Risk Reduction (2019)” (Figure 2-19).

Figure 2-19: Global Assessment Report on Disaster Risk Reduction

The research is a core activity of the Digital Belt and Road international network. On the one hand, the regional networks have been expanded through collaborative research; on the other hand, the construction and quality control of regional spatial databases on climate change and disaster risk have been substantially improved due to the international cooperation between the regional networks, which facilitate data sharing and application, in turn expanding the influence of the network in the Belt and Road countries.

Figure 2-20: **Disaster risk in "One Belt One Road"**



◆ **Serious Gaming: Risk Assessment Model Simulation for Emergency Training Exercise (RAMSETE)**

Enhancing synergies for disaster prevention in the European Union (ESPREssO) project is a coordination and support action funded by the European Union's Horizon2020 research and innovation programme. ESPREssO aims to contribute to a new strategic vision on disaster risk reduction (DRR) and climate change adaptation (CCA) in Europe and the promotion of new ideas on what should be a future roadmap and agenda for natural hazard research and policy making. When considering issues such as the three ESPREssO challenges (list as below), a core problem is trying to identify what the opinions and needs are of the various stakeholders.

Challenge 1: Integrating Climate Change Adaptation and Disaster Risk Reduction, to propose ways to create more coherent national and European approaches to DRR, CCA and resilience strengthening;

Challenge 2: Integrating Science and Legal/Policy issues in DRR and CCA, to enhance risk management capabilities by bridging the gap within these domains at local and national levels in six European countries;

Challenge 3: Improving national regulations to prepare for trans-boundary crises, to address the issue of efficient management of crises requiring a coordinated effort from two or more countries in the EU, and/or the support of the EU Civil Protection Mechanism.

For this reason, a major product of the project made by **IRDR NC-Germany** was the Risk Assessment Model Simulation for Emergency Training Exercise (RAMSETE) series (German Committee for Disaster Reduction (DKKV e.V.), 2018). A serious game is one where the primary intention is education, rather than entertainment. Usually, such exercises are employed for training and teaching purposes. In this case, the games were intended to focus on the three challenges of the ESPREssO project.

RAMSETE I focused on developing of a common strategy on integration of DRR and CCA. The aim was to maximize the security and well-being of the population of a fictional country by integrating DRR and CCA policies. RAMSETE II challenged participants to manage a cross-border natural crisis. The aim for the stakeholders was to find a solution on a local, national and international level. RAMSETE III – "Uncertainty – from Science to Policy"- addresses the tree main challenges under the headline "Uncertainty and decision making". Herein, participants have to deal with a hurricane and make decisions about when to evacuate the citizens, make political decisions, and inform the population. The players take on different roles from science, civil defence, as decision makers and as government spokespersons. The main focus is on deciding when to integrate scientific based or civil protection recommendations in order to make evidence -based decisions. There serious games are earmarked for further development and have been actively used in workshops. A RAMSETE III developer set can be downloaded from the DKKV website (Lauta et al., 2018).

◆ Promoting disaster risk reduction as the first step to climate change adaptation

There is a high level of uncertainty associated with climate projections for Southeast Asia (IPCC, 2013). In view of this situation, the research collaborations of **ICoE-SEADPRI-UKM** promotes disaster risk reduction as the first step to climate change adaptation for the region. In addition, tools to build resilience, such as insurance and decision support systems as also investigated. Key research projects are as follows: Integrating CCA, DRR and Loss + Damage to Address Emerging Challenges due to Slow Onset Processes, involving 5 ASEAN Member States funded by APN (2014-2017); Assessing Community Risk Insurance Initiatives for Disaster Risk Reduction, Case-study of Malaysia, funded by IGES, Japan (2014-2017); Building Resilience of Urban Communities to Climate Induced Hazards, funded by Newton Ungku Omar Fund, British Council Linkages Programme (2015-2016); Disaster Resilient Cities - Forecasting Local Level Climate Extremes and Physical Hazards for Kuala Lumpur, funded by Newton Ungku Omar Fund (2017-2019); and Promotion of Social Entrepreneurship in Disaster Risk Reduction to Build Community Resilience, involving 2 ASEAN Member States, funded by IDRC (2019-2022).

◆ Bridging gaps between the city governments & the surrounding village authorities

The **IRDR ICoE on Resilient Communities & Settlements (IRDR ICoE-RCS, India)** was established with the objective of promoting advanced and scientific approaches to policy and decision-making pertaining to risk reduction in central region of India, which are known to be more vulnerable for climate disasters including heat waves and hydro – meteorological calamities. Taking advantage of its prominent geographical location on the Deccan plateau in central India, the ICoE (which is hosted by Visvesvaraya National Institute of Technology, Nagpur) has been making vital efforts towards understanding the vulnerabilities of these inland regions, sharing such knowledge in global forums such as IRDR. Since its inception in June 2018, IRDR ICoE-RCS has been actively engaging with various stakeholders from science, academia, governmental agencies as well as the local communities through various initiatives and consultation workshops. These initiatives are oriented towards establishing a better understanding of knowledge needs at local level for disaster risk reduction, decision-making in changing risk contexts at local levels and making the integration of climate change mitigation and adaptation more feasible and effective through knowledge-based actions.

For example, a series of community level interactions and consultations were carried out by the ICoE in various rural settlements in surrounding region of Nagpur city that are vulnerable to both water scarcity as well as floods. Community level actions for nature conservation, best practices in water management, the co-benefits of ecosystem management for gaining resilience, etc. were documented and challenges for their upscaling were identified through these consultations. A need for synchronization between approaches developed by the knowledge institutions and those adopted by governing authorities & local communities towards building disaster risk resilience has been voiced through all global forums. With the objective to act as a platform to bring together these three crucial stakeholders in building disaster risk resilience at city & regional levels, IRDR ICoE-RCS organised multi-stakeholder consultations in Nagpur Metropolitan Region involving high rank administrators such as the Mayor of Nagpur city, the CEO of Nagpur Smart & Sustainable City Development Corporation Ltd., the Director of Town Planning, Nagpur Metropolitan Region and the village heads from surrounding regions. The consultations were aimed at evolving integrated framework for natural resource governance and collective actions for resilience against water woes faced by both urban & rural areas. These consultations acted as a bridge between the city governments & the surrounding village authorities and resulted in formulation of a unique Urban-Rural Partnership Forum for collectively addressing issues of common concerns to city and its rural counterpart regions.

The Paris Agreement, Sendai Framework and the SDGs all have emphasized enhancing the abilities of Governments & local communities to adapt to the adverse impacts of climate change and foster climate resilience. The capacities of local Governments to develop relevant strategies for resilience are crippled owing to their poor technical & financial performances. In case of the city of Nagpur, a need for knowledge and decision-making support with regards to managing disasters was expressed during the consultation workshops. Following up on this, IRDR ICoE-RCS brought together various agencies dealing with disaster management including the National Fire Service College, the National Civil Defence College, the Fire Department of Nagpur Municipal Corporation, the District Disaster Management Office, the All India Institute of Local Self Government, and selected NGOs. A City Resilience Forum that would act as a support center for the local governments to better understand their vulnerabilities through scientific as well as community-based studies and prepare locally appropriate resilience strategies was then proposed as a result of IRDR ICoE-RCS's efforts.

◆ Guidelines formulated to support the alignment of development and DRR processes

IRDR ICoE on Transforming Development and Disaster Risk (IRDR ICoE-TDDR, Stockholm Environment Institute) engaged with officials in Tacloban and in other settings (e.g. at global and regional level DRR conferences and workshops), and this led to the development of a shorter, more targeted discussion brief (Stockholm Environment Institute, 2018), and the TDDR Guidelines (Tuhkanen et al., 2020). The aim of these guidelines is to support the alignment of development and DRR processes so that they contribute to sustainable, resilient and equitable development outcomes. They are designed to encourage critical reflection on development decision-making processes and the implications of decision-making outcomes for risk creation and risk reduction and to foster equitable resilience today and in the future. The guidelines can also be the basis for trainings where there is ample time to read through the conceptual guidance, to consider the questions, and to discuss relevancies to specific situations.

A framework for transforming the relationship between development and disaster risk

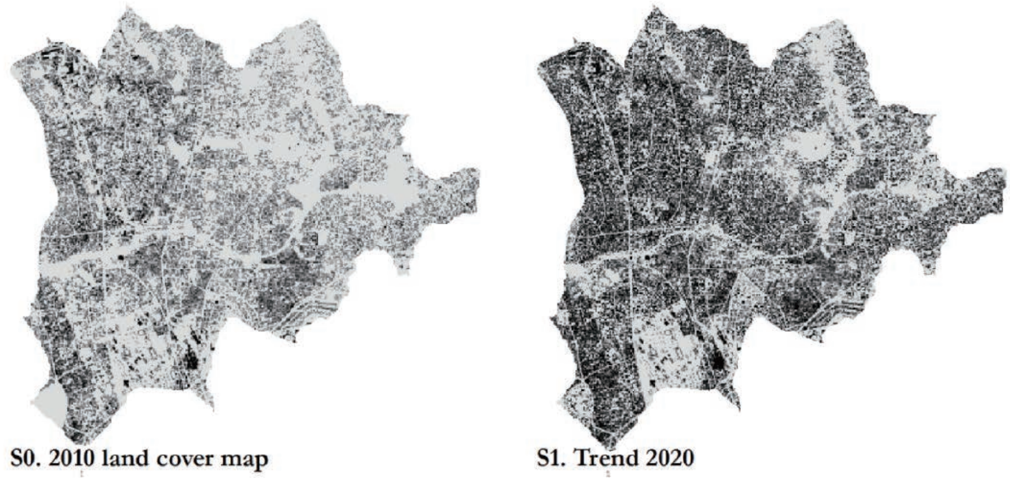
Development is vital for reducing disaster risk, yet many current development models are unsustainable and are instead driving and creating disaster risks. At the same time, disasters can destroy development gains, and many existing disaster risk reduction (DRR) and resilience approaches are not sufficiently contributing to social equity and sustainable development. Significant and simultaneous progress towards both the Sendai Framework for DRR targets and the SDGs is a complex challenge that requires work on many fronts with a diversity of disciplines and stakeholders. We argue that transformation is a legitimate and necessary pathway for moving from development patterns that increase, create or unfairly distribute risks, towards equitable, resilient and sustainable development outcomes for all. This paper presents an analytical framework for transforming the relationship between development and disaster risk. Specifically, we discuss three interlinked opportunities for transformation: (1) exposing development-disaster risk trade-offs in decision-making and policy; (2) prioritizing equity and social justice in approaches to secure resilience; and (3) enabling transformation through adaptive governance. We then highlight key findings from an application of this framework in seeking to understand disaster recovery processes in the city of Tacloban in the Philippines following Typhoon Haiyan/Yolanda, which struck in November 2013 – with a specific focus on the extent to which relocated communities are able to access equitable, resilient and sustainable livelihood opportunities.

--By **IRDR ICoE-TDDR**

◆ Improving spatial planning and governance

Risk information is only partly useful without discussion with stakeholders and stakeholder-based spatial planning. Many cities do not have a large planning department capacity and lack master plans, while they develop very rapidly. Cities in Africa and Asia in particular often expand outwards with rapid conversion from rural to urban areas. **IRDR ICoE-SDS IDRR** has done research into the interaction between city development scenarios up to 2050 and the interaction with flood risk with city growth modelling, for Kampala (Uganda) and Kigali (Rwanda) (Pérez-Molina et al., 2017). In fact, in both cases the immediate short-term changes from population growth (natural and migration) far surpass the immediate effects of climate change, although they are related. The focus of implementing changes in planning and mitigation should be on the fringes of cities that are growing, as centers are often established with little room for change. Furthermore, the many informal settlements (slums) are elusive when it comes to quantifying exposure and risk. The number of people and their vulnerability in slums remains very dynamic.

Figure 2-21: Densification of housing in Northern Kampala and loss of green areas leading to increased runoff and flooding, following a medium growth trend (Pérez-Molina et al., 2017).

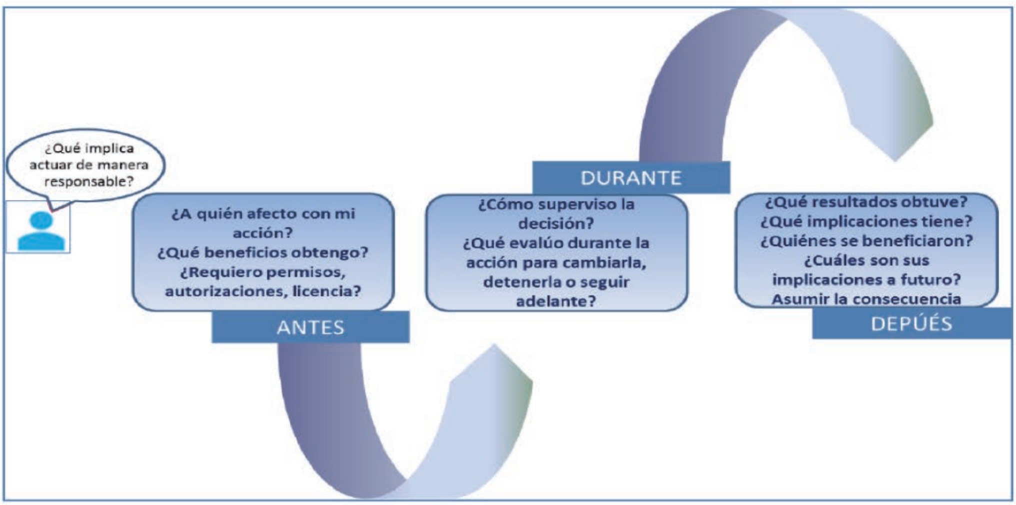


◆ Risk Management: A task for everyone

IRDR NC-Colombia developed the Policy Guidelines for public, private and community sectors in disaster risk management which is based on Article 2 of Law 1523 and the National Risk Management Plan, guiding instruments for the actors involved in risk management, at all territorial levels and areas of action. Also, these guidelines are conceived as a strategy to promote the dialogue between different sectors and stakeholders to achieve disaster risk management goals.

In terms of risk management, the responsibility of reducing disaster risks relies on the entire society and its public and private organizations; therefore, no one is exempt from responsibility, particularly before a disaster occurs, whatever its origin (Figure 2-22).

Figure 2-22: Context of responsibility



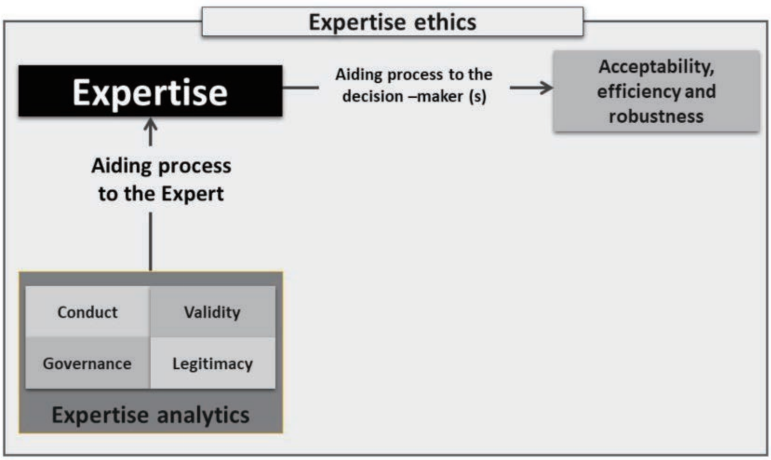
◆ Analytics and Ethics of Disaster Risk Decision-Making in France

The issue of the analytics and ethics of disaster risk decision-making (Table 2-6) has drawn the attention of major research centers. Attention is placed on the questions of the validity of data and models, the robustness of expert findings and conclusions from decisions, and on the question of the legitimacy of such decisions. The question of legitimacy in particular refers to the coherence and consistency of risk governance models implemented at different territorial levels (Figure 2-23), with tension between the traditional centralization regulation mentality of the French State on one hand and an increasing trajectory of decentralization on the other.

Table 2-6. Improving the quality of decisions and science-based expertise (decision aid)

Principles	Characteristics	Key questions
Validity	Robustness	Are risk problem well stated? Are the conclusions framed usingconsistent methods? Are the biases considered and reduced?
	Effectiveness	Will the risks be reduced for people, goods and environment?
	Efficiency Sustainability	Is the expertise process taking into consideration contextualconstraints? Are conclusions context-effective? Will the conclusions remain consistent in the medium and the long terms?
Legitimacy	Transparency	Are the expertise process and the conclusions clearlycommunicated to all actors and stakeholders?
	Accountability Legality	Are responsibilities for expertise and liability of expertise clear andaccepted? Are the expertise conclusions compatible with national /international laws?
	Fairness	Are risks and benefits distributed equitably?
	Participation	Have all actors with stakes been consulted and involved?
	Responsiveness	Have actors/stakeholders and shareholders views been taken intoaccount?
	Ethical behaviors	Do the expertise process and the conclusions meet moral anddeontology standards?

Figure 2-23: Framework for responsible decision and decision-aiding for risk prevention



Obj. 3: Reducing risk and curbing losses through knowledge-based actions

This objective focuses on applying the integrated, combined understanding from numerous fields of expertise to the understanding of the causes of disaster, hereby providing practical guidance on the reduction of risk and the curbing of losses. IRDR NC-France has also made a major shift in its approach to forms of disaster risk regulation from normative to a normative-in-action approach based on sectoral or territorial pilot cases. Thus, since the technological and natural risk law of 30 July 2003, various pilot cases (e.g. the development of Risk Prevention Plans) have served as in-vivo observatories. NCs and ICoEs from America (Canada, Colombia and USA), Africa, Asia (China and Nepal), Europe (France, Germany, Netherlands and UK) and Oceania (Australia and New Zealand) have contributed greatly to this objective.

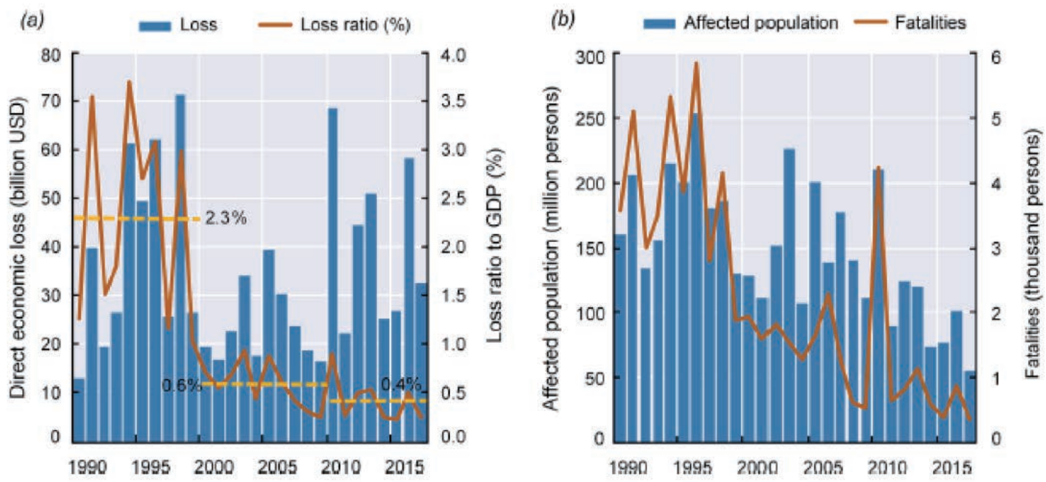
Local vulnerability has been assessed based on extreme disasters such as 1998 Yangtze River flood in China, 2010-2012 Canterbury earthquakes sequence in New Zealand, 2017 Hurricane Maria in USA. Indices, framework, research priorities, vision papers, and so on are provided in order to reduce risk and curb losses. Promoting disaster awareness as an important approach for curbing losses is suggested by more than one community. Disaster recovery and the “build back better” concept from Sendai framework are all been discussed. The research under this objective draws lessons from the disasters that have occurred, and then tries to reduce future risks and losses.

O3.1 Vulnerability assessments

◆ Lessons learned from the Yangtze River flood in 1998 and 2016, China

In 1998 and 2016, mega-floods swept through China’s major river basins and led to huge economic losses and agonizing human deaths. In order to curb losses from floods, **IRDR NC-China** put strong emphasis on post-disaster reconstruction and actively promotes a comprehensive water governance, harmonizing human activities with water management by: employing systematic governance for middle and small rivers, changing ‘passive governance’ to ‘positive governance’; and strengthening basic research (Cheng et al., 2018). Novel flood adaptation policies are required to address the (uncertain) future challenges. Such policies should be based on a well-established and up-to-date risk assessments, assessments which also should take into account future changes in climate and socioeconomic conditions. One component of an new policy could be enhanced flood protection systems, especially in urban areas with high economic values and large exposed populations (Ward et al., 2017). However, structural measures can also cause the “levee effect”, further stimulating exposure in protected areas. Hence, additional measures and regulations are required to solve this paradox between urban development and structural protection, to sustain and enhance environmental values, and to reduce flood risk in areas where dikes are not cost-effective. Besides, any novel policy should integrate flood management into urban planning; strengthen governance and coordination; improve information sharing and public participation (Du et al., 2019).

Figure 2-24: **Flood losses (a) and flood fatalities (b) in China from 1990 to 2017 (Data source: Ministry of Water Resources of the People's Republic of China: China Water Statistical Yearbook 2017).**



◆ Conceptual development of vulnerability and resilience assessments

IRDR ICoE-VaRM is an international leader in the development of social vulnerability and resilience metrics. While not explicitly stated as a science objective in the IRDR Science Plan, ICoE-VaRM's work in increasing utilization of evidence-based measurements for depicting spatial and temporal variability in vulnerability and community resilience has been recognized by the scientific community and has been of great interest by researchers (including students and early career scholars), policy-makers and practitioners alike, with the Center receiving numerous requests for consultations. Social vulnerability metrics (SoVI®) and indicators for community resilience developed by the IRDR ICoE-VaRM have been incorporated into the U.S. Federal Emergency Management Agency's National Risk Index for Natural Hazards (NRI), freely available on the web[23] to support risk communication and mitigation planning at local to national scales.Many studies are employing the metrics to describe vulnerability patterns and compare newly devised measures to existing ones (de Oliveira Mendes, 2009), such as in Australia (Singh-Peterson et al., 2014), China (Li & Zhai, 2017), Indonesia (Kuscahyadi et al., 2017), Norway (Holand et al., 2011; Scherzer et al., 2019), Portugal (Guillard-Gonçalves et al., 2015), Romania (Armaș & Gavriș, 2013) and the US (Cutter & Derakhshan, 2020).

◆ Liquefaction Resistance Index Map

Following the Canterbury earthquakes, the focus and efforts of **IRDR NC-New Zealand** were quickly diverted towards investigating the performance of buildings (unreinforced masonry, concrete, steel), non-structural elements, infrastructure and lifelines. Extensive ground damage as a result of liquefaction and lateral spreading was a critical issue, and a research program examining the impacts of liquefaction, soil profiles and triggering factors was initiated.

Over the longer-term, research sought to bring improvements to design practices and recommendations to achieve tolerable impact

23 https://www.fema.gov/flood-maps/products-tools/national-risk-index/overview

levels with respect to building functionality and safety at varying intensities of earthquake hazard. The geotechnical work included field data and modelling to understand soil-structure interactions, underground pipe networks, restoration times, damage costs, and impacts of mitigation measures. Research outcomes were shared with recovery agencies, government and the engineering sector. The Canterbury program was influential in introducing low-damage technologies into some of the new construction in Christchurch, and to some extent was mirrored in Wellington following the Cook Strait-Lake Grassmere earthquakes.

The risks related to unreinforced masonry and options for retrofit were made clearer. On 1 July 2017, the Building (Earthquake-prone Buildings) Amendment Act 2016 came into force, modifying how local councils, engineers and building owners are to carry out assessment and deal with earthquake-prone buildings. This remains a contentious issue however, with ongoing debate of both political and economic aspects and implications.

Researchers have further contributed to standards and guidelines in the engineering profession. This includes an update of the Detailed Seismic Assessment Guidelines for concrete, steel, timber and URM buildings, and the development of Guidelines for Earthquake Geotechnical Engineering Practice. Much of this work was informed by the Canterbury experience.

The research team is also continuing studies on residual capacity. In other words, investigating the impact of prior earthquake damage on a structure and how it affects downstream performance in subsequent events. To give but one example, the inspection of precast concrete floors in Wellington buildings following the Kaikōura earthquakes (NHRP, 2018) clearly demonstrate the critical importance of such studies.

◆ Social Vulnerability, Resilience, and Justice during Disaster Recovery

IRDR NC-USA completed a study report using interview and observation data with healthcare workers across Puerto Rico to better understand what kind of impacts the hurricane had on people's health, and who was most impacted. The report focused on Hurricane Maria, one of the most devastating storms in United States history. The tremendous force of the hurricane, along with the associated wind, rain, flooding, and damage to critical infrastructure, caused incredible disruption to lives and livelihoods. Scientists sought to understand how healthcare workers responded to the crisis in order to reach communities in need. The study highlights how and why people with chronic health conditions, those who were economically disadvantaged, rural populations, and older populations were particularly vulnerable to the health impacts of the storm and massive, extended disruptions to key infrastructure. Scientists also explore how Puerto Rico's colonial relationship to the United States, migration patterns, economic recession, and underfunding of health care services contributed to health vulnerabilities. Despite severely compromised health facilities and services across Puerto Rico, the healthcare workers that participated in this study accomplished incredible feats in their efforts to reach people in need. Flexibility in roles and local knowledge of communities were key for effective medical outreach and knowing the kinds of services to provide (Niles & Contreras, 2019).

Disasters also expose social structures that put marginalized communities in harm's way. The impacts of Hurricane Harvey on low-income Hispanic communities in Houston, Texas, illustrate patterns of historical inequalities that have led to poor minorities in the United States being disproportionately exposed to environmental risks. In disaster contexts where inequality increases vulnerabilities and reduces adaptive capacities and resilience for marginalized groups, it can be argued that effective disaster recovery initiatives call for stakeholders to better understand and explicitly address structural barriers to resilience rooted in social injustice. The report explores post-Harvey disaster recovery as a lived experience at the household level (from the perspectives of community residents), and as an issue of neighbourhood organization at the community level (from the perspective of community advocacy groups). The project considers the collective conversation surrounding these themes 6 and 12 months after the storm to assess how community residents and local advocacy groups prioritize and address needs during the crucial first year of recovery efforts after the storm.

The key takeaways from the Phase 1 field visit include: the importance of social capital and information resources to support disaster preparedness and recovery; the significance of social justice and its connection to the root causes that shape household vulnerabilities; and information on the ways in which community advocacy organizations respond to immediate community needs while fostering long-term development to minimize vulnerability and support resilience in the face of future disasters. The first year after a disaster strikes is crucial to preserving well-being and empowering communities to ensure their participation and agency in shaping their recovery. An in-depth qualitative data analysis using Maxqda will be conducted after a follow-up field visit to identify broader themes and patterns. It is important to note that, while the information gathered through this small number of interviews cannot be generalized, it does suggest themes for more expansive research.

Research outcomes will be aimed at informing future disaster recovery processes through a more comprehensive understanding of the barriers that exacerbate the vulnerabilities and impede resilience for marginalized communities; through approaches that allow community advocacy groups to address vulnerabilities and support resilience in culturally-appropriate ways at the local level; and via mechanisms that can improve the effectiveness of organizations addressing vulnerabilities and supporting resilience at larger scales (Azadegan, 2018).

PERIPERI U, host to **IRDR ICoE for Risk Education and Learning (IRDR ICoE-REaL, South Africa),** also published many articles and reports on risk and vulnerability assessments. The following table (Table 2-7) lists some of the key publications.

Table 2-7. Key publications of PERIPERI U

Output type	Title	Partner	Authors	Year
Research report	IARIVO Project: Strengthen the resilience of the most flood-vulnerable communities of the Urban Commune of Antananarivo	Tana	Tana and other PERIPERI U team members	2016
Research report	Effectiveness of Early Warning of Seismic Vulnerability: Assessing the National Data Centre (NDC) in Ghana	Ghana	Peters MK et al.	Ongoing
Journal article	Community-level adaptation to minimize vulnerability and exploit opportunities in Kampala's wetlands	Makarere	Kemp J, Orach C & Isunju J	2016
Journal article	The complex interplay between everyday risks and disaster risks: the case of the 2014 cholera pandemic and 2015 flood disaster in Accra, Ghana	Ghana	Songsore J	2017
Journal article	Rural Households' Vulnerability to Poverty in Ethiopia	BDU	Kasie, TA & Demissie S	2017
Journal article	Quantitative risk analysis using vulnerability indicators to assess food insecurity in the Niayes agricultural region of West of Senegal	GBU and SU	Diack MM, Loum CT, Diop A & Holloway A	2017
Case study	Implementation of a participatory risk and vulnerability assessment for communities around Kizinga River catchment area in Temeke Municipality	Ardhi	Kiunsi R et al.	Ongoing
Research report	Collection of Vulnerability Assessment Methods for Buildings	USTHB	Meziane YA & Benouar D	Ongoing

◆ Evolution in the Characterization and Assessment of Vulnerabilities

Although the characterization and assessment of vulnerabilities made by **IRDR NC-France** has long been based on "hazard-centered" approaches, practically it was and will continue to evolve. The first change was through the introduction of the systems-based approach where subsystems generate and absorb flows of vulnerabilities and resilience in time, space and by actors (e.g. MADS-MOSAR[24] approaches, cindynics[25] hyperspace). It later incorporated analytical approaches and organizational diagnostics of safety and security. These first two developments made it possible to extend the scope of vulnerability assessment beyond the initial analysis of structural vulnerabilities to organizational, societal and governance vulnerabilities. The most recent evolution has been in the conception of what is vulnerable (structure or culture). The issue of co-constructing a risk/safety/safety culture will make it possible to extend the scope of governance from the representative model to participatory and deliberative models.

It should be further noted that, in practice, consideration of vulnerability has been limited. Thus, often consideration of vulnerability in instruments such as Risk Prevention Plans (PPRs) has been limited to an analysis of the stakes on the territory, or at best to an analysis of the structural vulnerability of the latter. The Risks Act of 30 July 2003 will open the way to ratification of the Aarhus Convention and extend the mechanisms for bottom-up and top-down dialogue and consultation by risk basin, territory and/or hazard.

◆ Extreme Events, Critical Infrastructures, Human Vulnerability and Strategic Planning: Emerging Research Issues

IRDR ICoE on Critical Infrastructures and Strategic Planning (IRDR ICoE-CI&SP, Germany) aims at exploring the resilience of Critical Infrastructures from various perspectives in order to provide a comprehensive platform for this evermore-important topic and to substantially advance the depths and breadths of the currently narrow approaches. In this regard, the analysis of the resilience of Critical Infrastructures, such as energy, water, transport, health services, will not primarily focus on technical details of the respective systems, but rather on cross-cutting and interdisciplinary challenges that are, for example, linked to the identification of interdependencies and cascading risks between Critical Infrastructures or to the shifting governance implications, including new organizational requirements and behavioral adaptations. For example, Joern Birkmann et al. (2016) at the IRDR ICoE-CI&SP outlined key research challenges in addressing the nexus between extreme weather events, critical infrastructure resilience, human vulnerability and strategic planning. Using a structured expert dialogue approach particularly based on a roundtable discussion funded by the German National Science Foundation (DFG), their paper outlined emerging research issues in the context of extreme events, critical infrastructures, human vulnerability and strategic planning, providing perspectives for inter- and transdisciplinary research on this important nexus. The main contribution of their paper is a compilation of identified research gaps and needs from an interdisciplinary perspective including the lack of integration across subjects and mismatches between different concepts and schools of thought.

24 Systems Malfunction Analysis Methodology - Systemic Organized Risk Analysis Methodology.

25 Risk and Hazard Science.

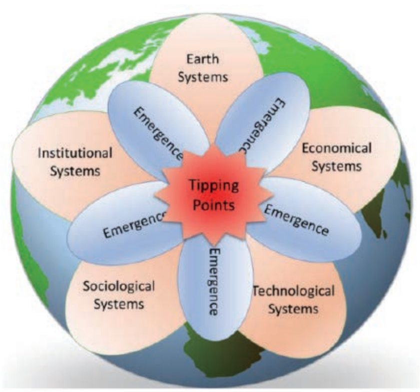
O3.2 Effective approaches to risk reduction

◆ Institutional-socio-earth-economical-technical-systems (ISEETS) framework

IRDR NC-China presents an institutional-socio-earth-economical-technical-systems (ISEETS) framework for integrated risk governance in the Anthropocene, based on complex systems theory. ISEETS is different from other theoretical frameworks due to its emphasis on the importance of institutional and technological systems in risk governance, and the potentially irreversible changes facing whole earth systems. These are distinctive and increasingly crucial elements of the Anthropocene. The complex systems science foundation of ISEETS are: tipping points, emergence, intrinsic structure, function, and relationships across the five subsystems. The ISEETS framework has been applied to the Montreal Protocol on Substances that Deplete the Ozone Layer and the Dujiangyan water project in China. Global and local cases illustrate the usefulness and indivisibility of this framework.

The inclusive and extensive features of ISEETS enable systems thinking, analysis, tipping points identification, and opportunity emergence, in different sectors and various temporal and spatial scales for Anthropocene risk governance, such as the recent wildfire and global scale pandemic risks. The existing theories, models, data, and methodologies in the context of ISEETS are reviewed for integration and re-engineering. ISEETS allows practitioners to rapidly and robustly probe interconnectedness in this new normal age. Ideally, the ISEETS framework would be applied to support practical risk management and decision-making process. But in the meantime, its theoretical and methodological research already demonstrate great potential for further evolution.

Figure 2-25: **The framework of Institutional-Socio-Economic-Ecological-Technological Systems (ISEETS) (Source: Qian Ye from Beijing Normal University).**



◆ Increasing earthquake awareness among vulnerable communities

IRDR ICoE for National Society for Earthquake Technology - Nepal (IRDR ICoE-NSET, Nepal)'s work focuses on aspects of earthquake risk management, primarily in Nepal and to a limited degree in countries in South Asia and Southeast Asia. In Nepal, NSET focuses on increasing earthquake awareness among vulnerable communities, on helping communities enhance the resistance of school buildings to seismic shocks, and on improving earthquake preparedness in the schools and education system. NSET collaborates closely with urban and rural municipalities to enhance code compliance in the building permit application and inspection processes, and with hospitals and health institutions in enhancing seismic resilience of the physical infrastructure, especially for critical facilities. In South Asian and Southeast Asian nations, NSET, alongside formal emergency systems and organizations already in place, sets up organized training programs in topics such as Medical First Response (MFR), Collapsed Structure Search and Rescue (CSSR), Swift Water Rescue (SWR), Hospital Preparedness for Emergencies (HOPE), Community Action for Disaster response (CADRE) and more community-based disaster preparedness programs, as well as helps and advises on pre-positioning of emergency food and non-food supplies. At the request of partners of the Asian Disaster Reduction and Response

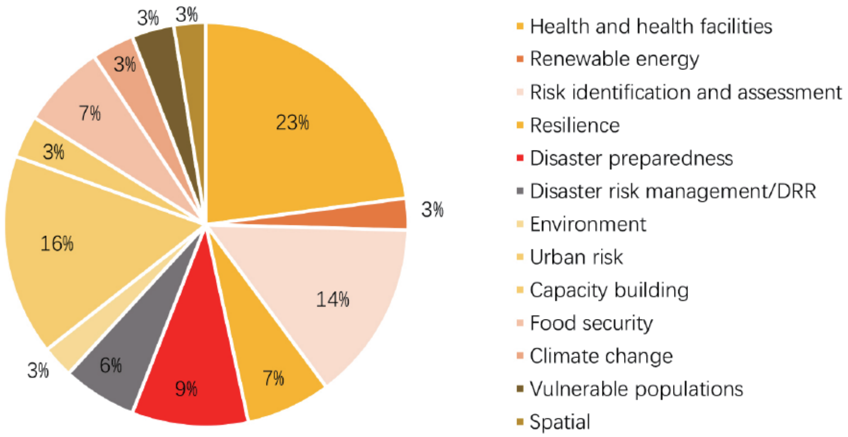
Network (ADRRN[26]) and UN agencies and donors, NSET is also able to dispatch teams of professionals and building construction technicians (masons) to different earthquake affected areas in Gujarat, Banda Aceh, Bam, and Pakistan, sharing their experiences in capacity enhancement for earthquake response and reconstruction. In turn, NSET is able to learn from working at the earthquake theatres, developing a series of methodologies and the corresponding training curricula for vulnerability and damage assessment, loss estimation and impact scenario development, action planning and vulnerability reduction. That information can then be used back home in Nepal, providing more training to a variety of stakeholders.

NSET also collaborates with the Global Earthquake Model (GEM) in integrated risk assessment to develop a score card method for the assessment of social vulnerability and resilience in the conditions of developing countries. Understanding and integration of social and economic vulnerabilities among marginalized and highly vulnerable groups (such as women, children and people with disabilities) and those marginalized from the mainstream national economic and educational processes is key. NSET works with them, adopting an approach which overlays modern innovative technologies onto the locally practices of traditional wisdom. Implementing DRR and CCA initiatives is hence a collaborative work. This approach has helped NSET build up trust, and allows it provide services to the people and the government at central and local levels pre-, during and post-disaster, as exemplified by the 2015 Gorkha earthquake. It also has allowed NSET to adjust quickly to the new conditions of the ongoing COVID 19 pandemics.

◆ Generating and communication of risks and vulnerabilities related research outputs

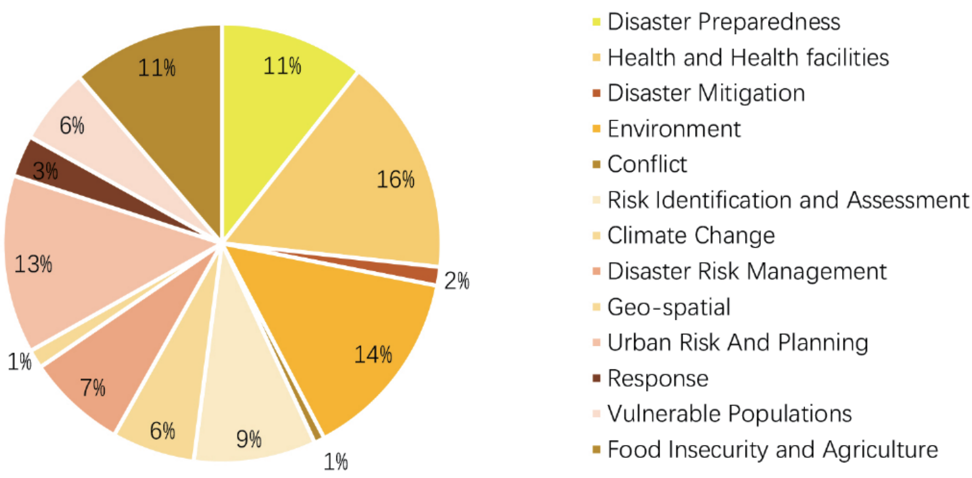
A major Focus of the **PERIPERI U** partners is the generating and communication of applied research outputs related to the risks and vulnerabilities in African countries. Between 2016 – 2019, PERIPERI U partners produced 83 publications and reports focused on disaster risk related issues. These included 52 peer-reviewed

Figure 2-26: Distribution of research themes of outputs produced by PERIPERI U partners between 2016 - 2019.



26 https://www.adrrn.net/

Figure 2-27: **Distribution of research themes of theses produced by PERIPERI U students between 2016 – 2019.**



journal articles, 5 books or book chapters and 26 research reports and case studies. An additional 37 research projects are still ongoing. Research focused primarily on risk identification and assessment and local and sub-national level, gathering data on hazards and vulnerabilities that could serve to inform local policy and planning to assist in reducing disaster risk, and enhancing resilience and sustainability.

In addition to the research and publications produced by its partners, 416 student research theses had been completed at the time of reporting. A further 267 are currently still ongoing (or under review) at time of writing. These too are highly diversified, covering a vast range of fields, sub-disciplines and geographic areas.

◆ The implementation and the monitoring of informed risk reduction decisions

The third IRDR objective, which is related to risk reduction through knowledge-based actions, has been the implementation and the monitoring of informed risk reduction decisions in the framework of disaster risk management and adaptation to climate change. Derived from trans-disciplinary and comprehensive understanding of vulnerability and risk, this objective takes into account the underlying development causes, from social, economic, governance, and environment perspectives. Examples of such efforts by the **IRDR-ICoE-UR&S** are listed in the following table (Table 2-8).

Table 2-8. **Examples of ICoE UR&S's efforts in the implementation and the monitoring of informed risk reduction decisions.**

Examples of achievements	IRDR WG related
Indicators of Risk and Risk Management for Barbados in the beginning and the end of the Coastal Zone Management Agency CZMA project of disaster risk management	RIA, DATA, FORIN
Development of the Integrated Disaster Risk Management Plan and the Emergency Response Plan of Manizales base on the uses of the Risk Management Index (RMI)	FORIN
Development and application of the Disaster Deficit Index (DDI), the Local Disaster Index (LDI), the Prevalent Vulnerability Index (PVI) and the Risk Management Index (RMI) for 24 countries of the Americas and the Urban Disaster Risk Index (UDRi,) applied in different urban centres worldwide	RIA, DATA, FORIN
System of Indicators of Disaster Risk and Risk Management for the Americas (application and update for 24 countries)	RIA, DATA; FORIN

◆ Providing science and evidence-based disaster risk management knowledge

The Institute for Catastrophic Loss Reduction (ICLR), which hosts **IRDR ICoE-DRHBPI**, provides science and evidence-based disaster risk management knowledge, which it makes publicly available through its publications and website. ICLR works through direct partnerships and is in direct communication with all levels of governance in Canada (with an emphasis on city-level) and partners globally to support the Sendai Framework for Disaster Risk Reduction and the IRDR Objectives and Themes.

ICLR shares its findings through a proactive engagement program with cities and municipal decision-makers, homebuilders, the insurance industry and the public. Its library includes research papers across the hazards and on issues of public policy and health, and over 50 articles published in magazines that are directly applicable to enhancing the IRDR theme of capacity building – for the general public, government, as well as private sector. Ranging from case studies, demonstration projects to assessments, the library is a rich source of information.

ICLR works to understand when buildings and communities are vulnerable and at risk of experiencing loss from natural hazards, using the knowledge gained to champion actions to reduce such risk and increase resilience. Priorities that ICLR has been addressing include the risks for homeowners, such as basement flooding; the need for construction of disaster-resilient homes; and enhancing the resilience of existing homes (Kyriazis et al., 2017). Another important project is the ICLR's Quick Response Program, which is designed to allow social, behavioural and economic scientists to quickly deploy to a disaster-affected area in the aftermath of a flood, extreme weather event or earthquake to collect perishable data. ICLR has also contributed to research studies on issues of communicating risks (Kyriazis et al., 2017), extending earthquake risk modelling (Tiampo et al., 2017) and the concept of "Build Back Better" (Tamura et al., 2018).

◆ The intersection of health and disaster risk reduction: the concept of Health-EDRM:

IRDR ICoE for Collaborating Centre for Oxford University and CUHK (CCOUC) for Disaster and Medical Humanitarian Response (IRDR ICoE-CCOUC, China) has been promoting Health Emergency and Disaster Risk Management (Health-EDRM) as the overarching approach to risk reduction, and bottom-up resilience as the key aspect of capacity building. Throughout several landmark UN agreements adopted in 2015-16, including the Sendai Framework, the 2030 SDGs, the Paris Climate Agreement, and the New Urban

Agenda (Habitat III), Health is recognised as an outcome and a goal of disaster risk reduction. The broad intersection of health and disaster risk reduction is captured in the concept of Health-EDRM, which encompasses various fields. The focuses of Health-EDRM include: an all-hazards approach that incorporates the full spectrum of hazards; a holistic all-needs approach, including physical, mental, and psycho-social health and wellbeing; research and interventions facilitated during all phases of a disaster; disaster risk identification for populations with specific health needs such as children, people with disabilities, and the elderly; and research on and the building of health resilience in all communities.

◆ Improving resilience and Building back better

In 2019, the **IRDR ICoE in Spatial Decision Support for Integrated Disaster Risk Reduction (IRDR ICoE-SDS IDRR, Netherlands)** created a Princess Margriet Chair for Spatial Resilience in collaboration with the Dutch Red Cross. Prof Maarten van Aalst, director of the Red Cross Climate Centre, is the first to occupy that chair. His research will focus on:

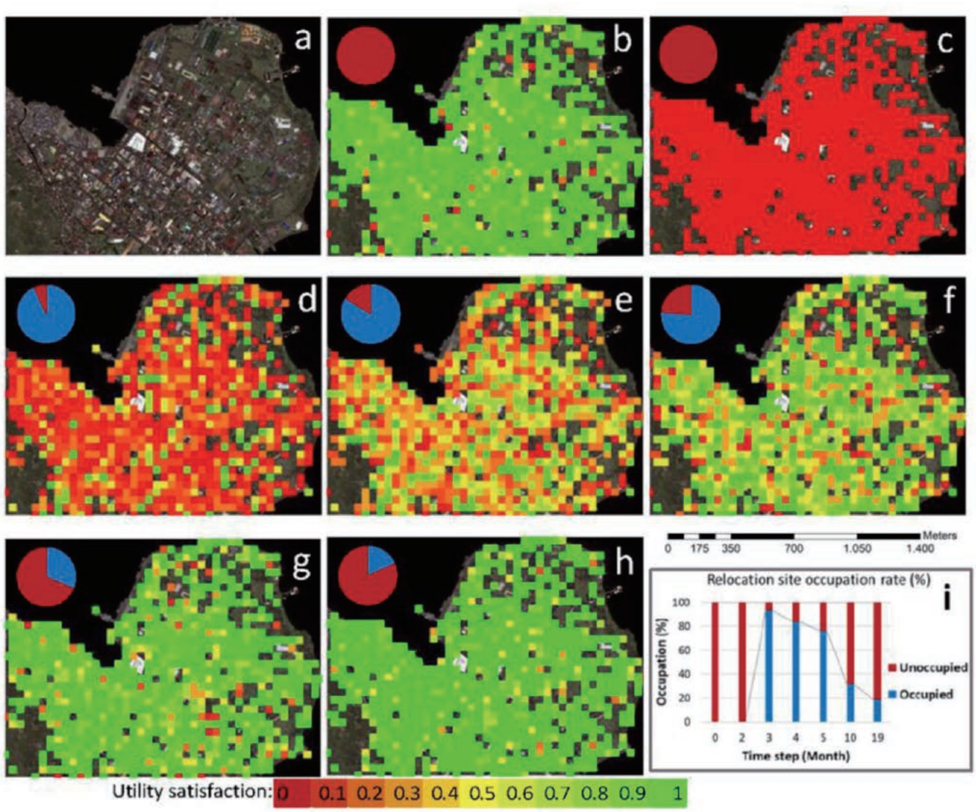
1) Extreme event attribution: unraveling the complexity of the causes and effects of the impact of extreme events, where climate change, urbanization, scarcity of resources all play a role. This will help bring into focus the most important processes leading to better resilience.

2) Forecast based financing: Given that donors are willing to allocate a part of the funds that are freed after a disaster to the process of prevention if the benefits are proven by solid science, better understanding of system dynamics, harnessing of hazard and risk assessment and strategic scenario development can be used to harness this willingness into more effective prevention.

3) Connecting scales of resilience: local communities, their environment and resources, the national government and international science and policy communities.

One of the most interesting fields in DRR research is Recovery Assessment. How fast are areas recovering, in what way and can we detect and monitor this using earth observation techniques? Prof. Norman Kerle is engaged in various EU funded projects such as RECONASS (Reconstruction and Recovery Planning: Rapid and Continuously Updated Construction Damage, and Related Needs Assessment), and INACHUS (Technological and Methodological Solutions for Integrated Wide Area Situation Awareness and Survivor Localization to Support Search and Rescue Teams). Central to both projects is a research focus on UAV-based structural damage mapping. Using remote sensing on a larger scale, he has been leading a project in Tacloban (Philippines) to follow the reconstruction of the area after Typhoon Haiyan. This work also exemplifies the movement towards using crowd-sourcing and citizen science for sources of information to better inform research.

Figure 2-28: **Restoration of buildings and facilities from 0 (red) the moment of Haiyan, to Green (1) 19 months later, based on a high-resolution image analysis and OBEIA type methods (Ghaffarian et al., 2020).**



◆ Tsunami Blue Lines

In 2010, Wellington City Council's Emergency Management team (a predecessor to the current Wellington Region Emergency Management Office or WREMO) worked with the residents of Island Bay to develop an effective public education campaign to show where the largest tsunami might reach. After seven months of planning, a community-driven tsunami awareness plan was developed by **IRDR NC-New Zealand** which included the innovative 'blue line' concept. Wellington City Council painted blue lines across local streets in key areas at the maximum possible run-up heights of large tsunamis. These lines are based on modelling by GNS Science and Greater Wellington Regional Council.

Blue lines serve as indicators of show of where you need to get past in such an event. Large earthquakes that take place in the water could create tsunamis. If an earthquake is a long or strong earthquake (one that lasts for over a minute or is strong enough to knock you off your feet), get past the Blue Lines immediately, without waiting for an official warning. If possible, evacuate by foot, or cycle. Stay past the Blue Lines until the official "all clear" is given.

The initial Blue Line Project won the Global and Oceania awards for Public Awareness by the International Association for Emergency Managers in 2012. Since 2012, Blue Lines have been painted in the Hutt Valley and planning is underway for lines in the Wairarapa region. It has also been influential overseas. Tsunami blue lines now exist on the west coast of the USA and parts of Indonesia.

Figure 2-29: Tsunami blue line (NHRP, 2018)

◆ National Research Priorities for Natural Hazards Emergency Management

What are the most significant natural hazard emergency management issues Australia faces over the next ten years? This was the question posed to the Australian emergency management sector in a series of workshops hosted by the Bushfire and Natural Hazards CRC between 2015 and 2017. Drawing conclusions from the workshops, **IRDR NC-Australia** published a series of three publications on national research priorities, documenting the major research issues in natural hazards emergency management[27]. These were considered and noted by the Australia-New Zealand Emergency Management Committee in June 2017.

By synthesizing this information, it will be easier for researchers, policy makers and practitioners at all levels to plan and priorities their work, to enable a nationally coordinated research addressing the major issues of our day, and to support the uptake of that research into practice. These research priorities represent the consensus view of industry experts and are based on extensive consultation and discussion.

The purpose of these publications is to inform key stakeholders, influence decisions, and provide support across a range of functions. They provide an agreed set of high-priority topics to guide conversations, build relationships, and develop project opportunities.

The major issues identified in the series of publications, align with the priorities from the Sendai Framework, which guide the Australian Government on future planning in disaster risk reduction. Additionally, we note that these publications are the beginning of a process, not an end. A national discussion within the emergency management sector has identified themes for research priorities, but this is not intended as either a final or comprehensive list. As new themes and research priorities are identified in coming years, the documentation will be updated to reflect them.

The process to identify the national research priorities for natural hazards spanned a diverse range of topics from specific physical hazards through to the societal, organisational, and governmental contributors to resilience. Four major issues arose repeatedly as key to advancing the state of natural hazards emergency management in Australia. These were:

1. Shared responsibility and community engagement
2. Communicating risk and understanding the benefits of mitigation
3. Impacts of climate change
4. Predictive services, data and warnings

◆ Enhancing Synergies for disaster Prevention in the EurOpean Union (ESPREssO) Vision Paper

In connection with the priorities defined by the Sendai Framework and the related European

27 https://www.bnhcrc.com.au/nationalpriorities

Union Action Plan 2015-2030, as well as the key outcomes and actions identified by the UNISDR Science and Technology Roadmap, **IRDR NC-Germany** published the "Enhancing Synergies for disaster Prevention in the EurOpean Union (ESPREssO)" Vision Paper, with the aim of providing support for the preparation of the Horizon Europe Framework Program 2021-2027. The Vision Paper (Zuccaro et al., 2018) represents the contribution of the ESPREssO project towards a new strategic vision on disaster risk reduction and climate change adaptation in Europe, and promotes new ideas for the future roadmap and agenda of natural hazard research and policymaking over the next ten years. The findings from ESPREssO Stakeholder Forums have been confronted with the four priorities of the Sendai Framework. Based on the four Sendai priorities, the opportunities emerging from an integrated vision of the Disaster Risk Management (DRM) cycle and its linkages with key overarching issues emerging from the networking activities of the ESPREssO project (such as the integration of DRR and CCA) are explained. With connections to the topics of Research and Innovation topics in the field of natural hazards, the ESPREssO vision presents the identified gaps and needs and addresses them in the form of five broad "missions" which outline the scope and expected impact of the proposed actions (Zuccaro et al., 2018). The five missions are as follows:

1. Exploring new frontiers in the field of probabilistic simulation models, vulnerability and risk assessment
2. Increasing quality, reliability and availability of data for performing quantitative assessments
3. Improving risk governance approaches should be explored.

Table 2-9. Some projects which were conducted by IRDR ICoE-RIA

The Names of Projects	Main contents or contributions
Urban Africa Risk Knowledge (Urban ARK)	January 26 2015: formal start date for £3.3m, 36-month DFID-ESRC funded research programme Urban ARK. Mark Pelling is lead researcher with collaboration from African universities and research centres: Mzuz University Malawi, University of Ibadun Nigeria, African Population and Health Research Centre Kenya, Université Abdou Moumouni Niger, University of cape Town South Africa; policy actors: UNHABITAT, IIED, Save the Children and International Alert and UK universities: King's College London and University College London. In addition to bringing together two of the ICoE members (KCL and UCL), IRDR committee member Shuaib Lwasa sits on the Urban ARC Advisory Board. An inception meeting was held in Cape Town in May 2015.
Building resilience and adaptation to climate extremes and disasters programme	Two projects, both 3 years in duration have been funded by the Department for International Development (DFID) as part of a major investment. The Building Resilience and Adaptation to Climate Extremes and Disasters (BRACED) programme was launched at Sendai. King's leads the Knowledge and Learning strand of work led by Christian Aid in Burkina Faso and Ethiopia. The work studied the social production of climate knowledge from technology exchange between the UK and in-country met. Offices, communication with BBC Media to village level action delivered by Christian Aid. They provided an academic space for free reflection and critique but are closely entwined with the policy and aid delivery processes to influence this. The work focussed on transformative adaptation and on gender.
Linking preparedness, response and resilience in emergency contexts	A DFID funded project running for 3 years embedded within a consortium of ten NGOs including Oxfam, Christian Aid, Muslim Relief, Age Concern, ActionAid. The project aims to understand why despite 15 years of evidence and agreement development is still not integrated into disaster response work, strands will examine post-conflict and post-disaster contexts including field work in Kenya, Philippines, Bangladesh, Pakistan.
Transformation and Resilience on Urban Coasts (TRUC)	TRUC, hosted by Joern Birkmann, aimed to build an original integrated, participatory framework in collaboration with stakeholders to first characterise and then identify interactions between bio-physical, land-use and decision-making processes. The aim was to reveal the pathways and trade-offs through which systems interactions constrain or open opportunities for resilience or transformation how these outcomes themselves interact and influence sustainable development; offering scope for considerable theoretical, methodological and practical advancement.

4. Overcoming the "implementation gap" requires the promotion of innovative approaches to exploit the results of research advancements into resilience-driven investments.

5. Effectively integrating social and behavioural sciences in DRR, CCA and DRM domains.

◆ Making efforts to understand and respond to social, ecological and political crises

The Centre for Integrated Research on Risk and Resilience (CIRRR), which hosts **IRDR ICoE in Risk Interpretation and Action (IRDR ICoE-RIA, UK)**, brings together researchers from across disciplines in order to explore risk and resilience as ways of understanding and responding to social, ecological and political crises today. In order to better understand the social production of vulnerability to environmental change and hazard, and in partnering with practitioner organisations in promoting proactive and egalitarian international risk reduction agendas, they conducted many related projects.

Highlight of results and impacts of IRDR work, per each of three IRDR cross-cutting themes

Theme 1: Capacity building

Capacity building aims to develop human skills and societal infrastructures within a community, nation or region in order to reduce the level of risk. Asian countries made the most contributions under this theme, though NCs and ICoEs from Africa, America (Colombia and USA), Asia (China, India, Indonesia, Iran, Malaysia, Nepal, Pakistan and Republic of Korea), Europe (France and Germany), and Oceania (Australia and New Zealand) all contributed under this objective. Key questions that are tried to be addressed under this objective are list as below.

Key questions:

- How is adequate capacity measured in relation to known hazards in different geographical regions?
- How does capacity account for variations in resilience to hazards?
- Are existing national and international training institutions, methods and tools adequate?
- What are the needs, gaps and deficiencies in capacity to reduce disasters?
- How do social-economic inequalities influence the capacity to manage hazards?
- Are there any capacity-building success stories? What can we learn from them?
- How can the existing capacity be best enhanced and enabled?
- How can capacity/resilience best be transferred, expanded and disseminated among communities and nations?
- How can self-sustaining capacity for disaster-resilient communities (and nations) be built?
- In what ways can indigenous knowledge and capacities be best used, enhanced and incorporated into natural hazard management?
- How can communities be engaged to identify their own capacities to reduce vulnerability to disasters and build resilience?
- Capacity-enabling environment.
- Capacity for risk mapping, monitoring, early warning and information dissemination.
- Capacity for formulating and implementing

disaster reduction policies backed by appropriate legal and monitoring frameworks.

- Mechanisms for mainstreaming disaster reduction into development programmes.
- Investigating and implementing innovative capacity-building schemes – e.g. learning from past success stories.

In different institutions, they had great success for the ongoing capacity-building, and they intervened to build and enhance self-sustaining capacity at various levels for different hazards, including making risk management capabilities guidelines, conducting cross-disciplinary cooperation, training workshops and researches, participation in disaster risk prevention as a non-governmental role, etc. Moreover, they utilized regional/national/communal resources to develop academic programs and public education campaign to enable the continuity in capacity building.

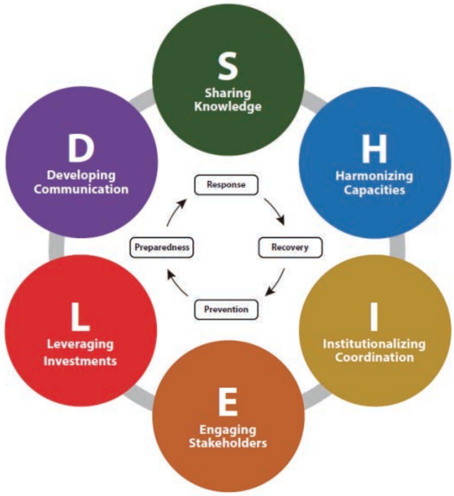
T1.1 Map capacity for disaster reduction.

◆ Enhancing Risk Management Capabilities Guidelines

The Enhancing Risk Management Capabilities Guidelines (German Committee for Disaster Reduction (DKKV e.V.), 2018) developed by **IRDR NC-Germany** represent one of the main outputs of the ESPREssO project. The guidelines are designed to guide and support stakeholders, especially at the administration level. They are designed to improve the capabilities of risk management for EU Member States. The present guidelines add new dimensions by insisting on the need for a stronger governance focus on the Risk Management Capability Assessment of the European Commission (European Commission, 2015). These guidelines are based on different research and participation activities that took place thought the ESPREssO project.

These guidelines are all built around what is referred to as the SHIELD model, developed by

Figure 2-30: The SHIELD model revolving around the four disaster management phases



the ESPREssO team. This model encompasses a set of general recommendations for how to optimize risk management capabilities through disaster risk governance. The SHIELD model refers to the risk reduction cycle of response, recovery, prevention and preparedness. The guidelines are meant to offer practical guidelines to DRR managers at local, regional and national scales, while simultaneously providing a methodological framework to work with disaster governance.

◆ Cross-disciplinary research and cooperation

A. Collaboration between ICoE and researchers/scientists

IRDR ICoE-VaRM's collaborations with researchers in Chile (Pontificia Universidad Católica de Chile, Universidad Austral de Chile), Norway (Norwegian University of Science and Technology), Australia (Australian National University, Charles Darwin University), and Spain (Universidad Pablo de Olavide, Sevilla Spain) include joint publications, grant proposals, and short study exchanges and seminars. Particularly noteworthy was ICoE-VaRM's engagement with the Economic Research Institute for ASEAN and East Asia in the production of their Policy Index for Natural Disasters Resilience[28]. Also noteworthy are the collaborations with other **IRDR ICoE-CR** (Massey University) and **IRDR ICoE on IRDR Science (IRDR ICoE-IRDRS, Australia**; Australian National University) with participation in summer institutes and lecture series. The ICoE-VaRM is also a partner in the Digital Belt and Road (DBAR) International Centre of Excellence on Big Earth Data for Coasts[29]. Notable publications include Anderson et al. (2019); Cutter (2018); Villagra (2019), with the latter two based on collaborations with visiting scientists.

B. DRR researches based on interdisciplinary strength

Banking on the strength of its host institution in interdisciplinary research, **IRDR ICoE-RCS** has been effectively promoting research and education in the fields of climate change and disaster risk reduction. This has been evident from the increasing number of academic projects being taken up by students and scholars as well as research grants being received by the Institute in the domains of Disaster Risk Reduction. The research is also supported through an Incubation Centre established under a MoU with Keio University, Japan and RIKA, India. Simultaneously, an integrated academic forum for disaster risk reduction studies lead by IRDR ICoE-RCS has been formed at the Institute level, bringing various Departments at VNIT and their ongoing initiatives and projects oriented towards building resilience in human settlements onto a single platform. This enables a synergy between different initiatives, addresses various cross-cutting issues in building resilience more comprehensively, and takes the results from various projects beyond the doors of VNIT, contributing to decision-making for safer and resilient futures of human settlements.

C. Cross-disciplinary training and visiting programs

IRDR ICoE-Taipei (China: Taipei) has been pursuing the goal of capacity building for the Asia-Pacific region, with a cross-country and cross-disciplinary approach that provides increasing IRDR-themed training opportunities around the world, especially for small or island countries. IRDR ICoE-Taipei organizes different training workshops (Advanced Institutes), aimed particularly at young/ early-career scientists, and provides them with seed grants for initiating regional DRR theme projects (especially within the Global South). Training topics include researching different kinds of disasters, evidence-based knowledge of disaster risk management, and cross-disciplinary partnership models. Since 2012, IRDR ICoE-Taipei has held twelve Advanced Institutes (AIs) and hosted more than 300 scientists and/or practitioners in these training courses (Figure 2-31).

Figure 2-31: The participant increases in the training activities.

28 https://www.eria.org/Research-Summary-2016-17.pdf

29 https://icoe-coast.org/

IRDR ICoE-Taipei allocates another part of its resources to inviting scholars to visit and share their experiences and insight as it encourages the exchange of ideas and information among scientists from different disciplines between the research institutes. This visiting program is open to all applicants, though of course subject to the Centre's review mechanisms and criteria, with a review committee consisting of three members (which includes the Ex Officio and a couple of SAB members) reviewing submitted documents and deciding whether to support an applicant. The criteria for application, including expected outcome and expected contribution of the visiting scientist program to DRR research are decided by the review committee in advance. All aspects of the program, from application procedure to such criteria are posted on IRDR ICoE-Taipei's website and publicly available.

◆ Development of guidelines, curricula, manuals, methodologies and research papers

IRDR ICoE-NSET has been developing and publishing draft versions of guidelines, training curricula, manuals, and methodologies and research papers in peer-reviewed journals, local journals, news bulletins and in conference proceedings. These address a variety of issues, from problems in engineering, policy, strategy development, to hazard/risk assessment and identification and amelioration of social vulnerability. NSET follows an open access policy and all publications are freely available online or upon personal request, free of charge.

IRDR ICoE-CR, via WREMO, has also been involved in the development of the New Zealand Red Cross Hazard App[30], which launched in November 2015. This app, which is a development of an existing International Red Cross product, has been tailored for the New Zealand environment and messaging. It will help people in the community identify, prepare and respond to hazards in New Zealand, and is pre-loaded with information about hazards including floods, earthquakes, tsunami, fire, weather and biosecurity risks. The app helps users prepare an emergency response kit and plan, and guides them through what to do during an emergency and into recovery. The app also allows alerts to be sent in emergencies and/or for the user to receive information directly from agencies such as MetService and the NZ Transport Agency.

Figure 2-32: **The New Zealand Red Cross Hazard App**

30 https://www.redcross.org.nz/what-we-do/in-new-zealand/emergency-operations/hazard-app/

◆ Integrated Tsunami Research in Indonesia

The Indonesian Institute of Sciences (LIPI – Lembaga Ilmu Pengetahuan Indonesia[31]), which hosts **IRDR NC-Indonesia**, established a transdisciplinary approach in applied sciences through Community Preparedness (COMPRESS) Program as early as in 2006-2012. The program adopted an end-to-end approach towards research in disaster risk, looking at geo-history and dynamics hazard assessments, social and cultural research, policy research, school and community preparedness assessments, vulnerability assessment, risk assessment, institutional arrangements including mainstreaming disaster risk reduction into policies and practices, scientific communication and public education, and so on. Given the scale of the project, more than 10 research centers and bureaus in LIPI worked to complete the project's approach towards science-based risk reduction.

Internationally, LIPI played significant roles in the establishment of the Indonesian Tsunami Warning System (InaTEWS), Landslide Warning System, as well as related disaster policies at national and local level. Between 2009-2012, LIPI lead the Indonesian-Japan Collaboration for Research on Disaster Reduction, which brought together more than 100 scientists with multi-disciplinary backgrounds from both Indonesia and Japan through the JICA JST (SARTREPS) project.

With the establishment of the International Center for Interdisciplinary and Advanced Research (ICIAR) in 2009, LIPI envisioned a strategic long-term position for the institution and Indonesia in general as leaders in the research on environment and human security, including disaster research and capacity strengthening. For this purpose, LIPI established a twinning network with the United Nations University – Institute for Environment and Human Security (UNU EHS). Through the program, LIPI and UNU EHS developed activities to strengthen research capacities, with programs related to increasing human resource capacities especially under the spotlight. Further collaboration and exchanges (for both researchers and students) with German universities occurs as part of the TWIN-SEA network project.

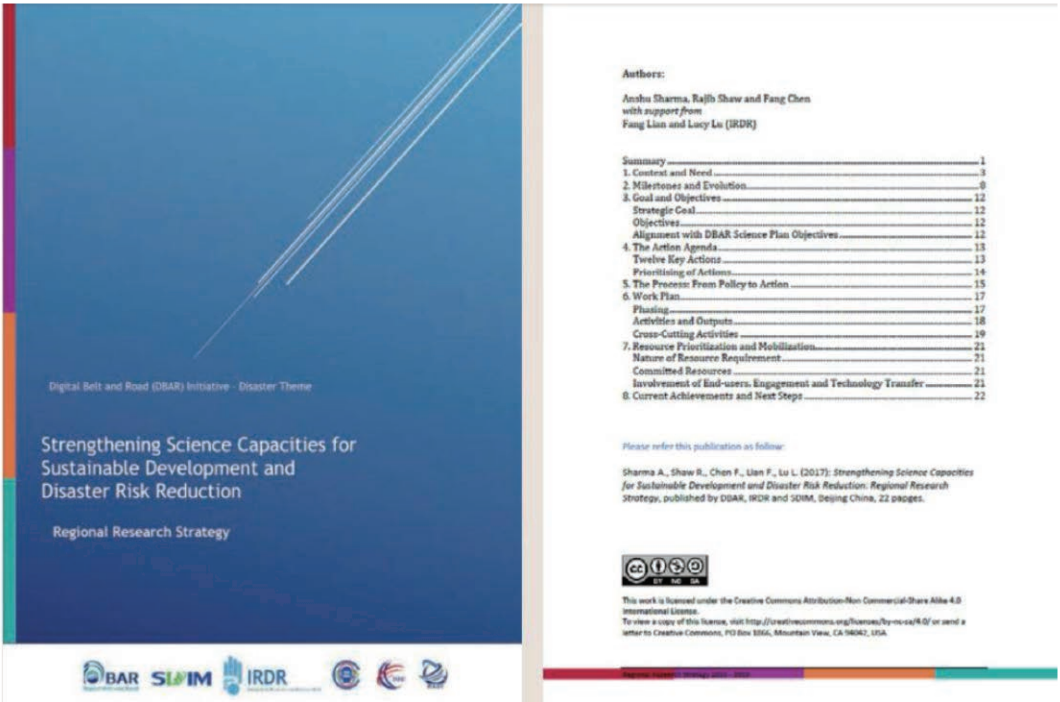
T1.2 Build self-sustaining capacity at various levels for different hazards

◆ A Regional Research Strategy Report for DRR

The call for enhancing the scientific and technical work on disaster risk reduction and its mobilization through the coordination of networks and scientific research institutions occurs at all levels and in all regions, such as the Chinese Academy of Science's Digital Belt and Road Program. With the support of the United Nations Office for Disaster Risk Reduction Scientific and Technical Advisory Group, **IRDR NC-China**, jointly with IRDR-IPO, the International Society for Digital Earth (ISDE), and others, released a 2017 regional research strategy report for DRR. The report helps identify research and technology gaps and set recommendations for research priority areas in disaster risk reduction, and provides guidance on methodologies and standards for risk assessments, disaster risk modelling, and the use of data (Sharma et al., 2017).

31 http://lipi.go.id/

Figure 2-33: Regional research strategy report for DRR



Digital Belt and Road (DBAR) Initiative - Disaster Theme

Strengthening Science Capacities for Sustainable Development and Disaster Risk Reduction

Regional Research Strategy

DBAR SDIM IRDR

Authors:

Anshu Sharma, Rajib Shaw and Fang Chen
with support from
Fang Lian and Lucy Lu (IRDR)

Please refer this publication as follow:

Sharma A., Shaw R., Chen F., Lian F., Lu L. (2017): *Strengthening Science Capacities for Sustainable Development and Disaster Risk Reduction. Regional Research Strategy*, published by DBAR, IRDR and SDIM, Beijing China, 22 pages.

◆ National Disaster Resilience Strategy - Rautaki ā-Motu Manawaroa Aituā

New Zealand has a strong involvement in the initiation of IRDR, promoting and developing transdisciplinary research within IRDR and then translating it into the structure of its own national research programs. Building on this and the outcomes of the Sendai Framework, **IRDR NC-New Zealand**, along with its host organization, developed the National Disaster Resilience Strategy - Rautaki ā-Motu Manawaroa Aituā. The role of the Strategy is to set out goals and objectives for disaster risk and emergency management over the next ten years, and replaces the previous strategy (which was over ten years old, and predated the 2010 and 2011 Canterbury and 2016 Kaikōura earthquakes). This Strategy aims to incorporate lessons learned from these and other events in New Zealand and overseas, and takes a fresh look at priorities, with an especially strong focus on wellbeing. The Strategy reflects an increased understanding of national risks and responds to increased community expectations of New Zealand's emergency management system. It also builds on the Government's work to reform the emergency management system to improve how New Zealand responds to natural disasters and other emergencies (National Disaster Resilience Strategy, 2019).

◆ Explaining and extending the "+2 formula" into tasks

IRDR's Science and Technology Major Group (STMG) delivered a statement in 2015 explaining the 4+2 formula to achieve the Sendai priorities. The **IRDR ICoE-Taipei** has deliberate efforts in the "+2 formula" which are cross-cutting domains: 1) Communication and engagement: closer partnerships between policy, practitioners, research and between researchers themselves to facilitate evidence-based decision-making at all levels of government and across society; and 2) Capacity building: promoting risk literacy through curricular reform, professional training and life-long learning across all sectors of society. IRDR ICoE-Taipei extends these two formulae into specific, practical tasks. To give but a quick summary, the tasks include building the capacity for the countries in the Asia-Pacific region, facilitating collaborative research, and establishing an effective open platform to connect scientists, engineers, government officers, practitioners, and stakeholders to roadmap SFDRR priorities (see Table 2-10).

Table 2-10. 2011-2019 IRDR ICoE-Taipei Activity Roadmap for the Implementation of SFDRR

SFDRR IRDR ICoE-Taipei	Priority 1: Understanding disaster risk	Priority 2: Strengthening disaster risk governance to manage disaster risk	Priority 3: Investing in DRR for resilience	Priority 4: Enhancing disaster preparedness for effective response and to "Build Back Better" in recovery, rehabilitation and reconstruction
Capacity Building	• TW-NDRMA 2016 • AI-SOCD 2017 • AI-LRR&TS 2018 • TC-EHRA 2018 • AI-Hi-ASAP 2019 • AI-Hi-ASAP 2020	• TW-SAMD 2015	• TW-MFSWRST 2016	• AI-DATA 2012 • AI-FORIN 2012 • AI-DRRLM 2015 • AI-KBA 2017 • AI-SOCD heat 2018 • TC-EEW 2019 • TC-LIHM 2019 • AI-ACV 2019
Collaborative Research	• Seed Grant: AI-LRR&TS • Seed Grant: TC-EHRA • Seed Grant: AI-SOCD 2017 • Seed Grant: AI-Hi-ASAP 2019	• Seed Grant: AI-Hi-ASAP 2020		• Seed Grant: AI-DRRLM • Seed Grant: AI-SOCD heat • Seed Grant: AI-KBA 2017 • Flagship Project
Networking	• Young Scientists Conference • Workshop on Exposure Assessment	• PARR Fellowship • Workshop to Strengthen Scientific Advisory Capacities • Relevant Meetings	• CAR II 2011 • Flagship Project • Relevant Meetings • PIAD	• WSS-ISSC Seminar • PIAD • Relevant Meetings
Others	• Visiting Scholar	• SAB meeting • Visiting Scholar	• WSS-ISSC Seminar	• Report: FORIN case study • Article: Improved Evacuation Procedures • Article: Improved Evacuation Procedures

(For activity information please refer to Table 2-11)

Table 2-11. IRDR ICoE-Taipei Activities from 2011 to 2019

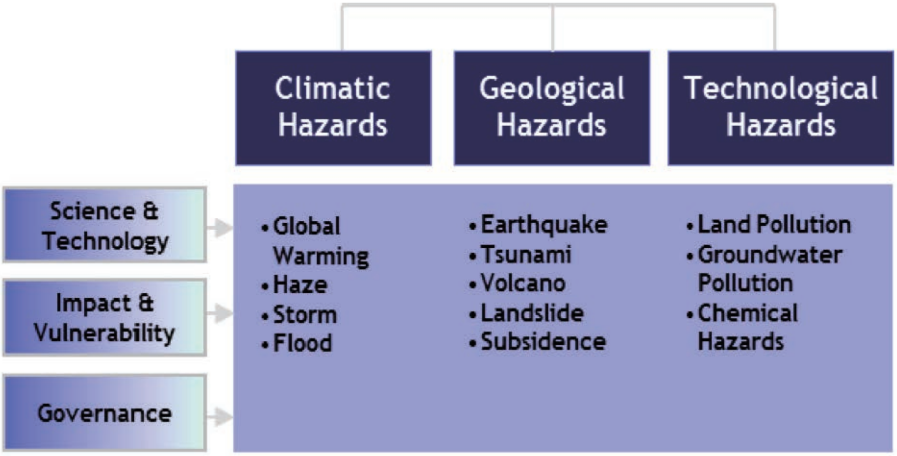
Date	International Activities Conducted or Co-sponsored by ICoE-Taipei	Seed Grant
APR, 2011	Cities at Risk: Building Adaptive Capacities for Managing Climate Change Risks in Asian Coastal Cities (CAR II)	
MAR, 2012	Advanced Institute on Forensic Investigations of Disasters – Southeast Asia (AI-FORIN)	
OCT, 2012	Advanced Institute on Data for Coastal Cities at Risk (AI-DATA) IRDR Working Group – Disaster Loss Data & Impact Assessment (DATA) 1st Expert Meeting	
APR, 2013	Brainstorming Session on "Future Asia"	
OCT, 2013	Young Scientists' Conference on IRDR, Future Earth, And Sustainability	
MAY, 2014	Report: Forensic Investigation of Typhoon Morakot Disaster: Nansalu and Daniao Village Case Study	
OCT, 2014	2014 SAB Meeting	
OCT, 2014	Pan-Asia Risk Reduction (PARR) Fellow Program Seminar	
NOV, 2014	World Social Science Fellows Seminar Sustainable Urbanization – Transfor-mations to Sustainability in Urban Contexts (WSS-ISSC Seminar)	
MAR, 2015	Article: Improved Evacuation Procedures Save Lives in Taiwan From Severe Flood and Debris Flow on UNISDR/ Prevention Web STAG Page	
APR, 2015	Advanced Institute on Disaster Risk Reduction and Loss Mitigation (AI-DRR & LM)- with seed grant projects	♠
APR, 2015	Training Workshop on Systems Approach on Management of Disasters	

Date	International Activities Conducted or Co-sponsored by ICoE-Taipei	Seed Grant
SEP, 2015	Pathway to Deep Decarbonization Symposium	
NOV, 2015	4th PIAD (Psychological Intervention After Disasters) Workshop	
NOV, 2015	2015 SAB Meeting	
JAN, 2016	UNISDR Science and Technology Conference on The Implementation of the Sendai Framework for Disaster Disk Reduction 2015-2030	
FEB, 2016	Future Earth Asian Perspective Symposium on Air Pollution Transdisciplinary Collaboration	
JUN, 2016	The 23rd Pacific Science Congress – "Science, Technology, And Innovation: Building A Sustainable Future on Asia And the Pacific"	
AUG, 2016	The 1st Workshop to Strengthen Scientific Advisory Capacities for Disaster Risk	
SEP, 2016	The International Training Workshop on Natural Disaster Reduction – Natural Disaster Risk Modelling and Applications	
NOV, 2016	The 5th Workshop on Psychological Intervention after Disaster (PIAD)	
NOV, 2016	Training Workshop on Monitoring and Forecasting Severe Weather with Re-mote Sensing Technology	
JAN, 2017	2016 SAB Meeting	
JAN, 2017	The 2nd Workshop to Strengthen Scientific Advisory Capacities for Disaster Risk	
APR, 2017	Advanced Institute on Knowledge-Based Actions for Disaster Risk Reduction (AI-KBA)	♠
JUL, 2017	Advanced Institute on Disaster Risk Reduction with Systems Approach for Slow-Onset Climate Disasters (AI-SOCD) Air Pollution, Sensors, and Big Data	♠
OCT, 2017	Joint Meeting between IRDR ICoE-Taipei and ICSU-ROAP	
OCT, 2017	32nd ICSU Meeting	
JAN, 2018	2017 SAB Meeting	
JUN, 2018	Advanced Institute on Disaster Risk Reduction with Systems Approach for Slow-Onset Climate Disasters (AI-SOCD) Heat Stress Sensors, Early Warning, and Information Technology	♠
JUN, 2018	Workshop on The Application of Micro-Sensors and Exposure Modelling in Personal/Population Exposure Assessment and Epidemiology	
AUG, 2018	Advanced Institute on Landslide Risk Reduction Training School – Landslide Hazards: From Site Specific to Regional Assessment	♠
OCT, 2018	Training Course on Earthquake Hazard and Risk Assessment in East Asia	♠
NOV, 2018	2018 SAB Meeting	
MAR, 2019	Training Course on Earthquake Early Warming (EEW) In East Asia	
JUL, 2019	2019 Advanced Institute – Training Course on Landslide Investigations and Hazards Mitigation	
SEP, 2019	Advanced Institute on Health Impacts and Air Sensing in Asian Population (AI-Hi-ASAP)	♠
OCT, 2019	2019 Advanced Institute on Asian Consortium of Volcanology (AI-ACV) – 4th Field Camp of Asian Consortium of Volcanology	
DEC, 2019	2019 SAB Meeting	

◆ Coordination between ANCST and ASEANadapt

IRDR ICoE-SEADPRI-UKM expands knowledge in the fields of climatic, geological and technological hazards, focusing on science, technology, impact, vulnerability and governance, to benefit the region (see Figure 2-33). IRDR ICoE-SEADPRI-UKM also serves as the coordinating centre for two networks that conduct regular training workshops and other activities for early career scientists, facilitate their participation in IRDR events and expand their linkages in the region. The consolidation of work to support the research goals of the IRDR was further strengthened in the SEADPRI-UKM Plan (2016-2020). In addition, a Memorandum of Understanding signed with the National Disaster Management Agency of Malaysia (NADMA) in 2019, further enhance the policy relevance and mainstreaming of its research products within the country. This formal collaboration also allows IRDR ICoE-SEADPRI-UKM to avail itself to existing mechanisms within NADMA, which is also the focal point in connection to the UNDRR and ASEAN, to extend its reach in the region and further the goals of IRDR.

Figure 2-34: **The research programme of IRDR ICoE-SEADPRI-UKM takes an integrated approach to disaster risk reduction and its linkages to climate variability and change, in line with the goals of IRDR.**



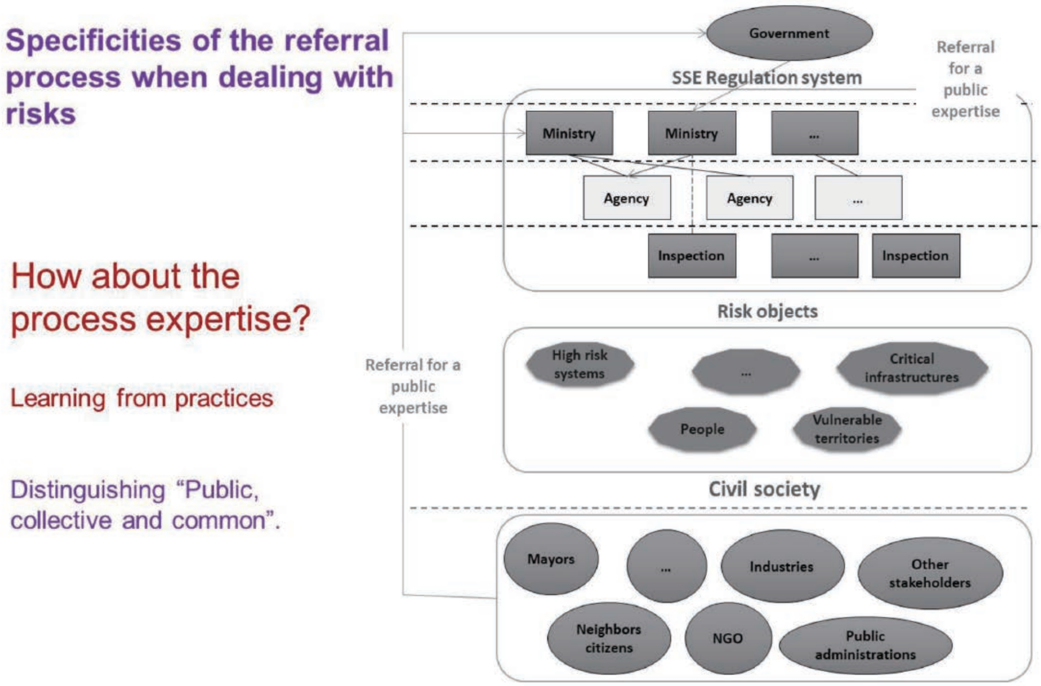
IRDR ICoE-SEADPRI-UKM serves as the coordinating centre for the Asian Network on Climate Science and Technology (ANCST[32]), a self-organised virtual network that links researchers working on climate science of importance to Asia, established in 2013 with seed-funding from the Cambridge Malaysian Education Development Trust in association with the Malaysian Commonwealth Studies Centre. In addition, IRDR ICoE-SEADPRI-UKM hosts the network of ASEAN Partner Institutions on Climate Change Adaptation (ASEANadapt), which was formally recognised by the ASEAN WG on Climate Change (AWGCC) in 2016. IRDR ICoE-SEADPRI-UKM has availed itself to the existing communication pathways of both ANCST and ASEANadapt to fulfill the IRDR cross-cutting themes of capacity building. The key activities of ANCST are capacity building training workshops with a specific focus on early career scientists as well as science-policy interfacing to bridge climate science and disaster risk reduction. Since 2013, IRDR ICoE-SEADPRI-UKM and ANCST have convened 43 workshops and associated events involving 1600 scientists, policy-makers and private sector practitioners in the region, and enhanced their engagement in global processes such as the Sixth Assessment Report of the IPCC. Both ANCST and ASEANadapt promote exchange of scientific findings to enhance awareness, advance risk informed decision-making and strengthen adaptive management to build disaster resilience in the changing climate. The ANCST Bulletin is a useful tool to advertise and facilitate participation in IRDR events, particularly for early career scientists. The ANCST Bulletin also broadcasts opportunities that link climate change – disaster risk reduction in the region, which is further disseminated by the IRDR IPO on behalf of IRDR ICoE-SEADPRI-UKM to reach out to the broader network of disaster risk researchers. Through the self-sustaining and annual training workshops of ANCST, there is continuity in capacity building of early career scientists in the region. The initiatives of ANCST have and continue to help IRDR ICoE-SEADPRI-UKM in bridging climate science and disaster risk reduction.

32 http://ancst.org/

◆ Research, expertise and regulation of disaster risks in France

Research, expertise and regulation of disaster risks in France are organized in seven levels (see Figure 2-34). The first level is the construction of public policies on disaster risks. This part is under the responsibility of the DGPR (Ministry in charge of the environment, sustainable development and ecological transition). The second level is the institutes, agencies and research centers under the supervision of DGPR, which are responsible for building the necessary corpus of regulations and methodological tools. The third level consists of the inspectors in the control authorities such as DREAL, ASN and makes it possible to report on territorial and sectoral issues, to inspect the proper conduct of regulation in the territories and to identify challenges in terms of expertise and research that it will report to the DGPR. The fourth level is the research centers, under the supervision of the Ministry of Research in particular. The fifth level represents the stakeholders. Organized by associations, by scientific and technical theme, by territory, by problem or by nature of the actors, they complete the national public and private panel of expertise on the theme of disaster risks. The sixth level represents the insurance sector. The seventh level consists of the local territorial actors, both at the administrative level (territorial engineers and local technical service providers) and at the political level (elected officials). These actors are at the heart of the articulation and coherence between the central and territorial levels. When a disaster occurs, ad-hoc inquiry commissions are appointed. These commissions of inquiry make it possible to investigate the root causes of disasters and at the same time to test the robustness and relevance of public policies on disaster risks.

Figure 2-35: Organization of research, expertise and regulation of disaster risks in France.



The host of **IRDR NC-France**, AFPCN (Association Française de Prévention des Catastrophes Naturelles[33]), belongs to the fifth level. The main objective of AFPCN is to mobilize, in support of the Delegate for Major Risks (DRM), all stakeholders in natural risk management. It represents the non-governmental part of the national platform for disaster risk prevention. This is why it works in association with the Ministry in charge of natural risks, which subsidizes it for this purpose. Since its creation, AFPCN has endeavored to network the stakeholders in risk prevention. These stakeholders can be citizens interested in the issue of risks, local authorities, State operators, private companies, associations, etc.

◆ What You Should Know About Forest Fires

IRDR NC-Colombia published a short guide entitled "What You Should Know About Forest Fires" aimed to inform, increase awareness and promote community participation on risk management of forest fires[34]. Also, this guide recalls the importance of forest fires´ causes, consequences, and potential solutions of prevention. Finally, it highlights the importance of the stakeholder's organization and collaboration to reduce forest fire occurrences.

The forest fires in Colombia are recurrent during the annual dry periods. Both the area affected and the frequency tend to increase, particularly

Figure 2-36: **What You Should Know About Forest Fires**

"**Lo que usted debe saber** sobre incendios de cobertura vegetal"

Tabla de contenido

33 https://afpcn.org/

34 https://repositorio.gestiondelriesgo.gov.co/handle/20.500.11762/28309

in the paramos and humid forests in the Andean region. Furthernore, forest fires are usually related to human activities and a lack of prevention promotion measures.

Apart from the physical, environmental and climatic characteristics, social practices such as agriculture and livestock raise the risk of forest fires, becoming a socio-natural factor that hinders forest growth. The social practices are relevant to the country's institutions and public policies to convert these practices into sustainable ones.

Regarding the latter, the Ministry of Environment and Sustainable Development has created norms and regulations to prevent forest fires. This publication emphasizes what actions of risk reduction to apply since these events are mainly anthropic in origin and can be prevented. The guide is directed to a broad public and designed as a tool for fast reading, learning, and a permanent reminder to prevent forest fires.

T1.3 Establish continuity in capacity building

◆ Academic Programmes and Summer Courses

A. Expansion of academic programmes and modules

Table 2-12. List of Academic Programmes hosted by PERIPERI U partners

Univ.	Prog.	Programme name	Launched
ABU	PgDip	DRM and Development Studies	2015
	MA	DRM and Development Studies	2014
	MSc.	DRM and Development Studies	2016
	MPhil	DRM and Development Studies	2016
	PhD	DRM and Development Studies	2016
Ardhi	MA	Disaster Risk Management	2010
	MSc.	Disaster Risk Management	2009
	PhD	Disaster Risk Management	2018
BDU	BSc.	Disaster Risk Management & Sustainable Development	2005
	MSc.	Disaster Risk Management & Sustainable Development	2007
	MSc.	Climate Change and Development	2016
	MSc.	Livelihoods and Development	2019
GBU	MSc.	Prevention & Risk Management of Food Insecurity Risk	2015
Makerere	MPH	Public Health Disaster Management	2014
SU	MPhil	Disaster Risk Studies & Development	2016
Tanà	MSc.	Multidisciplinary Disaster and Risk Management	2010
UBuea	MSc.	Disaster Risk Management	2018
UDM	BSc.	Environmental Engineering and Disaster Management	2013
	MSc.	Technical Education, Development and Disaster Management	2013
USTHB	MSc.	Structural Dynamics and Earthquake Engineering	2016
	PhD	Earthquake and Flood Risk Reduction	2015

One of the key initiatives of **PERIPERI U** is a focus on building and enhancing capacity in the field of disaster risk in Africa, to contribute towards creating a more resilient continent. Between 2016 – 2019, PERIPERI U has expanded its academic programmes and modules boosting the consortium's academic portfolio to 47 offerings. A list academic programmes and modules across the 12 PERIPERI U Partners can be found in the two tables below. In total, an estimated 3,842 (2,254 postgraduates and 1,588 undergraduate) students registered across the 12 partners between 2016 - 2019. An additional 381 students graduated, of whom 39.9% were female. A particular milestone for PERIPERI U was achieving 40.6% female student representation across its various academic offerings, a major challenge in a field which has been largely dominated by men and across a continent in which women's participation in academia still face many obstacles and challenges.

Table 2-13. List of Modules and Courses hosted by PERIPERI U partners

Univ.	Prog.	Programme name	Launched
Ghana	Undergrad Hons.	Policies and Strategies for Integrated Disaster Risk Reduction	2011
	Undergrad Hons.	Theories and Analytical Methods for IEH and Integrated DRR	2011
	MA	Concepts and Methods in Advanced Integrated DRR	2011
	MA	Applied Integrated Disaster Risk Reduction in Urban Ghana	2011
Makerere	Undergrad	Environmental Emergencies	2015
	Undergrad	Management of Public Health Disasters	2015
Moi	Undergrad	Nutrition in Emergencies	2014
	Undergrad	Environmental Health: Community Nutrition, Food Science & Technology	2014
	Undergrad	Risk Analysis	2018
	Undergrad	Community-based Education and Service (COBES 2)	2018
	Undergrad	Community-based Education and Service (COBES 5)	2018
	MA	Principles of Disaster Management and conflict Resolution	2017
	MA	Disease Surveillance	2017
SU	BSc.	Environmental Processes and Hazards	2019
	Hons.	Disaster Risk Studies	2012
Tanà	BSc.	Economic Valuation Techniques	2012
	Hons.	Introduction to Disaster Economics	2018
	MA	CNTMAD	2017
	MA	Introduction to DRM/DRR	2017
UBuea	BSc.	Natural Hazards, Disasters and Impacts of Climate Change	2016
	MA	Global Commons, Natural Disaster and Environmental Risk Management	2016
	MA	Groundwater, Pollution and Protection	2016
	PhD	Current Topics in Climate Change	2016
	PhD	Current Trends in Environmental hazards	2016
	PhD	PhD Research Project/Thesis	2016
	PhD	Advanced Topics in Surface and Groundwater Management	2016

PERIPERI U has also hosted 55 short courses, reaching over 1600 participants between 2016 - 2019. These short courses offer training opportunities to academics, practitioners as well as those that are unfamiliar with field of disaster risk but operate in related domains. Such courses provide participants with new insights and understandings of the field of DRR, as well as participative platforms where academics, researchers and practitioners can collaborate to share experiences, uncover important applied research gaps and discuss difficult risk-related problems.

PERIPERI U partners have been involved in 196 technically-oriented events, attended by a total of about 8,760 people total. Below are some examples of the various technical events that's PERIPERI U partners participated in;

1. USTHB representative attended the Global Risk Assessment Framework (GRAF) Expert Group Meeting in November 2018 in Geneva, Switzerland concerning the creation of a new framework for risk assessments which support states seeking to reduce disaster losses through implementation of the Sendai Framework for DRR and the 2030 Agenda for Sustainable Development.

2. Various PERIPERI U partners were selected to sit on inaugural boards of the AYAB-DRR and AfSTAG committees, to discuss how to advance DRR awareness and initiatives across the continent.

3. BDU sponsored and co-hosted its 5th Annual National Conference on the theme "Agriculture and Environmental Management for Sustainable Development". Hosted discussion panels and presented on various topics related to 'Agriculture and Environmental Management for Sustainable Development', 'Building Disaster Resilient Communities' and 'Geosciences for Sustainable Natural Resources Development'.

4. From 18-19 December 2019, ABU participated with other Nigerian Universities to validate and concretize a number of policy documents developed by NEMA for the 8th Country Programme of the FGN/UNDP Plan of Action.

5. In April 2017, SU hosted a seminar in which experts from various fields and institutions were brought to engage with the public (SU students and staff included) on the Western Cape Drought in South Africa.

6. Makerere participated in the monthly Refugee Health and Nutrition Coordination meetings convened by the UNHCR in Kampala. Makerere staff and students engage with various non-governmental organisations that provide assistance to displaced populations in Uganda to discuss and strategize on initiatives to assist refugees in the country.

B. Summer courses and free online courses

IRDR ICoE CCOUC published 14 papers in the field of bottom-up resilience, and conducted following training activities.

1. Croucher Summer Course 2017

With generous support from the Croucher Foundation, CCOUC organised a course on Research Methodology for Disaster and Medical Humanitarian Response in July 2017, admitting five young scientists. This was the third iteration of this five-day residential course designed to provide prospective professionals in disaster risk management intensive training on research methodology for disaster and medical humanitarian response. Attracting participation by post-graduates, early career researchers, experienced practitioners and policy-makers with research responsibility alike, a total of 37 participants from 22 countries and regions have completed the course across three iterations. The academic and cultural diversity among the participants stimulated a vibrant exchange of disaster management knowledge and experience. Professors and experts from world-renowned tertiary institutions and organisations served as instructors, covering a broad range of topics disaster risk reduction ranging from global warming to the "Sendai Framework" and disaster risk management under China's Belt and Road Initiative. In addition, on the first day, participants were able to partake in an open seminar by members of the UNISDR Asia Science Technology and Academia Advisory Group (ASTAAG) on the latest challenges and research gaps on disaster risk reduction. The course provided precious opportunity for the participants to advance their research skills and knowledge in disaster response, as well as build up a global network for future collaboration in conducting research in related fields.

2. Free online courses on disaster and medical humanitarian response

As part of CCOUC's knowledge transfer endeavours, the online course "Public Health Principles in Disaster and Medical Humanitarian Response" launched in April 2014 on the Oxford University platform was successfully completed in October 2019, during which time 10 cohorts, totaling more than 8,000 students from more than 150 countries, enrolled.

In response to the widespread campus closures globally due to the COVID-19 pandemic, 10 free online courses on disaster and medical humanitarian response are currently being offered, on topics including: Climate Change and Health; Research Methodology; Human Security; Core Public Health Concepts; Managing Disaster; Occupational Health; Food Security; International Humanitarian Law; Basic Sign Language; Crisis and Risk Communication.

C. "Safe Schools, Resilient Communities" Program

IIEES, the host of **IRDR NC-Iran**, in collaboration with the National Disaster Management Organization (NDMO), the Ministry of Education, the Red Crescent Society (RCS) and Islamic Republic of Iran Broadcasting (IRIB) have organized 20 annual "Earthquake and Safety Drills" in Iranian schools since 1996, the first three of which were first performed locally in Tehran but since 1999 have been on the national scale. These drills were implemented with the aim of promoting awareness in students and staff of earthquake risk and emergency response and action during and after the event.

Since 2015, IIEES has taken these drills to the next level and started to involve the local communities living near the safe schools as well. Supported by UNESCO, this program is further going to be implemented in neighbouring countries where it will be known as: "Safe Schools – Resilient Communities". The main objective of this program is to raise awareness of resilience at local level, engage local communities in DRR activities and empower them to become prepared to respond to potential earthquakes by using the capacities of safe schools.

Schools can be perfect nodes for raising awareness and organizing such programs as they are local hubs bringing together parents, children, teachers and education specialists. The interaction between community residents and school teams helps improve human capital, community involvement, civic awareness and social cohesion. Nevertheless, promoting resilience needs constant awareness and continuous actions. It is an ongoing process of learning and engagement.

Safe schools are set as centers for managing DRR activities in each neighbourhood, providing necessary trainings, resources and supports with assistance of local governments. In addition, they may work as emergency evacuation places and response center at local levels in the event of earthquakes. Basic necessities for the first three days following the disaster are also provided for each school. This will initiate introduction of schools as local nodes for disaster management in communities and develop an operational bridge between residents, students, parents as well as school staffs. This procedure will ensure that the process of neighbourhood betterment and vulnerability reduction will be continued by the people and specialists alike with the help of the

Figure 2-37: **Safe School – Resilient Community Drills (2015-2019).**

local people and neighbourhood managers. At the end of each program, a preparedness drill will be organized in each neighbourhood to evaluate the effectiveness of the trainings given.

For the moment, this program is being conducted at the national scale with the involvement of international organizations. In 2017, at ECO Summit in Ankara, the program was approved to be implemented in all member states as a flagship program in line with Sendai Framework of DRR. IIEES and UNESCO will bring technical support the neighbouring countries to implement this program and involve local residents in DRR (Amini-Hosseini & Izadkhah, 2020; Parsizadeh & Ghafory - Ashtiany, 2010).

D. Strengthening Graduate Education and Research in Earthquakes and Active Tectonics at Bandung Institute of Technology

Experience prior to the establishment of the Disaster Risk Science Institute (DRSI, formerly Institute for IRDR Science, **IRDR ICoE-IRDRS**) supports the underlying principles guiding IRDR activities: a focus on partnerships and practical benefits; the importance of cross-disciplinary engagement; the value of focused case studies linked by common questions and comparable approaches; and the imperative to link research to education, training and policy outreach. The establishment of a seminar series, distinguished visitor and lecture program and post-graduate research training forums all aim to disseminate research findings to a wider audience of researchers and practitioners. Continuing undergraduate courses and education programs in areas including humanitarian engineering, fire science, water resource management, climate science, natural hazards and disaster management, remote sensing and epidemiology are being assessed for application into larger and more coherent programs to provide the broad-based training and expertise needed for disaster risk reduction. Recent disaster and pandemic events have sharpened the need for tailored, flexible, intensive courses available to professional as well as academic audiences. The project “Strengthening Graduate Education and Research in Earthquakes and Active Tectonics at Bandung Institute of Technology”[35] is but one example of the education and training flowing from established areas of scientific research.

◆ Training workshops for scientists

A. Training workshops from IRDR ICoE-DCE

In terms of capacity building, **IRDR ICoE-DCE** regularly organizes training workshops for capacity building of young scientists and mid-career scientists. The IRDR ICoE-DCE research group develops new techniques and methodologies in DRR, then transfers such to the key stakeholders through training workshops and symposia. During past two years, the following three training workshops were organized: 1) “Advanced

35 https://researchers.anu.edu.au/projects/19320

Table 2-14. Training workshops of IRDR ICoE UR&S

Name	Courses	Audience	Partner
International Graduate Course on Integrated Disaster Risk Management and Urban Planning (e-learning and internship in Manizales, Colombia)	11 courses	Latin America and the Caribbean	Florida International University, USAID-OFDA
Earthquakes of 1979 and 1999 in the Coffee Growing Area of Colombia – Forty and Twenty years after	Disaster Risk Management progress and challenges	\	\
Interdisciplinary Symposium on Adaptation and Disaster Risk Management	\	Local level in Manizales and Colombia	\
Workshop on Innovation and Risk Reduction	\	Local level in Argentina	Inter-American Development Bank
International Congress of Social Sciences and Disaster Risk Management.	\	\	University of Manizales and UBA

Research Methods and Materials" (July 7-10, 2019, Bara Gali Summer campus, University of Peshawar; 2) "Spatial Data Modelling and its Application in DRR and Climate Change" (July 1-5, 2019, IER Conference Room, University of Peshawar); 3) "Trends and Prospects of Geography in Higher Education" (June 22-25, 2018, Baragali summer campus).

B. Training workshops from ICoE UR&S

IRDR ICoE UR&S has been contributing to capacity building through the training of institutions and the next generation of disaster risk researchers, and the development of demonstration projects, assessment and data monitoring of hazards and risk. Table 2-14 lists the main training workshops conducted.

C. Training Workshop from IRDR ICoE PERIPERI U

PERIPERI U also launched a series of Summer School-styled training workshops, named the 'African Risk Methods School' (ARMS). The first ARMS was hosted by ARU in Dar es Salaam between 10 -22 September 2018. ARMS I was a collaborative effort, jointly convened by PERIPERI U, the United Nations Development Programme (UNDP) and the World Health Organisation (WHO). ARMS I took place over a two-week period, with 36 attendees from across 11 countries, with seven courses offered across four streams. The courses drew on contemporary disaster risk theory and grounded application, with the aim to build 'future-ready' DRR skillsets that are interdisciplinary, applicable and integrated, and which respond to Africa's fast-changing disaster risks. The second ARMS was held in Addis Ababa during 28 October to 1 November 2019. ARMS II was a collaborative effort, jointly convened by PERIPERI U partners SU and BDU, as well as UNESCO who provided funding for accommodation, venue hire, travel, per diems and salaries for teaching and administrative staff. ARMS II was originally envisioned to take place in West Africa hosted by GBU, however it was requested by the donor UNESCO to be held in Ethiopia. ARMS II took place over a five-day period offering one compulsory two-day course on 'Integrated Disaster Risk Reduction Science & Action', with 30 participants choosing to take one of two courses, either 'Urban Geophysical Risks' or 'Urban Hydrological Risks'.

D. Training Workshop from NC-China

IRDR NC-China co-hosts international training workshop for early- and mid-career scientists from developing countries annually since 2013. The training workshops stretch over a 1 or 2-week period, and covers both theoretical and practical aspects on the use of space technologies for disasters mitigation. The workshop supports 20 participants (drawn from 400 applicants) each time. In total, more than 100 scientists were trained through the program.

The training workshop focused on the scientific application of big Earth data for reducing disaster risks along the Belt and Road, with emphasis on the Goal 11 “Sustainable Cities and Communities” and Goal 13 “Climate Action” of the UN SDGs, and on disaster risk reduction based on the “Belt and Road” big Earth data analysis and decision-making support system.

Figure 2-38: International training workshop events.

(a)Training work shop in Kashi, China 2014

(b)Training course in Sanya, China 2016

Figure 2-39: International training workshop events.

Main Training Courses

Big Earth Data for Disaster Risk Reduction

- Disaster risk under changing climate
- Earthquake disaster risk assessment
- Crop classification using time series remote sensing data
- Mapping proximate causes of global forest loss
- Mapping individual building with VHR images
- Mapping landslides in Nepal using Landsat images
- Monitoring of Glacial Lake Outburst Floods (GLOFs) in High Mountain Asia

◆ Public Education Campaign

A. International Day for Disaster Risk Reduction

The International Day for Disaster Reduction (IDDR) started in 1989 following approval by the United Nations General Assembly. It is a day to acknowledge the efforts of communities to reduce their exposure to natural disasters. The UN General Assembly sees the IDDR as a way to promote a global culture of disaster reduction, including disaster prevention, mitigation and preparedness.

In order to reduce damage and disruption to basic services and critical infrastructure, the Bushfire and Natural Hazards Cooperative Research Centre (CRC)[36], which is host to **IRDR NC-Australia**, has since 2014 held a series of free public forum on IDDR. The forum focuses on the latest research, policies and practices targeted at reducing the number of people affected by natural disasters around the world. Speakers explore Australia's contribution to reducing impacts from a range of natural disasters, addressing the following questions in particular.

1. What are the challenges we face in preparing and responding to natural disasters and how can they be addressed?
2. What can we do today to reduce costs tomorrow?
3. What policies and practices need to be created, better implemented or changed at a national, state and local level?

The event speakers include both practitioners and researchers discussing how their work is helping build disaster resilient communities across Australia.

B. Award-Winning Framework for Public Engagement about Risk

The New Zealand Ministry of Civil Defense & Emergency Management (MCDEM) "Shakeout" drill has been regularly run to assist people in protecting themselves during future earthquakes. Research included by **IRDR NC-New Zealand** has found that the Shakeout program encourages participants to take protective action during an earthquake and enhances preparedness.

In response to the challenges in the public's response to tsunami, and based on research on warning system effectiveness, MCDEM has initiated several additional new initiatives. These include the development of new tsunami evacuation maps, the 'Long or Strong Get Gone' public education campaign, the 'Tsunami Safer Schools' project, rapid public alerting to mobile phones (Emergency Mobile Alerts, MCDEM 2017[37]), effective short warning messages, and practical recommendations for vertical evacuation for tsunami. An example of a successful project for engaging with the community is the 'I can live with this' research project. This project sought to elicit local perspectives in the Bay of Plenty about tolerable and intolerable risks, and build these into the land-use planning process for natural hazards (Kilvington & Saunders, 2019).

Research on risk reduction and preparedness has highlighted important lessons for individual households and communities, and for institutional and government preparedness. A key aspect of preparedness requires engaging with communities to grow their understanding of hazards and build resilience (Becker & Johnston, 2018).

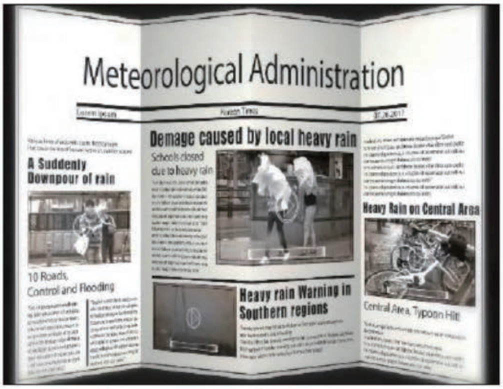
C. Making Education Videos related to DRR

The strategies for DRR after the Sendai Framework were discussed at the 12th International Workshop of WGDRR's Typhoon Committee, held in Ulsan, Republic of Korea in 2017. Participants such as ESCAP, WMO, the National Disaster Management Research

36 https://www.bnhcrc.com.au/

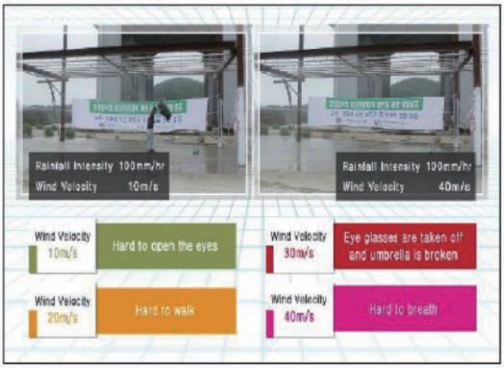
37 https://www.civildefence.govt.nz/get-ready/civil-defence-emergency-management-alerts-and-warnings/emergency-mobile-alert/

Figure 2-40: **The Education Videos made by NDMI.**



<Promotion Video by NDMI>

<Dr. Jaehyun Shim / Director-General of NDMI>



<Video shot in NDMI experiments>

Institute (NDMI) of Republic of Korea (the host of **IRDR NC-Republic of Korea**) and experts in DRR discussed Annual Operation Plans (AOPs) to enhance international cooperation for implementation of the Sendai Framework. All 2017 AOPs agree on the need to share information on disaster management, with AOP number 6, "Making Education Videos related to DRR" the selected method for doing so. Since then, educational videos demonstrating how people can respond to accidents from flood damages (which cause the loss of human lives every summer).

◆ Digital Belt and Road (DBAR) Program

The "Digital Belt and Road" (DBAR) program was formulated in 2016, and is in agreement with and supports agreed global frameworks that include the Sendai Framework, the SDG and the Paris Agreement. Under the DBAR framework, starting from 2016, DBAR, jointly with IRDR IPO, IRDR China, RADI, ISDE, and CAS-TWAS SDIM conduct an international research programme and forms a DBAR Disaster Risk Reduction Working Group (DBAR-Disaster WG) to strengthen science capacities for sustainable development and disaster risk reduction.

The disaster risk reduction approach taken by the DBAR-Disaster WG considers satellite, information, and communication technologies; implementation-oriented technologies that involve hardware solutions to risk reduction challenges;

Figure 2-41: **DBAR Disaster Risk Reduction WG founded.**

process technologies that are concerned with decision making, collaboration and people's engagements; and transferrable indigenous knowledge most countries of the region are very rich in.

The DBAR DRR WG formed at the end of the First Consultative Workshop of the DBAR Regional Research Platform for DRR identified the opportunity to promote the scientific implementation of the Sendai Framework along the Belt and Road. The WG works to advance the disaster reduction under the framework of DBAR, forming an effective and win-win international cooperation mechanism for disaster reduction for the Belt and Road Initiative, shedding light on the priority areas of cooperation in disaster reduction and the training of young talents, and promoting the implementation of the Sendai Framework.

DBAR DRR WG initiated research collaborations with Mongolia, Pakistan and Russia centered on space technology for disaster risk reduction. The collaboration facilitates development of research capacity between the cooperating parties. Under the collaboration, joint field experiments were conducted to collect localized data in support of space-based observations for disaster mitigation.

For example, DBAR DRR WG worked with Mongolia to develop a region-specific, multi-index drought monitoring model, with the adaptability analysis of the drought index already successfully completed. This analysis addresses problems such as the poor temporal-spatial adaptation of the drought monitoring techniques, the vagueness of current descriptions of the occurrences, and the development of a single drought index. With the successful completion of a Drought Watch-Mongolia system that provides continental-scale drought analysis in Mongolia, the product was officially handed over to the Mongolia National Remote Sensing Center in September 2018.

Figure 2-42: **The Drought Watch model and system developed for and delivered to Mongolia.**

DBAR DRR WG also collaborated with the Indonesian National Board for Disaster Management, the University of Peshawar-Pakistan, the National Society for Earthquake Technology-Nepal, and Bangladesh Agricultural University to develop space technologies and application systems that facilitate disaster risks reduction for floods, glacier lake outbursts, and landslides. This collaboration also led to sharing of local observation data, disaster statistical data and space observation data between the parties involved, a collaborative R&D model that is highly suitable for any future projects between Belt and Road countries.

◆ Tool for the implementation of public policy for disaster risk management in Colombia

IRDR NC-Colombia created a series of publications that guide decision-making for the operation of the National Disaster Risk Management System at the territorial level, and used to achieve the public policy for disaster risk management in the nation.

A. Public real estate insurance and risk transfer guide: financial protection against disaster risk[38]

This publication is directed to decision-makers in Colombian territories and the public interested in understanding the public real estate insurance to have precise information when signing insurance policies to optimize territorial performance in financial protection against disaster risk. The purpose of this publication is to guide, facilitate and promote with the territorial institutions the insurance of public real estate, considering the terms and conditions for the subscription of insurance policies.

B. Guide to develop the organizational structure of disaster risk management in the territorial institutions[39]

This guide is directed to local decision-makers as city mayors, governors, and public administrators to guide and inform on the profile characteristics of the head or coordinator of the agency in charge of disaster risk management at the territorial level.

38 https://repositorio.gestiondelriesgo.gov.co/handle/20.500.11762/20604

39 https://repositorio.gestiondelriesgo.gov.co/handle/20.500.11762/27251

C. Territorial Strategies for Emergency Response Methodological Guide – 2018[40]

The Emergency Response Strategy (ERE for its Spanish acronym) is the primary planning instrument for the attention and management of emergencies and disasters at the territorial level. ERE is a priority at the National Government to support local, district, and provincial administrators with a methodological framework that allows the authorities to have technical, methodological, and normative guidelines that lead the construction of response strategies.

Theme 2: Case studies and demonstration projects

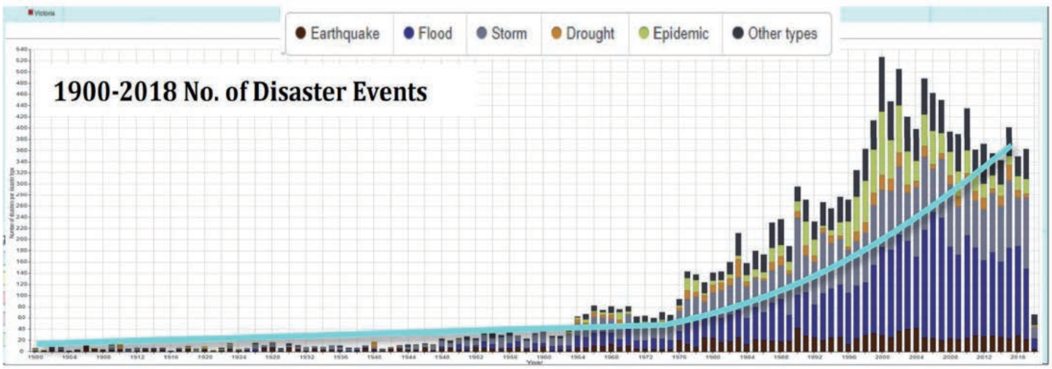
A wide range of hazards, including earthquakes, tornadoes, and multi-hazard, at different scales occurred in different geographical regions. Case studies aim to analyse crises or disasters caused by natural phenomena to draw lessons for the future. NCs and ICoEs from America (Canada and Colombia), Asia (China, Japan, Malaysia and Nepal) and Oceania (New Zealand) contributed greatly under this theme.

These case studies engaged social scientists in the hazards field and to promote collaboration between natural and social scientists. The projects helped catalyze the science community and policy-makers to help them develop better prevention, preparedness, response and recovery strategies.

◆ SiDRR, the Flagship Project of IRDR

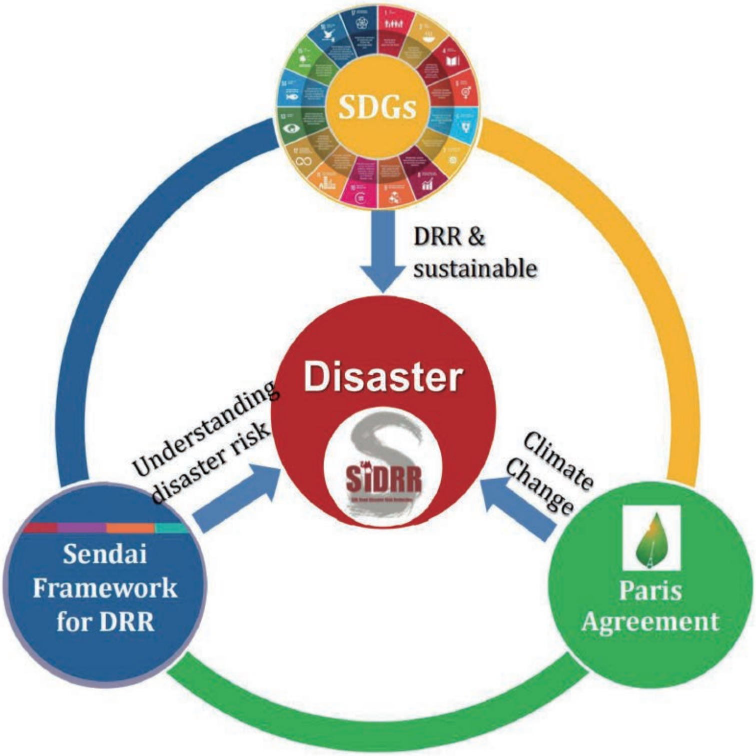
The Silk Road, which links four ancient civilizations, is a well-known ancient trade and cultural exchange route. The modern Silk Road, which inherits the spirit of the ancient Silk Road, encompassing a vast area with more than 140 countries and nearly 66% of the world's population (Cui et al., 2017; Lei et al., 2018). Due to the complex geological and geomorphological settings and an increasing number of extreme weathers under global warming, not only has the number of natural hazards reported in the Silk Road area been increasing year by year, they have also been steadily worsening (Figure 2-43). This trend poses considerable threats to the Silk Road countries and the livelihoods of their people (Cui et al., 2018; Lei et al., 2018). Furthermore,

Figure 2-43: **Trend of Disaster Events and Casualties in the Silk Road Area (data source: EM-DAT).**



40 https://repositorio.gestiondelriesgo.gov.co/handle/20.500.11762/27698

Figure 2-44: **SiDRR and international agreements.**



many countries in this area are developing countries, and this increasing occurrence of disasters could significantly hinder human safety and sustainable development. Indeed, statistics show that the average economic loss due to disasters (as measured against GDP) for the Silk Road countries was twice the world average, with the annual mortality risks in this area also much higher than that of the rest of the world (Lei et al., 2018).

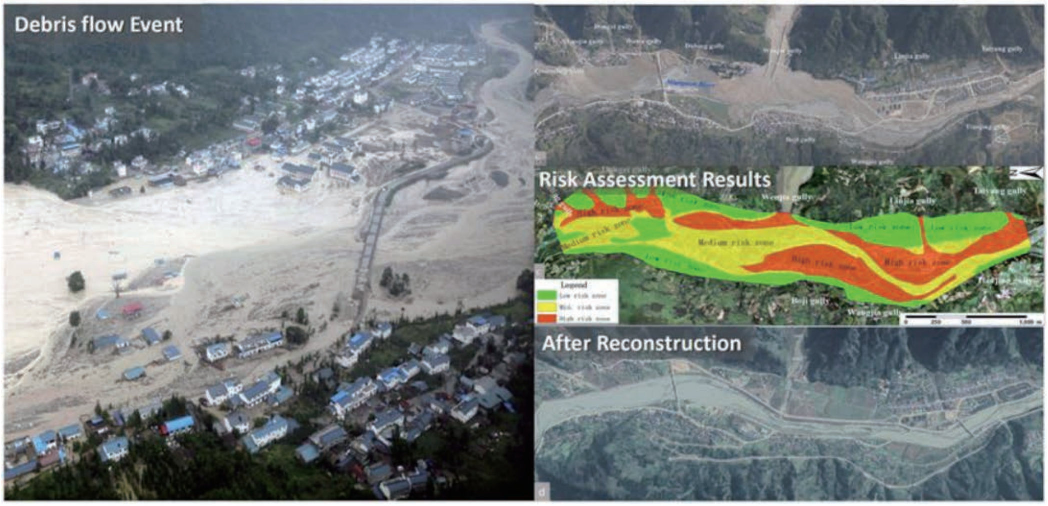
In line with the Sendai Framework and the UN's SDGs 2030 Agenda, the **Silk Road Disaster Risk Reduction (SiDRR)** was launched in 2016 as an international research program on disaster risk reduction (Lei et al., 2018), with the goal of enhancing global actions towards a greener and more resilient Silk Road by joining the forces of over 20 research institutes and scientists globally. Sharing the same vision of collaborative efforts towards disaster risk reduction as IRDR, SiDRR was selected as **IRDR's Flagship Project**.

A. Multi-scale disaster risk assessment for the Silk Road

To better understand disaster risks and obtain more robust support for risk-informed sustainable development in the Silk Road area, a disaster risk assessment of the entire Silk Road area is indispensable. SiDRR aims to provide scientific suggestions and support for decision-makers in the Silk Road area to minimize losses due to disasters during economic development. The program mainly assesses five types of disasters and their risks: 1) mass movements, 2) floods, 3) droughts, 4) earthquakes and 5) ocean disasters at four scales: 1) global, 2) regional, 3) local and 4) infrastructure-focused.

One application of the risk assessment is shown in Figure 2-44. A town in west China was struck by debris flow, with nearly half of the town destroyed. A local-scale risk assessment was implemented at the resolution of 1:10000 to identify the risk level. The risk map was subsequently used during reconstruction planning, with the town knowing to avoid putting accommodation or high-value facilities in the high-risk zone.

Figure 2-45: Risk assessment at the local scale to support the planning of reconstruction.



B. Atlas of Silk Road Disaster Risk and Glance at Silk Road Disaster Risk

As a next step to enhancing understanding of the disaster risks, SiDRR consolidated its research results by publishing the "Atlas of Silk Road Disaster Risk" in 2020. The Atlas consists of 158 maps that provide details on the environment and disaster characteristics, along with 19 disaster case studies, and disaster risk assessment results at various scales throughout the Silk Road area.

Along with this Atlas, SiDRR put forth the related report "Glance at Silk Road Disaster Risk", which presents a detailed explanation and description of the maps that have been presented in the Atlas, along with descriptions of the social dimensions of disasters from the perspectives of disaster risk management.

The Atlas and the report are set to create an important platform for scientists to share the latest researches in DRR. Meanwhile, as a bridge among different DRR stakeholders, these two publications will play an indispensable role in delivering better understanding of disasters and disaster risk and in aiding stakeholders make more scientific decisions in line with the Sendai Framework and SDGs. Through the efforts of SiDRR as well as all the stakeholders, it is possible to envision a safer and more resilient Silk Road in the near future.

Figure 2-46: **Drawing from the Atlas of Silk Road Disaster Risk.**

C. Development of early warning systems

SiDRR developed a "Marine Meteorological Disaster Prediction System" for Sri Lanka and its surrounding waters. The system provided a high-resolution short-term forecast for the surrounding waters of Sri Lanka and gave 72-hour weather and ocean (including temperature, air pressure, heavy rain, clouds, waves, and storm surges) forecast services. At the 45km scale, it can provide 15-day forecast results ranging from the western Indian Ocean to the South China Sea; at 15 km and 5 km scale, it can deliver the forecast results of 0-72 hours covering the north-central region of the eastern Indian Ocean and the whole of Sri Lanka and the surrounding region.

Since the system was brought online, the intensity and movement of tropical storms that have caused excessive damage to Sri Lanka have been predicted and tracked successfully. Now, in collaboration with Luhuana University, an MOU has been signed to further promote this system so that the data and information generated can be delivered to all stakeholders.

D. Establishment of the Alliance of International Science Organizations on Disaster Risk Reduction

After years of international scientific exchange and dialogues among different stakeholders, SiDRR launched the Alliance of International Science Organizations on Disaster Risk Reduction in 2019. This alliance quickly gained the approval of the Alliance of International Science Organizations (ANSO), which in the same year officially embraced the proposal and adopted the new Alliance (ANSO-DRR) under its framework on December 11, 2019, with Prof. Peng CU and Prof. Gretchen Kalonji appointed as co-Chairs for the first three years. It goes without saying that ANSO-DRR embraces the vision of the UN landmark framework agreements for sustainable development, including the SDGs, the Paris Agreement, and the Sendai Framework.

◆ Kuala Lumpur Multi-hazard Platform

IRDR ICoE-SEADPRI-UKM: The Kuala Lumpur Multi-hazard Platform is a key product of the project titled “Disaster Resilient Cities - Forecasting Local Level Climate Extremes and Physical Hazards for Kuala Lumpur”, supported by the Newton Ungku Omar Fund (Pereira, Pulhin, et al., 2019). Located at the City Hall of Kuala Lumpur, the Multi-hazard Platform is designed for managing and communicating risks and enhancing disaster resilience in Kuala Lumpur as the climate changes (Figure 2-47). The project, jointly led by Professor Joy Jacqueline Pereira of IRDR ICoE-SEADPRI-UKM and Lord Julian Hunt of the University of Cambridge, involved physical scientists, engineers, economists and social scientists and more, representing 16 entities from Malaysia and the United Kingdom. Project members worked closely with policy and decision-makers from the City Hall of Kuala Lumpur to co-generate the deliverables. The Multi-hazard Platform is now operational and provides forecasts of rainfall, temperature, wind, humidity, air quality levels at the street level for the Emergency Response Department. Capacity building is ongoing, with training for emergency respondents, land-use planners and development control officers to use the Platform to make informed decisions, improve planning and ensure better protection for the community from climate extremes.

Figure 2-47: The Kuala Lumpur Multi-hazard Platform, a product of the Newton Ungku Omar Fund project, is located in the City Hall of Kuala Lumpur (DBKL) to support emergency planning, land-use planning and development control. DBKL officers are being trained to use the Platform as part of their routine operations.

◆ Open access digital platform for data and information sharing

Over the decade, the assessments conducted by **IRDR ICoE-SEADPRI-UKM** has generated a plethora of data, some of which are restricted while others are open. Plans are underway for the next phase of operations, namely to develop a SEADPRI-Multi-hazard Platform, an open access digital platform with monitoring capability using crowd-sourced information. The purpose of the Platform is to enable communities to access information on hazards, vulnerability and exposure in their respective areas, so that they can make informed decisions on reducing their risk. This is particularly relevant as the world head towards global warming of 1.5 ℃ , where Southeast Asia is projected to be among the most vulnerable regions exposed to extreme events (IPCC, 2018). There is need to change the “business as usual” approach for disaster risk reduction and climate adaptation, where information on hazards and risks tend to be restricted in many parts of the region. An open access multi-hazard platform with crowd-sourcing capability will be a game changer in promoting transformative action to build community resilience as the climate changes. If widely implemented and sustained, this could contribute to address knowledge gaps on climate change in the region (Pereira & Hunt, 2019). IRDR ICoE-SEADPRI-UKM is collaborating with several parties including the previously mentioned Digital Belt and Road Program Disaster WG (DBAR-Disaster WG) in developing the digital platform. The IRDR guidelines for consistent data management will be followed, the means in which local assessments can serve global needs and vice-versa will be explored, and how data is managed to best develop the monitoring capacities of the open-access platform will be assessed. Such an open access monitoring platform will serve as an important legacy of the IRDR Programme in the region.

◆ Innovative programs related to earthquakes in the IRDR ICoE NSET

In the next sections, the main achievements of **IRDR ICoE-NSET** are discussed, including research, training, awareness, and DRR implementation including earthquake reconstruction.

A. Building Code Implementation Program (BCIPN) and Earthquake Reconstruction program Baliyo Ghar

This program involves providing technical assistance to about 50 main municipalities and more than 50,000 households in three severely damaged districts of Nepal. Enhancing awareness, building and institutionalizing capacity and policy improvement for effective implementation of the national building code and seismic retrofitting programs. The outcomes are very encouraging – the level of code compliance in new building construction has shot from a meagre 15% to over 80 % in the past six years, and more than 90% of the damaged building are reconstructed up to code. Thanks to such experience, NSET is now able to work with the central, district and local level authorities in other areas of Nepal, both rural and urban, a trusted agency in providing such technical assistance.

B. School Disaster Safety Program

NSET started a successful program for school earthquake safety enhancement way back in 1999. Since then, the program has been extended to ensuring safety of school buildings and system against a variety of natural hazards, which is combined with the establishment of a system of disaster education, disaster drills and safer and environment-friendly and inclusive physical infrastructure improvements. Funding from DFID-UK Aid has further enabled the building of a state-of-the-art earthquake-resistant school building for demonstration purposes under the Nepal Safer Schools Project (NSSP).

C. Community Based Risk Management (CBDRM)

Localization of DRR has been the centrepoint of NSET's approach linking science, technology and national and global policy frameworks such as SFDRR and SDG goals. Almost all of NSET activities target local, ground-level realities. To give but one example, NSET implements several Community Based Disaster Risk Management (CBDRM) programs. Such programs contain the following: Awareness & Education on local hazards, risks, resources, capacities and traditional wisdom, self-help and mutual help; Institutional Development & Capacity Building for Disaster Risk Reduction and Preparedness; Sample Demonstration/Pilot Project on DRR; Networking Coupled with Gender Equality and Social Inclusion (GESI) and Sustainability considerations.

D. Shaketable Demonstration and Landslide Demonstrator

NSET's simplified Shaketable demonstration is a highly effective awareness tool used for demonstrating and convincing people on the effectiveness of earthquake-resistant construction practices. Following the principle of "Seeing is Believing", NSET successfully organized more than 100 broadcasts of its demonstrations in more than 10 countries of Asia including in Japan during the UN World Conference on DRR in 2015 (Figure 2-48). Currently, NSET is collaborating with the Institute of Hazard, Risk and Resilience of Durham University in developing a similar demonstration for landslide processes and prevention (Figure 2-49) under the project "Live Demonstrations for Landslide Risk Reduction", which is also part of the on-going PhD research of Mr. Gopi Basyal (Basyal, 2018).

Figure 2-48: Shake-table demonstration set up of NSET (Source: NSET, Safer Society Report 2018).

Figure 2-49: Landslide Demonstrator helped people to understand the process of slope movement in their localities, thereby enhancing their involvement in decision making for environmental protection (left photo: 3D model of hillslope with shear failure; Right photo: same terrain after rainfall. Image credit: Bijay Krishna Upadhyay, NSET, Nepal).

E. Research in indigenous building technology with low-strength masonry

A research project titled "Development, testing, demonstration and training of better-built procedures and retrofit techniques for non-engineered housing in urban and peri-urban areas of the Himalayan belt" yielded much needed evidence for the Gorkha earthquake reconstruction in Nepal. The research was conducted in collaboration with the International Center for Collaborative Research on Disaster Risk Reduction ICCR-DRR of Beijing Normal University (BNU) (NSET, 2017). The testing facilities of the laboratories in Beijing Normal University and Kunming University of Science and Technology (KUST) were used for experimental tests on stone masonry buildings to identify the optimal intervention for improving seismic performance of vernacular buildings damaged by the Gorkha earthquake (Figure 2-50).

Figure 2-50: Set-up of house (stone, mud, with wood bands) being tested at Lab of Beijing Normal University. IRDR ICoE-NSET was one of the major collaborators. (Source: NSET (2017)).

◆ Integrated Research after Christchurch Earthquake

The Christchurch earthquake in February 2011 was a turning point for researchers and policy makers, overcoming the great challenges in gathering the data and expert opinion, and providing the advice necessary to the public and decision-makers. Christchurch also made clear the importance of the pre-existing fault network geometry, the role of earthquake stress triggering, and the influence of crust rheology, which all played important roles as the Canterbury earthquake sequence unfolded. The lessons from Christchurch were put to good use following the 2016 Kaikōura Earthquake.

The extended Canterbury earthquake sequence provided scientists with a wealth of knowledge about rock fall, cliff collapse, and landslides, enabling researchers to develop a comprehensive picture of landslide hazards. Laboratory studies by **IRDR NC-New Zealand** to characterize the properties of the rocks and soils involved in the landslides in particular helped researchers better understand how these materials responded to triggering events. Data collected from repeat surveys of cliffs in the Sumner and Red Cliffs area using a terrestrial laser scanner revealed that the amount of material shed by the cliffs was directly related to the strength of shaking, material type and slope geometry. Numerical modelling of slope behaviour and detailed slope models built from the survey data help provide insights into potential future behaviour and help identify areas of future vulnerability. Finally, extensive risk analyses were made to prepare detailed maps of life-safety risks. These maps were used as the basis for declaring 400 residential properties unfit for habitation. The life-safety risks were deemed unacceptable (the properties were 'red-zoned'), and the life-safety risk maps were subsequently used to update Christchurch City Council's District Plan (Dellow & Massey, 2018).

The CERA Wellbeing Index and Survey[41] which is funded by the NHRP Canterbury earthquake recovery program focus on the questions of understanding recovery needs over time and how to best design interventions to increase wellbeing. In 2014, the New Zealand government allocated an additional $13.5 million for psychosocial services as a result of on-going need identified by the Survey, with similar provision of services following the Cook Strait and Kaikōura earthquakes (Morgan et al., 2015). The Canterbury Wellbeing Index and Survey is a global leader in post-disaster recovery indicators, and has contributed greatly to global knowledge of recovery. Though CERA has been disestablished, the survey is still in operation, now under the Canterbury District Health Board.

The Canterbury earthquakes also highlighted the pivotal role provided by Iwi and Maori stakeholders in recovery efforts. Maori in particular were key participants, for example working at recovery assistance centers where food and shelter were provided for those in need. Lessons from the earthquakes are highly relevant for regional and emergency management planning across New Zealand (Kenney & Phibbs, 2015). New Zealand research teams have also studied the actions of people during and after earthquakes, which often affect their risk of injury or death, as well as interactions and crowd behavior (e.g., how the actions/inactions of an individual influence the actions/inactions of another) (Lambie et al., 2017).

Figure 2-51: Dislodged boulders near the RSA clubrooms following the Feb 2011 Christchurch earthquake. Photo: Margaret Low, GNS Science.

41 https://www.cph.co.nz/your-health/wellbeing-survey/

◆ Northern Tornadoes Project (NTP)

The ICLR, which hosts **IRDR ICoE-DRHBPI**, encourages trans-disciplinary analysis to understand the vulnerability of buildings, infrastructure and systems to damage. Evidence indicates that, compared to the extensive engineering information available for the construction of buildings and other public infrastructure, there is a large knowledge gap regarding best practices in the design and construction of private homes. Working with experts on wind engineering from Western and other universities and groups, in particular the Boundary Layer Wind Tunnel Laboratory (BLWT)/Alan Davenport Wind Engineering Group (pioneers in the field of wind tunnel testing and analysis and with extensive experience working on building projects, providing solutions to planners, architects and engineers all round the world), ICLR seeks to remedy this gap.

The Wind Engineering, Energy and Environment Research Institute (WindEEE RI), established in 2011, provides novel opportunities in wind research with the world's first three-dimensional testing chamber, the WindEEE Dome, which promotes innovative research and extensive collaborations nationally and internationally. With such resources, ICLR's started the Northern Tornadoes Project (NTP) to better detect tornado occurrence throughout Canada, improve severe and extreme weather prediction, mitigate against damage to people and property and investigate future implications due to climate change. Combined with other ICLR projects in other disciplines, IRDR ICoE-DRHBPI is able to provide comprehensive research on matters regarding homes, buildings and infrastructure. ICLR projects include economic analyses (Porter & Scawthorn, 2020; Simmons & Kovacs, 2018) and wind safety for homes (D. Sandink et al., 2019). Finally, the latest Strategic Plan (2017-2021) having raised additional behavioural questions (such as: Why do some property owners take better care to maintain their homes and invest in protection measures like backwater values? Why do some community leaders actively champion disaster risk reduction, including implementation of a storm water master plan?), additional investigations need to be conducted. Some initial work on these behavioural questions is included in the ICLR Cities Adapt series of reports (which provide case studies of successful local leadership), but more work is needed.

◆ Japan Academic Network for Disaster Reduction (JANET-DR)

The Sendai Framework provides an opportunity to strategically promote the value of interdisciplinary/transdisciplinary research and collaboration in academic and scientific arenas, especially IRDR. Already, interdisciplinary scientific cooperation at national level has shown encouraging development, signaled for example by the experience of Japan through the Japan Academic Network for Disaster Reduction (JANET-DR[42]), the efforts of **IRDR NC-Japan**, as well as numerous other initiatives.

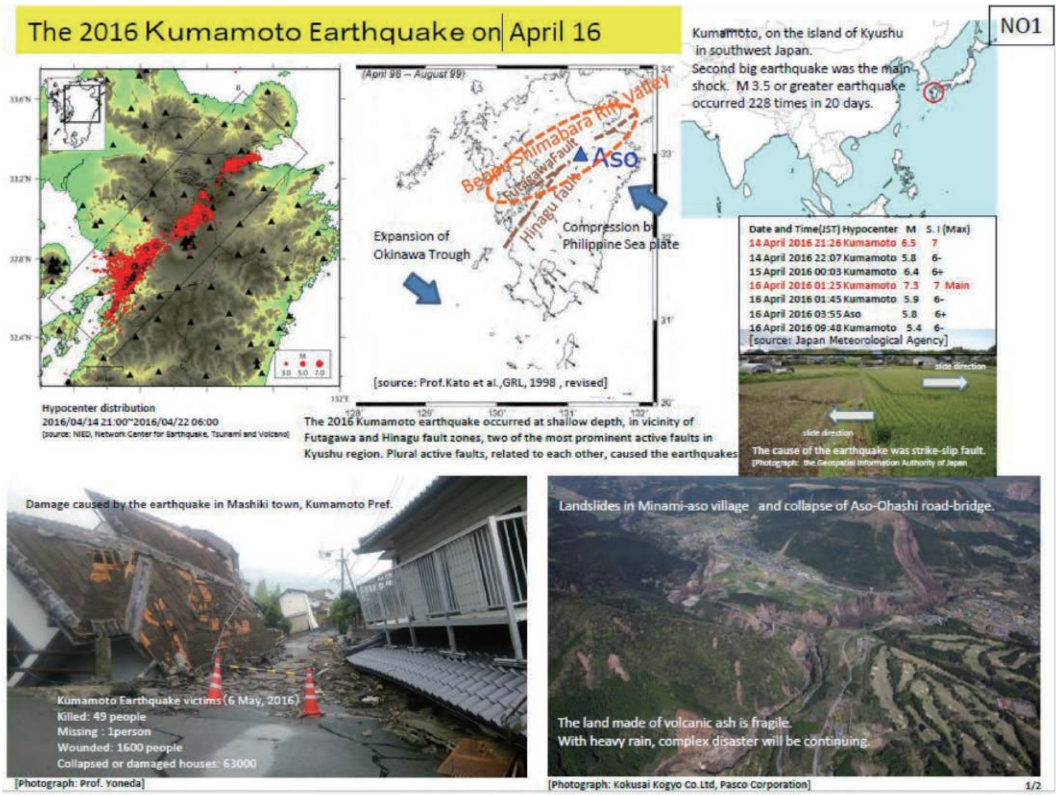
In the academic world, trends have been towards increasing specialization, with integration weakened as a result. To mitigate against such a trend, members of the Science Council of Japan (SCJ) and 47 academic societies (later 55) established JANET-DR which covers social sciences, life sciences, natural sciences and engineering. JANET-DR works well for promoting interdisciplinary collaboration and social implementation of research, as shown for example by the 2016 Kumamoto earthquake. JANET-DR further suggest collaboration and connection to the academic association "Transdisciplinary Federation of Science and Technology", a leading association for integration of specialties, which is expected to contribute disaster reduction. This later association aims to collaborate across academies and make efforts to integrate different specialties for disaster reduction. The two sources organize many lectures and discussions, with the main conclusions as to needed actions

42 https://janet-dr.com/

summarized below:

1. Understanding and even predicting the further development of the present activities of the active faults. In particular, finding how the series of earthquakes will affect other active faults or subduction-zones is what the society wants to know.
2. Understanding the expansion of landslide in mountainous areas where landslides took place due to earthquakes.
3. Understanding how the continuous two peaks of large-scale shocks affect the destruction of man-made structures.
4. Considering how we can reduce the people's anxieties or fears caused by the earthquakes.
5. Considering how we can propagate practical disaster-reduction measures, as the Kumamoto earthquake is likely to occur anywhere in Japan.
6. Considering how we can accelerate recovery and reconstruction making use of the past experience of disasters such as effective measures in loss of power, in evacuation centre management, and so on.
7. Strongly recommending retrofitting old buildings and housing that do not have the seismic capacity to withstand earthquakes

Figure 2-52: The 2016 Kumamoto Earthquake on April 2016.



◆ Early Warning for Drought in Colombia

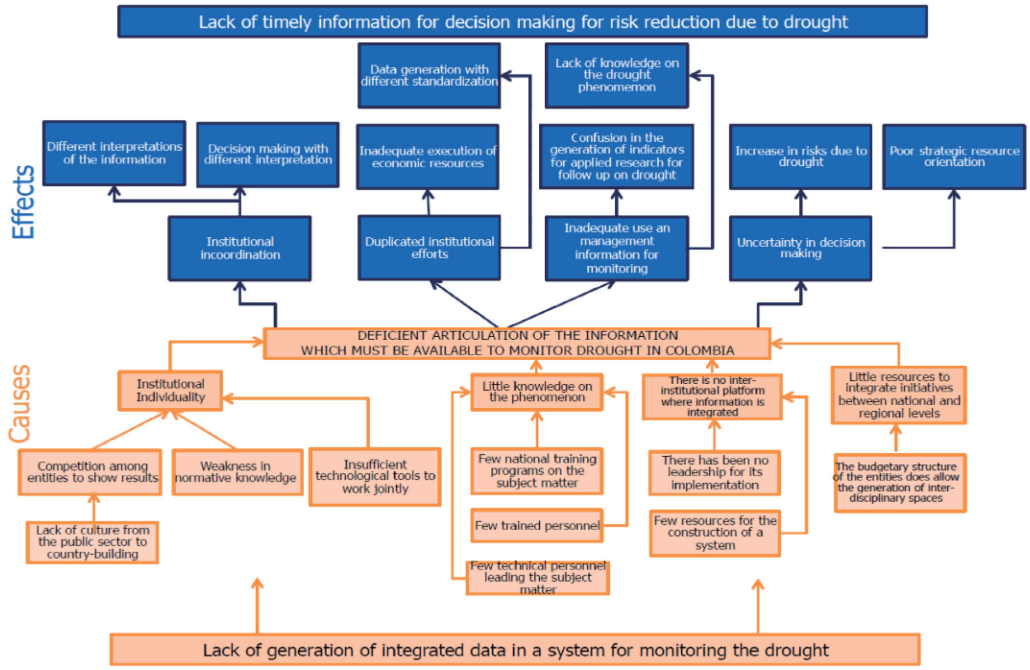
Climate prediction and climate variability in Colombia became a central theme in the government agenda. Lessons learned from past events of the El Niño-La Niña Southern Oscillation (ENSO) have shown the path to research the influence of this phenomena in Colombia. While El Niño reduces rainfall, especially in the Caribbean, Andean, and Pacific regions, La Niña increases rainfall.

Several questions arise when referring to a seasonal drought outlook for and appropriate and timely decision-making in agriculture and water resources. Perhaps a critical decision is how to use this information locally to reduce the risk of a disaster when applied. Fortunately, there is more access to information nowadays, with statistical and dynamic climate models from national, regional and global climate centers that have been adjusted to Colombia's conditions and parameterized for a better performance.

In this context, **IRDR NC-Colombia** implemented two pilot projects named "Early Warning for drought in Colombia: Strategies for seasonal drought perspectives to make appropriate and timely decisions in the field of agriculture and water resources", and named "Early warning for drought in Colombia: A reflection from institutional experiences: analysis of identification of problems and solutions to share information among different levels-national and regional." [43]

Publications of the first project emphasized the decrease in rainfall associated with the El Niño phenomenon. It approaches economic sectors with the health and water sector to propose strategies that optimize the seasonal climate

Figure 2-53: Problem tree of the information coordination for the monitoring of drought in Colombia.



43 https://repositorio.gestiondelriesgo.gov.co/handle/20.500.11762/26439

prediction, integrating information and products from national and international organizations as part of the process of the Drought Alert System. The second project identifies problems with their causes and effects and defines objectives for exploring solutions that lead to better climate predictions of the areas with rainfall deficits and previously report them.

Theme 3: Assessment, data management and monitoring

In order to determine the consequences of environmental hazards and disasters in terms of their impacts and effects, one needs baseline monitoring (including both long-term ground-based and remote-sense monitoring), pre-determined methodologies for data presentation, and identification of the gaps in our ability to rapidly provide this information to the disaster managers. This include actions undertaken in furtherance of Goal 2 (characterisation of hazards, vulnerability and risk) in IRDR's Strategic Plan. Key questions that are tried to be addressed under this objective are list as below. NCs and ICoEs from Africa, America (Canada), Asia (China, Japan, Pakistan and Republic of Korea) and Oceania (New Zealand) and the WG on Disaster Loss Data (DATA) project, contributed greatly under this objective.

Key questions:

- To develop a consistent procedure to assess different natural hazards proceeding from the probability of their occurrence and recurrence and using statistical, deterministic and combined approaches.
- To develop a commonly adopted system of hazards parameterization that can be applied across different hazards types. This would permit an estimation of the hazard energy (destructive force) as well as the affected area and the impact duration in a single measurement system.
- To develop a consistent procedure of building maps of separate and combined hazards at different temporal and spatial scales: global, regional, national, community and local levels.

In these institutions, they brought together loss data stakeholders in order to build a network of networks to reflect the data requirements in the Sendai Framework and take advantage of synergies between other global agreements. And they designed and developed consistent models, systems and tools for disasters assessment and management. Moreover, they endeavored to make the well-planned monitoring systems at all levels from global to local scales.

T3.1 Guidelines for consistent data management and assessments of hazards, risk and disasters

◆ Disaster Loss Data

The **Disaster Loss Data (DATA) WG** brings together loss data stakeholders in order to build a "network of networks" to reflect the data requirements in the Sendai Framework and take advantage of synergies between other global agreements such as the SDGs, the Paris Climate Agreement, and the Habitat III New Urban Agenda. Data infrastructure for disaster research connects disaster-related datasets of observations, analyses and statistics, minimum data standards, and data-sharing plans. Hence IRDR's DATA is designed to support information dissemination, networking and collaboration with a growing network of stakeholders from different disciplines and sectors to study issues related to the collection, storage and dissemination of disaster loss data. The WG links emerging research programs, and develops collaboration models through social media and citizen participation. The WG aims to be a reference point for sharing disaster loss news, proposals, results, and ideas; to identify the quality of existing data and what data are needed to improve disaster risk management; and to develop recognized standards or protocols to reduce uncertainty in the data.

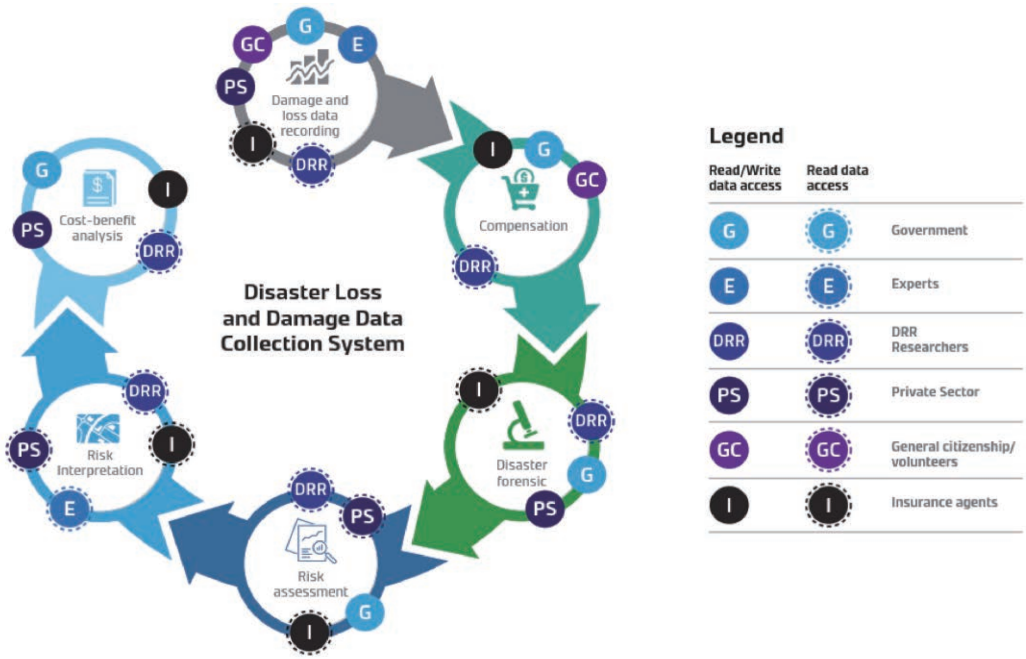
The DATA project has identified the following specific project objectives:

1. Bring together loss data stakeholders and develop and utilise synergies.
2. Identify the quality of existing data and what data are needed to improve disaster risk management.
3. Develop recognised standards or protocols to reduce uncertainty in the data.
4. Define "losses" and create transparent methodologies for assessing them.
5. Advocate an increased downscaling of loss data to sub-national geographical levels for policy makers.
6. Educate users regarding data interpretation and data biases.

A. Standard data collection system

Among the desired outcomes for the project are the production of unified standards on disaster loss assessment and an integrated methodology for disaster loss assessment. The value of standardized data is key to achieving loss estimation, risk assessment, and ultimately cost-benefit analyses for hazards. Only recently has there been a growing understanding of the importance of disaster risk reduction (DRR) and disaster loss databases as a necessary component for effective DRR. This project proposed a standard data collection system (Figure 2-54), which has since been adopted by many countries.

Figure 2-54: **Disaster loss and damage data collection system (Fakhruddin et al. 2019).**



The Sendai Framework for Disaster Risk Reduction 2015-2030 (Sendai Framework), endorsed by the United Nations (UN) General Assembly and adopted by UN member states, was the first major agreement of the post 2015 development agenda, which sets four priorities and seven targets for action covering global, national and local level disaster risk reduction. Three other UN landmark agreements linking directly to the health aspects within the Sendai Framework were made in 2015 and 2016 and include the SDGs, the Paris Climate Agreement and the Habit III New Urban Agenda. These frameworks, and in particular the Sendai Framework, provide a method to build research outputs, to enhance capabilities and decision-making to plan and prepare for, respond to and recover from natural hazards and other emergencies. Risk knowledge is vital in developing robust, effective policies and practices for disaster management.

Figure 2-55: Peril classification at the Family and Main Events levels.

Consequently, the Sendai Framework adopted 'Understanding disaster risk' as its first priority for action. Disaster loss data is fundamental for accurate risk assessments and can be critical in providing baseline for calibration and validation of results using verifiable information. The UN endorsement of the Sendai Framework reinforces the increasingly vital importance of amassing for disaster loss data in a usable format. National Loss Databases are crucial for producing and acting upon risk information that, in turn, advances appropriate policy making and governance. They also serve as the underlying mechanisms in assisting reporting on the Sendai Framework and any progress on reducing disaster losses and improving disaster risk management (Fakhruddin et al., 2017).

When considering the disaster data landscape and its complexities, and with the increasing amounts of loss data, data standardization is now of foremost importance. Across nations, information on the social, environmental, physical and economic losses caused by natural hazards or technical emergencies is collected and stored by various organisations as part of their response functions, thus managing data related their individual needs and interest and developing their own standards and procedures, without significant collaboration across sectors. This negatively impacts the thoroughness and accuracy of the data across nations and results in inconsistent overlaps, and bias that ultimately affect the quality of research conducted and policies made based on the data. For a comprehensive assessment of social, temporal, and spatial disaggregated impact data, disaster archives and collections of loss data should be standardized and combined.

B. Peril Classification and Hazard Glossary

In 2014, DATA WG produced a Peril Classification and Hazard Glossary. This glossary provides guidelines on event classification and a unified terminology for operating loss databases (IRDR, 2014). Though not intended as a comprehensive list of perils or as a conclusive definitional standard of hazards, this technical paper details the classification scheme (Figure 2-55) and hazard definitions used in loss database, and provides information that has been implemented over time by global databases such UN DesInventar, EM-DAT, NatCatService, and Sigma as well as in national databases such as SHELDUS (US).

The IRDR ICoE-VaRM supported the IRDR DATA project (2012-2016) as the founding leader of the project. The primary accomplishment of this initial effort was a reconciliation of peril classifications for hazards that was adopted by the majority of loss and damage global databases including MunichRe, EM-DAT, DesInventar (IRDR, 2014) and the development of potential guidelines for recording human and economic impact indicators (IRDR, 2015). DATA has now expanded and progressed to focus on the next generation of disaster data infrastructure to support not only the Sendai Framework but also the SDGs, the Paris Climate Agreement, and the Habitat III New Urban Agenda. Signature publications arising from IRDR ICoE-VaRM researchers on geospatial disaster loss and data include Cutter and Gall (2015); Gall (2015); Gall and Cutter (2016); Gall, Emrich, et al. (2014).

C. Disaster Loss Databases

Numerous loss and damage databases have been developed over the last several decades, and they collect and maintain data at a global, regional, and national level. Many countries are now realising the potential value of a standardized loss data collection system, which would allow them to acquire better information about the economic, ecological and social cost of disasters and to more rigorously collect data to inform future policy, practice and investment. To do this well, a multi-agency, multi-sectoral approach needs to be adopted to capture prior experience and the full range of relevant data. Accordingly, databases, including both those hosted by governmental institutions and by research institutions, universities, or NGOs, are often implemented through international support including the support of IRDR or the UN. For example, The United Nations Office for Disaster Risk Reduction (UNDRR), in partnership with United Nations Development Programme (UNDP), has supported many countries in building and updating disaster loss databases. This includes providing funding for both technical matters, as well as institutional support. DesInventar, for example, a software by La Red (a NGO consortium in Latin America), is used by nearly 90 countries, provides a systematic approach for data collection, documentation and analysis of data losses caused by disasters. Countries are using this platform to encourage consistency for data collection and reporting for the Sendai Framework. This software was developed by La Red, an NGO consortium in Latin America. Numerous platforms such as this one are now being used by countries to record and store loss and impact data from past events.

D. Applications of DATA disaster loss databases

Table 2-15 below highlights two in-depth case studies of successful implementation of disaster loss databases. Table 2-16, which follows, provides a list of other disaster loss database projects developed from the IRDR and UNDP projects. Additional countries that have implemented disaster loss databases in some way include: Cambodia, Nepal, Iran, Timor-Leste, Vietnam, Myanmar, Philippines and Pakistan.

Table 2-15. Two case studies of implementation of disaster loss databases

Case studies	
New Zealand National Loss Database	The Pacific Damage and Loss (PDaLo) Information System
In New Zealand, information on the social, physical and economic losses caused by natural hazards or technical emergencies is collected by various agencies as part of their response functions. The National Emergency Management Agency initiated the development of the first National Disaster Loss Database for New Zealand in 2018. The aim of this database was to provide a single-source location resource, suitable for display and extraction to support planning, decision-making, risk modelling and international on the Sendai Framework reporting requirements, and which would serve as a resource for interested agencies to understand and manage hazard risk. The current database contains information on impacts to people, buildings, infrastructure, primary industries and direct economic losses aggregated to the regional level for significant hazard events from the year 2015 – 2018. Funding has been provided to continue the further complement the database by further backdating and adding significant hazard events that took place from 2005 to 2015.	The Pacific Island are vulnerable to many natural hazards including tropical cyclones, earthquake, tsunami, storm surges etc. The PDaLo was established to provide information on damage and loss for disasters to support national planning and DRR related investment decisions. The PDaLo holds information on 1,183 hazardous events that have occurred and severely impacted the Pacific region between 1567 – 2013, which lead to a total loss of over $3.3 billion USD. The information system provides access to regional disaster data for the Pacific region and enables the monitoring, analysing and dissemination of information on key hazards and vulnerabilities. The database uses the DesInventar methodology to develop an inventory to have a common set of basic variables to measure that effects across nations. Government and agencies are looking at continuing these efforts towards maintain and updating the PDaLo in the future (SPC SOPAC, 2013).

Table 2-16. Disaster loss database projects in other countries

Case studies	
Country	**Loss database description**
Sri Lanka	Sri Lanka has one of the most advanced disaster loss databases, which contains records of disasters from the past 30 years. The database is available online and institutionalised in relevant government offices. It is mainly used by the Disaster Management Centre with continued commitments to collect and validate data. The database is used to inform risk analysis as well as assisting with the development of National Disaster Management Plans and policies.
Indonesia	The database was launched in July 2008 and has rapidly been adopted for use in guiding the ongoing processes of developing a National Disaster Risk Management Plan and for monitoring the impact of crisis to poverty at the community level.
Thailand	The purpose of Thailand's loss database is to utilize stored information to support better informed decision-making for relevant DRR related policy and strategies. The Department of Disaster Mitigation and Prevention, who 'houses' the disaster loss database has also developed a GIS system, similar to DesInventar, for capturing information about disasters and losses.
Maldives	The adoption of the National Post-Disaster Assessment Framework in 2015 enabled the Maldives National Disaster Management Centre to collect, verify and record data in post-emergency phases to understand the impacts on the country. The DesInventar platform is currently utilized as the main data management tool. However, due to institutional restricting, high staff turnover, and inadequate staff capacity, the database remains incomplete.
India	India has undertaken the establishment of a National Disaster Management Information System (NDMIS), an integrated disaster loss database aligned with the Sendai Framework. This database has the capability to track disaster damages and losses, revealing patterns of exposure and vulnerable hotspots. Implementation remains incomplete however, with states such as Uttar Pradesh, Orissa and Uttaranchal requesting support in developing their portions of the system, which is similar to DesInventar.

E. Lessons learnt from the Disaster Loss Data project

Establishing a comprehensive, national standardized loss database and management system is a highly complex endeavor due to its multi-sectoral, multi-layered requirements across the public and private sectors. The value of such systems is now well-proven however, and the ability to compare impacts and loss on a global scale worth the effort. Valuable lessons were learned from the implementation of disaster loss databases listed above, including the following:

1. Loss databases can be used as a central tool for governments, private sector actors, universities, and NGOs to better understand the impacts of past events in order to effectively mitigate and prepare for future events. Appropriate standardised disaster loss data quantification can identify gaps in risk assessment and improve disaster risk information, which can provide common guidelines on methods of hazard, exposure, and vulnerability assessments
2. Inconsistent standards and disaster data formats are key challenges to collecting and using data effectively and efficiently. The sharing of data resources in networked cooperation is becoming standard practice, particularly among more economically developed countries. The need for systematic data for disaster mitigation and prevention has been an increasing concern of both development and response agencies.
3. Data interoperability is essential to reduce duplications of data. Within the UN system there are several data collection system practices in addition to DesInventar (e.g. KoBo) and Rapid Pro. These need to be interoperable to effectively monitor the implementation of the Sendai Framework.
4. Consistent resource mobilisation for improvement of data collection, recording, and reporting at all levels should remain a key concern. Further investment in building local and regional data collection capacity and supporting IT infrastructure maybe be required for further improvements. Support should also be given to strengthen government systems and capacity-building through technical advice, specialist training and professional development. This is essential to ensure a continued, effective, and coordinated process towards successful implementation of disaster loss databases and disaster risk reduction.
5. The organisation of data ownership is heterogeneous between different countries. The different focal points responsible for reporting might not be the owners of disaster-related data. The process of disaster loss database development and implementation needs to be participatory and inclusive, involving any intra-government agencies, academic, private sectors and NGOs which may be responsible for part of the data collection. This provides the opportunity to improve partnerships and engagement across sectors to ultimately improve data reporting.
6. Challenges remain in converting disaster data into useful and useable form to provide informed evidence-based DRR policy and practice.
7. There is a need to provide support in customising the standardized database to meet the needs of individual countries, to ensure that such are in compliance with and complement existing government systems and requirements.

◆ Flood mapping and the Intensity-Duration-Frequency Curves under Climate Change tool

IRDR ICoE-DRHBPI: The recent ICLR study examining flood-mapping in Canada is a good example in addressing the IRDR Cross-Cutting Themes. Firstly, a science-based report for public use on flood mapping in Canada was produced, addressing the basic key issues (such as what flood maps are; how do they address inundation, hazards, risks and community awareness and why they are important and their availability in Canada (Institute for Catastrophic Loss Reduction, 2019)).

Flooding is the dominant, in terms of numbers, hazard event in Canada, and ICLR is working with research and engineering labs through an ICLR/University of Guelph/Western University research partnership. One project focused on lot-level flood protection (Kesik, 2015). Another project led to the development of the Intensity-Duration-Frequency Curves under Climate Change (IDFCC) tool of Professor S. Simonovic (Western and ICLR) (Simonovic, 2020). The IDFCC has become one of the primary sources of climate change data regarding management of extreme rainfall events in Canada, providing key information for water management professionals interested in understanding potential impacts of climate change on local extreme rainfall regimes. Related aspects are the social vulnerabilities of communities as studied by Oulahen et al. (2018), examining how multiple interacting exposures and unequal vulnerability in coastal communities lead to the production of risks. In the developing world, the issues become more complex and disastrous, such as impacts and adaptation constraints in slum communities in Nigeria (Ajibade & McBean, 2014).

◆ Landslide Dataset for Forecasting Models

The lessons from Christchurch were put to good use following the 2016 Kaikōura Earthquake. A landslide dataset made by **IRDR NC-New Zealand**, containing nearly 30,000 individual landslides, was compiled using high-resolution aerial photography, LiDAR and oblique aerial photography. Research related to the Kaikōura landslide has been used to develop new earthquake-induced landslide forecasting models using new methods not available during the Canterbury earthquake sequence, including artificial intelligence statistical techniques.

The landslide datasets also include rainfall-induced landslides, which occur frequently. The arrival of ex-tropical cyclones to the vulnerable Kaikōura region for example, resulted in remobilization of landslide debris and failure of cracked ground, causing ongoing hazards and risk to local residents. The ability to forecast rainfall-induced landslides is critical to understanding how changes in climate will impact our landscapes. The consequent increase in hazards is likely to result in much greater risks from landslides until we are managing those risks well (Dellow & Massey, 2018).

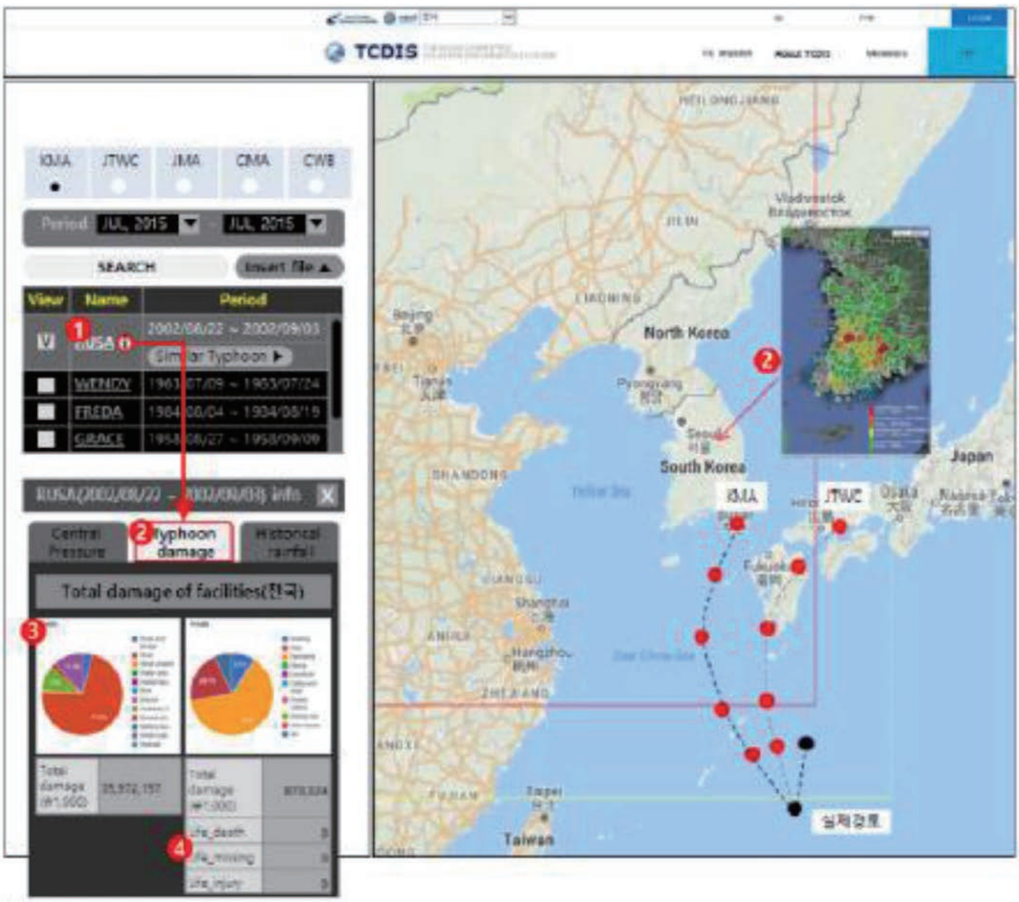
◆ Typhoon Disaster Information System (TCDIS)

During the 38th session of the Typhoon Committee (TC) in 2005, the members of WGDRR agreed to establish an efficient data sharing tool of various tropical cyclones disasters for the TC members. Therefore, WGDRR implemented its first project and established the 'Typhoon Disaster Information System (TCDIS[44]) website in 2006. Since then, NDMI, which is host to **IRDR NC-Republic of Korea**, has been designing and creating a Web-GIS based TCDIS containing disaster management systems for typhoon-related disasters. The objectives of the WEB-GIS based TCDIS are:

1. To develop understandings of typhoon phenomena and its impact on natural and social environment
2. To strengthen international cooperation and share information on disaster management
3. To provide a comprehensive and integrated disaster information system
4. To improve typhoon-trajectory prediction model with low-cost input
5. To collect historical climate and disaster data for to predict potential disasters
6. To provide disaster response information provided by members through the disaster recovery tool
7. To compare the new prediction model with other hydrological models
8. To establish a more accurate typhoon trajectory prediction model through collection of additional data from disaster reports.

44 www.tcdis.org

Figure 2-56: **Analysis Result of Historical Similar Typhoon.**



◆ Advanced technologies for DRR

Many countries have their own earth observation satellites, such as Landsat from the USA, Sentinels from Europe. China's earth observation data include meteorological satellites (FY series), resource satellites (CBERS series, ZY series), ocean satellites (HY series), environment and disaster reduction satellites (HJ series), high-resolution satellites (GF series) and Beidou navigation and positioning satellites. **IRDR NC-China** has conducted collaborative research to developed effective methods, models, and technologies for quick response to disasters.

1. In the 2013 Bushfire in New South Wales, Australia, NC-China carried out remote sensing monitoring and evaluation on the fires, and made preliminary interpretation and assessment on the fire sites, spreading areas, and developing trends for the surrounding areas of Sydney. The quality and timeliness of the fire monitoring products were highly praised by the Australian Ambassador to China.

2. On April 25 2015, Nepal was hit by an 8.1-Richter magnitude earthquake. Immediately after it occurred, NC-China organized science & research personnel to monitor the

earthquake and used it space technology and platform for disaster reduction to analyse the damages caused by the earthquake without delay. The satellite remote sensing data and scientific analysis for the earthquake-hit area was then shared with the International Centre for Integrated Mountain Development (ICIMOD) of Nepal upon its request.

Figure 2-57: **Bush fire in New South Wales, Australia.**

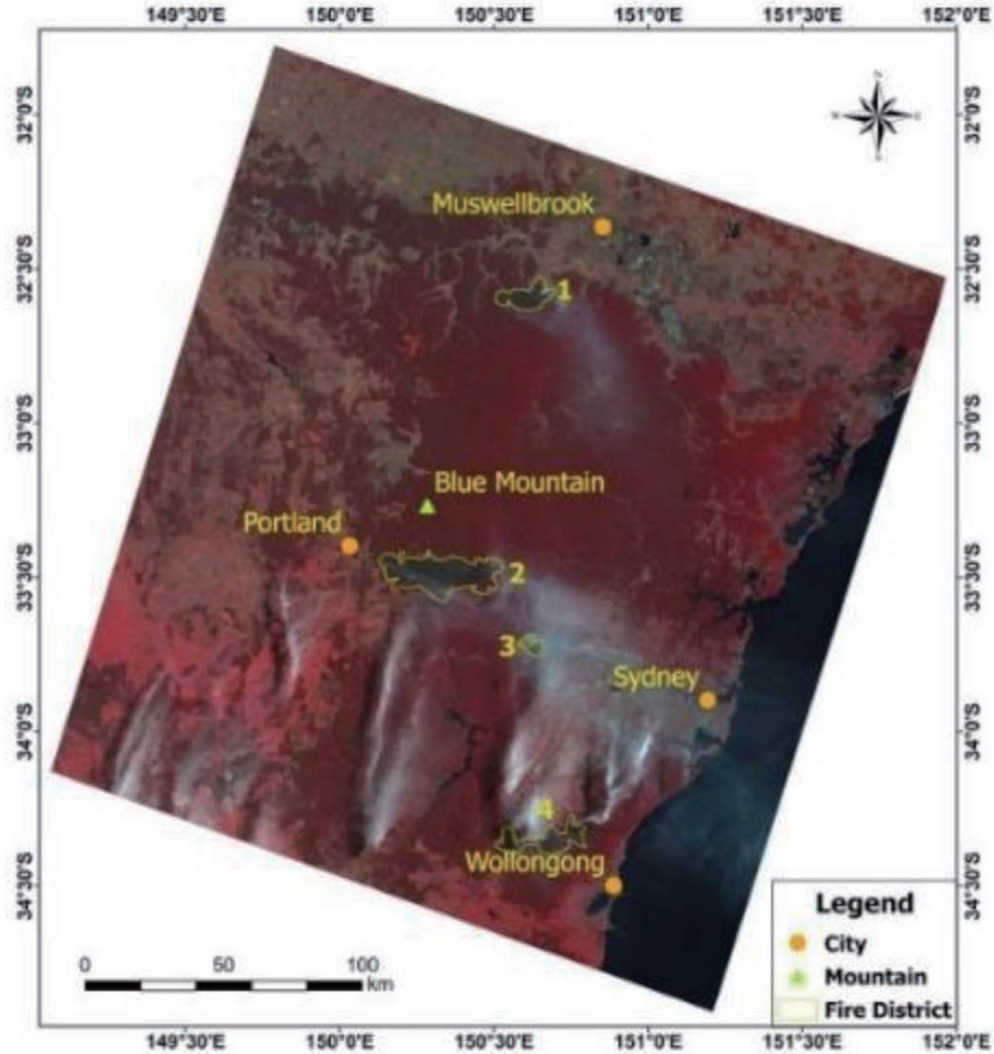


Figure 2-58: **GF images of Kal Mochan Temple in Kathmandu during 2015 Nepal Earthquake (Image from RADI, CAS).**

(a) 2015.4.11 before earthquake

(b) 2015.4.27 after earthquake

◆ National Periodic Synthesis Reports System

Why do we need synthesis reports? The Sendai Framework's Priority 1 highlights that policies and practices for DRM should be based on an understanding of disaster risk in all its dimensions. It also strongly stresses the leveraging of such knowledge for the purpose of pre-disaster risk assessment, for prevention and mitigation, and for the development and implementation of appropriate preparedness and effective response measures to disasters.

What are the periodic synthesis reports? In response to Priority 1 the periodic synthesis reports are reports aimed at bridging the gaps between science, policy and community. It provides reviews of scientific solutions as well as their practical applications in various areas of DRM. Specifically, the reviews are summaries of the recent advances or outcomes of scientific and technological research activities in relevant fields (at global, regional and national levels). The process of preparing such reports both requires and further promotes interdisciplinary and trans-disciplinary collaboration across different scientific branches. Finally, the information is presented in a clear and straightforward manner to enable ease of use by decision makers (both policy makers and operations leaders) in order to strengthen disaster risk governance at national and local levels.

Thus **IRDR NC-Japan** and the **Nation's Synthesis on DRR Supported by S&T WG** proposed an internet-based system[45] for collecting, analysing, publishing, re-analysing, critiquing, and reusing data and information for improving disaster resilience. The purpose of this system is to facilitate consilience on disaster and environmental risk reduction, hereby improving disaster resilience, an indispensable element of sustainable development. This system will provide a free internet environment, named Design Trend Press, for users in each country or region. All stakeholders involved in disaster risk reduction can make and register their own contributions

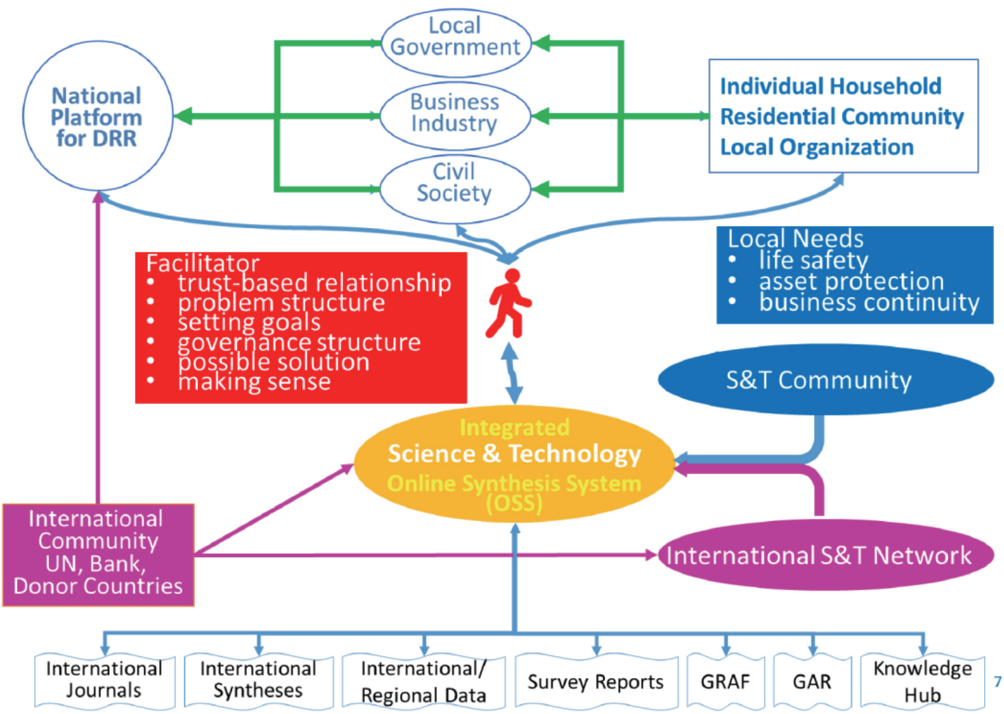
45 http://wci.t.u-tokyo.ac.jp/ResilienceForum2017/pdf/WG7_Periodic%20Synthesis.pdf

in various forms on this system using their own language, as long as they are presented in terms of the seven targets and four priority actions specified in the Sendai Framework. To make this project successful, an international advisory board should be established to supervise the selection of the keywords to be used for the classification and categorization of individual entries.

The WG's goal in creating these reports and systems is to promote dialogue between stakeholders and the science & technology community. To unlock the full potential of the system however, each country should first focus on developing an online national system to share synthesized information of science and technology among a broad range of stakeholders. With international cooperation, national databases can then be used to reach additional stakeholders worldwide. With this information infrastructure, the national platform of each country should address the status and issues of any current DRR efforts that they have implemented based on scientific knowledge. The national platform should then contain conclusions therefrom as to how DRR should be carried out for the country, and design practical measures to be implemented from a holistic point of view. The national and international platforms should contribute to the enhancement of dialogue, which will result in the production of better guidelines and synthesis reports.

The international system is supposed to take all hazards approach and cover all phases of disaster management. It registers data/information in the form of either file or web-link and supports activities to promote open science.

Figure 2-59: The online synthesis system.



NC-Japan plans to achieve these objectives in 3 steps: 1) Organizing broad science and technology communities; 2) Starting first with a simple, understandable and manageable system, and then up-grading the functions in response to users' needs; 3) Implementing pilot studies, and expanding the user community (Hayashi et al., 2018). After 3 years of operation, SCJ provided 4 recommendations in 2020: 1) the scientific community should develop the Online Synthesis System (OSS) to promote DRR and Sustainable Development; 2) the scientific community should foster Facilitators; 3) On-site stakeholders, in cooperation with Facilitators and effectively taking advantage of the OSS, should develop integrated scenarios for DRR and Environment/ Development and execute concrete measures toward enhancement of disaster resilience and achievement of SDGs; 4) International scientific organizations, UN/international agencies and international aid agencies should support the development of the OSS, Facilitators and integrated scenarios for each country and region to take actions.

T3.2 Applying local assessments globally and global assessments locally

◆ Research Report on Disaster Reduction in the Belt and Road Area

IRDR NC-China has carried out spatial monitoring of disaster environmental characteristics of multi-regional and diversified geomorphology units along the Belt and Road, and developed key regional disaster products for the areas where disaster statistics data are lacking or of low accuracy, thus providing background data useful for infrastructure construction in the region.

At present, the catalogue of disasters in countries along the "Belt and Road" has been completed for the past four decades (1980-2018), with the following five areas of focus:

1. The overall situation of disasters in countries along the "Belt and Road" and review of ten specific disaster events;
2. The types of major disasters in countries along the "Belt and Road" and associated losses;
3. Types of major disasters in the Asian region and associated losses;
4. Types of major disasters in the European region and associated losses;
5. Types of major disasters in the African region and associated losses.

Combined with China's existing research, a report on the risk prevention and capacity building of disasters of the "Belt and Road" countries entitled "Disaster monitoring and analysis of the SDG 13.1.1 indicator in countries and regions along the Belt and Road" was published.

Through analysis of data from EM-DAT[46] (the most widely used disaster database), IRDR NC-China conducted Research and Development of spatial processing technologies of disaster data, hereby addressing the problems of different warehousing standards of disaster events, low spatial degree and uneven data completeness. As a result, a statistical disaster database is now transformed into a statistical and spatial disaster database (Figure 2-60). Additionally, a research report on the impact of the earthquake and geological disasters, flood and drought disasters, storm disasters and climate change-related disasters on the urbanization process (especially that undertaken by China) was completed. The report (Figure 2-61) was included in the UN Global Assessment Report on Disaster Risk Reduction 2019 (Chen et al., 2019).

46 https://www.emdat.be/

Figure 2-60: **Disaster mitigation and monitoring products (Left: Fire protection product of the Belt and Road; Right: Flood protection product of Pakistan).**

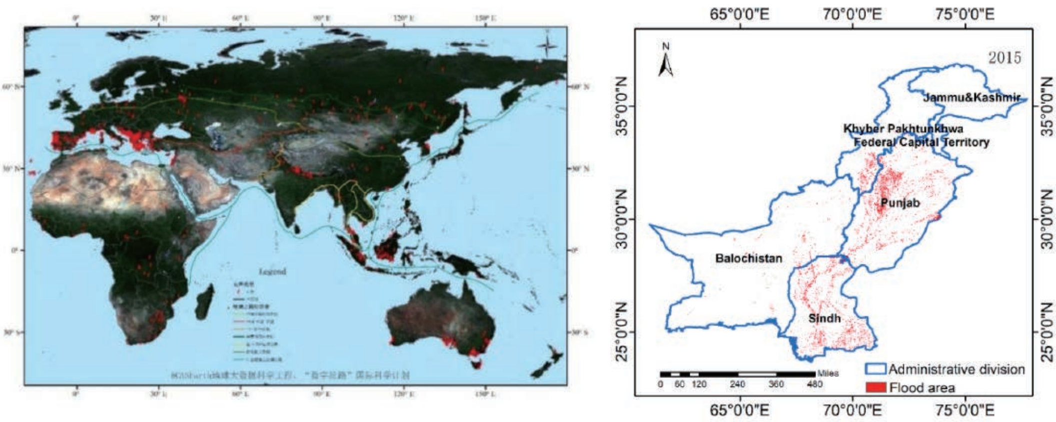


Figure 2-61: **Research report on DRR include in GAR 2019.**

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Disaster risks and response strategies in process of urbanization in China

GAR
Global Assessment Report on Disaster Risk Reduction
2019
Contributing Paper

This paper overviews the Chinese urbanization process, especially in light of the national new-urbanization plan released by the Chinese government in 2014. Over the past three decades, the economic opportunities in urban centers of China have accelerated the urbanization process, mainly as a consequence of rural to urban migrations. The new urbanization plan hopes to increase the proportion of urban population in the next decade, and it is projected that 80% of the Chinese population will reside in urban areas by 2050.

However, this process is faced with certain systemic risks due to disasters. A changing climate, increasing risk due to inter-connectivity of complex urban lifelines and weaknesses in disaster management complicate the disaster risk reduction efforts in urban areas of China. It is recommended that the urbanization process should move forward with an urban management theory integrated with disaster risk, vertical and horizontal integration of responsibilities, utilizing Big Earth Data and new emerging technologies, and supporting risk reduction by employing financial tools to confront disaster risk and, finally, efforts to improve international and regional cooperation.

This paper is a contribution to the 2019 edition of the Global Assessment Report on Disaster Risk Reduction (GAR 2019).

To cite this paper:

Chen, F.; Guo, H. Disaster risks and response strategies in process of urbanization in China. Contributing Paper to GAR 2019

2018 AMCDRR
3-6 JULY 2018
ULAANBAATAR
2018 AMCDRR

The Asian Ministerial Conference on Disaster Risk Reduction 2018, Ulaanbaatar, Mongolia 3-6 July 2018.

we Coordinate

◆ Multiple hazards, vulnerability, risk assessment and the spatial databases

IRDR ICoE-DCE research in Pakistan involves multiple hazards, and vulnerability and risk assessments in different environmental settings ranging from remote mountainous areas to plain and coastal areas. The wide range of hazards have been so far covered including flash floods, riverine floods, urban floods, drought, land-sliding, food security, urban drought etc. Investigations into the extent of communities' vulnerability were also carried out. Finally, contributions to risk assessment was another area of focus, with various methodologies and models were tested in different watersheds and physical regions. As a result, detailed spatial databases were developed, places with different levels of risk zonation were clearly demarcated, and extent of vulnerability were identified and mapped.

◆ Assessment on skilled human capital for DRR and resilience

PERIPERI U contributed the paper "Beyond fragility: Advancing skilled human capital for disaster risk reduction and resilience in Africa" to the Global Assessment of Risk report (GAR) 2019 which was launched at the GPDRR. The paper related to research undertaken by ARU, BDU, Makerere, SU, Tanà and UDM for a 'tracer' study of the career paths of approximately 400 (primarily) Masters graduates from newly introduced disaster risk-related academic programmes. The paper sought to critically examine whether purposeful investments in high-value disaster risk-related human capital and human resources, such as investing in DR-related education and training, enable progress towards strengthened risk reduction capability at national and subnational levels (Holloway & Fortune, 2019).

◆ Important achievements of IRDR that were not covered by IRDR Science Plan 2010-2020

Some achievements, while not covered by the Science Plan, do respond to the Strategic Plan's Goal 5 (Networking and network building) and Goal 6 (Research Support). The contribution made by WG/NC/ICoE/YSP that were not previously included are listed in the following parts. They focused on the DRR research in the coherence of Sendai Framework, Paris Agreement and SDGs. They paid attention to the increasing recognition and acceptance of the importance of higher education institutions in the field of disaster risk, and linking young scientists to IRDR network of professionals and practitioners. They also gave their advice on the transformation for the DRR systems development and developed analytical framework for transforming the relationship between development and disaster risk. Moreover, the IRAN-DRR tried to develop an effective system for financial recovery and compensation through insurance, financial incentives, and supporting funds, and designed Basic Disaster Insurance Pool Act (2019) to compensate portions of losses sustained in residential and commercial buildings due to natural disasters. After the magnitude 7.8 earthquake in 2015 in Nepal, the National Reconstruction Authority gained valuable lessons in post-disaster reconstruction and recovery, which will be useful for future planning.

◆ DRR, CCA and SDGs

The **IRDR DRR, CCA and SDGs WG** focuses on DRR research in accordance with the Sendai Framework, Paris Agreement and SDGs. Climate change is changing the characteristics of disasters. The world has adopted the Sendai Framework to help deal with disaster impacts through strengthened governance, better risk knowledge, resilience investment, and preparedness and recovery and reconstruction. To address climate change and its impacts, it adopted the Paris Agreement, focusing on strengthening institutions, planning and implementation of strategies for adaptation. DRR has also been suggested as the 'first line of defence' for CCA, with both advocating for vulnerability reduction, strengthening resilience, and integrations of climate risks considerations within development. Finally, the SDGs specifically recognize the importance of disasters and climate change (for example in goals 11 and 13). It is important that strategies to deal with DRR and CCA also strategically meet the SDGs. It is important to note that while these 3 international frameworks are clear in terms of their intended outcome, the way by which the progress can be measured remain unclear. Capacity for research and scientific engagement related to DRR-CCA-Development also need to be further strengthened, particularly by developing countries in Asia and Africa.

Key activities (2018-2020) are summarized below:

1. Developing a blue-print research agenda on the integrated approach of DRR-CCA-SDGs 2018-2020
2. Conducting research activities and publications, particularly related to:
   a. Harmonization of targets and indicators within the DRR-CCA-SDGs frameworks,
   b. Review of governance approaches and solutions in dealing with DRR-CCA-SDGs
   c. Documentation of emergent innovations at the local level, by non-traditional actors such as local communities, SMEs, NGOs in dealing with impacts of climate risks while also advocating for and creating better/expanded livelihood strategies
   d. Review of cities progress and programming at city level and innovative governance approaches by which they integrate DRR-CCA-SDGs.
3. Strengthening scientific networks and formation of community of practice especially within developing countries. Existing networks related to DRR-CCA-SDGs are to be identified and improved upon if needed to enable better connections. Better engagement through online conversation/collaborations/knowledge sharing is planned.
4. Participating in key and strategic political events, flagships and scientific conferences to introduce and advance the agenda
5. Working closely with two or three relevant ICoEs to foster partnerships
6. Involving IRDR Young Scientists in capacity building programs of research and scientific writing on DRR-CCA-SDG

IRDR DRR-CCA-SDGs WG, in collaboration with Tohoku University, Keio University, and UNU, conducted an online survey from December 2018 to January 2019 to identify the 10 most important innovations, from the global all the way to local level, dealing with impacts of climate risks and employing improved/expanded livelihood strategies (Izumi et al., 2019). The list of innovations provided options between 30 innovative products (14) and approaches (16) that have already contributed to reducing disaster risks and are considered to be extremely effective at it. The survey involved non-traditional actors such as local communities, SMEs, NGOs and received a total of 228 responses from universities (145), government (30), NGOs (24), the private sector (6), international organizations (16), and others (7). The survey requested to select three innovations considered most effective. The top ten innovations selected were as follows (Table 2-17):

Table 2-17. The top ten innovations from the global to local level

	Innovations
1	Community-based disaster risk reduction/risk management
2	Hazard mapping
3	GIS and remote sensing
4	Assessments and index approach: Vulnerability assessment, resilience, sustainability
5	Disaster risk insurance
6	National platforms for disaster risk reduction
7	Social networking service/system (SNS)
8	Drones
9	Disaster resilient materials
10	Indigenous DRR technology
11	Crowdsourcing

◆ Online Resource Center (ORC)

PERIPERI U launched and maintains an Online Resource Centre (ORC), a digital database of disaster risk literature, articles, reports and other documentation. The initiative was started when PERIPERI U was able to save thousands of disaster risk related materials which were going to be recycled from the Geneva UN Library. The primary goal of this initiative was to offer a platform for students across the partnership to access to disaster risk related documents to assist them with their learning and research. With increasing needs for systematic data management, the secretariat recruited a dedicated 'data capturer' in June 2017. This appointment strengthened maintenance support for the ORC, as well as capacity to upload and categorise electronic copies of reports, articles and documents onto the site. Since the launch of the ORC in early 2016, over 12.9 million searches have been conducted with over 660 000 PDF viewed.

◆ Increasing recognition and acceptance of the importance of higher education institutions (HEIs) in the field of disaster risk

A major objective of **PERIPERI U** is to increase recognition and acceptance of the importance of HEIs in the field of DR and their contribution towards DRR-based initiatives (Holloway, 2015). The partners utilised their attendance at major strategic events and forums as a platform to demonstrate the relevance of HEI efforts in DRR (104 events, attended by approximate 5,661 people) (28 hosted, 131 presented/technical advisor). The partnership's efforts were especially vigorous in Africa. This is reflected in active representation at the Africa WG on Disaster Risk Reduction (AWGDRR) meetings, jointly convened by the AUC and UNISDR/UNDRR in Livingstone, Zambia (October 2016), Addis Ababa, Ethiopia (March 2017), Mombasa, Kenya (September 2017), Bahir Dar, Ethiopia (March 2018), and Yaoundé, Cameroon (September 2018).

◆ Transformation on developments in reducing disaster risk

IRDR ICoE TDDR considers transformation as the altering of fundamental attributes of linked development-DRR systems, primarily through challenging existing governance arrangements, institutions, power paradigms, social values, and techno-centric practices. Transformation is increasingly seen as necessary because the macro-level status quo is not sufficiently equipped to address the environment and development, climate and disaster risk challenges facing the planet. Initiating and facilitating transformative processes requires adaptive governance, learning, innovation, and leadership. Development is vital for reducing disaster risk, yet many current development models are unsustainable and are instead driving and creating disaster risks. At the same time, disasters can destroy development gains, and many existing disaster risk reduction (DRR) and resilience approaches do not contribute sufficiently to social equity and sustainable development. Significant and simultaneous progress towards both the Sendai Framework targets and the SDGs is a complex challenge that requires work on many fronts with a diversity of disciplines and stakeholders.

Building on this context, IRDR ICoE-TDDR argues that transformation is a legitimate and necessary pathway for moving from development patterns that increase, create or unfairly distribute risks, towards equitable, resilient and sustainable development outcomes for all. To understand how to do this, an analytical framework for transforming the relationship between development and disaster risk was developed. Specifically, IRDR ICoE-TDDR explored three interlinked opportunities for transformation: 1) exposing development-disaster risk trade-offs in decision-making and policy; 2) prioritizing equity and social justice in approaches to secure resilience; and 3) enabling transformation through adaptive governance. The TDDR framework has been published as a journal paper (Thomalla et al., 2018) and as an IRDR Working Paper (Boyland et al., 2019). ICoE-TDDR has also published journal papers on each aspect of the framework: on trade-offs (Tuhkanen et al., 2018), on equitable resilience (Matin et al., 2018), and on adaptive governance (Munene et al., 2018). The framework was then applied and tested in different disasters and development contexts, for example in the city of Tacloban in the Philippines following Typhoon Haiyan/Yolanda, which struck in November 2013. In that case, the framework was employed to analyse disaster recovery processes, with a specific focus on the extent to which relocated communities are able to access equitable, resilient and sustainable livelihood opportunities. Following the completion and publication of that research, IRDR ICoE-TDDR conducted follow-up consultations and trainings with city-level officials in Tacloban to validate our findings and share lessons learned for how to operationalize the TDDR framework in decision-making.

◆ Iran Earthquake Insurance

Despite the fact that in theory private earthquake insurance has been available in the local market in Iran since 1992, it has been under-utilized, as in practice the government has acted as a free insurer to the private and public property owners by compensating recovery and reconstruction expenses to those who sustained losses from disaster. To change this trend and make use of insurance as an effective risk transfer mechanism, Iran's DRR goal is to: "Develop an effective system for financial recovery and compensation through insurance, financial incentives, and supporting funds; as well as promoting and regulating financial incentives for the general public, and integrating earthquake risk insurance into the construction process". Based on this strategy, **IRDR NC-Iran** undertook the following actions: 1) incentivizing catastrophe property insurance purchase; 2) familiarizing insurance market practitioners with the concept of natural catastrophe risk modelling; 3) improving and updating the existing earthquake insurance rate and zoning; 4) promoting risk assessment methods in evaluating important structures and infrastructures, instead of using fixed rate or loss history-based pricing; 5) providing disaster insurance for all home owners; 6) mandating the builders to purchase insurance policies for construction using bank finance; 7) considering the calculation of risk-based insurance premium for buildings; 8) establishing a Basic Disaster Insurance Pool; and 9) offering courses on natural hazard risk assessment and management in academic programs.

In addition, the proposed Basic Disaster Insurance Pool Act (2019) has been designed to compensate portions of losses sustained in residential and commercial buildings due to natural disasters (earthquake, flood, tornado, thunder, snowfall, liquefaction and tsunami, etc.). The coverage limit for Basic Disaster Insurance is based on the level of hazard and vulnerability of buildings, which would decide by Central Insurance of Iran in coordination with the National Disaster Management Organization (NDMO), and Ministry of Housing and Urban Development. In the proposed insurance program, a part of the insurance premium will be collected by the Pool from each and every owner of residential units while the remainder is paid by NDMO. The building owners' share of premium will be increasing gradually until 2030 when the entire amount of premium is solely paid by the owners. According to the proposal, the Central Insurance of Iran will provide reinsurance coverage of the Pool and NDMO will channel 15% of its annual budget to the program. From the moment this law becomes effective, NDMO will no longer be responsible for reimbursing the reconstruction expenses of buildings damaged in natural disasters. This Disaster Insurance Pool would create an opportunity for private insurance companies to provide complementary insurance coverage for those who requires further protection. Finally, 1% of the collected premium would be allocated for raising public awareness and promoting the purchase of insurance, strengthening community awareness.

◆ Post-Disaster Reconstruction and Recovery in Nepal

Back on 25 April 2015, Nepal was struck by a magnitude 7.8 earthquake causing extensive damage. The National Reconstruction Authority (NRA[47]), which hosts **IRDR NC-Nepal**, envisions the "establishment of well-planned, resilient settlements and a prosperous society." The NRA has been leading and coordinating multi-hazard resilient reconstruction, retrofitting and restoration of damaged infrastructures and houses, as per the Sendai Framework's recognition that post-disaster reconstruction is an opportunity to build back better. It is identifying appropriate sites to resettle displaced communities, building resilient communities and developing opportunities for economic growth.

After two and a half years, the NRA has gained valuable lessons in post-disaster reconstruction and recovery, which will be useful for future planning. Some key lessons are summarized below:

1. The damage assessment survey should be conducted using reliable and scientific tools to ensure that no victims are left ignored in the reconstruction process.
2. Mass awareness should be created on building quake-resilient structures and the beneficiaries should be effectively communicated the terms and conditions of receiving the government's private housing grant.
3. The official processes involved in transferring grant to the beneficiaries should be simplified and appropriate measures should be taken to ensure that the beneficiaries do not build uninhabitable houses just to receive the grant.
4. An efficient monitoring and evaluation system should be established.
5. A proactive and effective method should be employed to retain technical manpower at the local level.
6. It is necessary to provide subsidies on construction materials to earthquake victims, conduct research activities on disasters and establish resource centres at the local level.

◆ IRDR Young Scientists Programme

The **IRDR YSP** began in 2014 with a World Social Sciences Fellows workshop at the IRDR ICoE-CR. It was re-designed and has accepted applications twice each year since 2016. The programme promotes the capacity building of young professionals and encourages them to undertake innovative and needs-based research, which meets with IRDR's mandate for integrated research, capacity building, and the science-policy interface.

The objectives of this Programme are 1) Increase awareness among young scientists about implementation of Sendai Framework iand provide opportunities for further engagement through the YSP on DRR. 2) Collate existing research knowledge on DRR and identify research gaps and priorities in relation to the Sendai Framework Priorities for Action. 3) Identify opportunities to fund continued multi-disciplinary research by young scientists and early career researchers. 4) Provide technical support to promising young researchers in DRR fields. 5) Build and foster strong and dynamic networks among worldwide experts and institutions in DRR fields. 6) Develop, over time, a community of high-quality young professionals that can provide support for policy-making decisions related to DRR.

As for the IRDR young scientists, the program allows them to link to the IRDR network of professionals and practitioners and receive academic support and advice. They are also given priority to be selected to participate in the IRDR related training programmes, and are asked to contribute to innovative research in the field of DRR and act as ambassadors of

47 http://nra.gov.np/np

IRDR in conferences and/or social media. IRDR encourages them to continue their development and further network, especially among young professionals.

The first iteration of the programme started accepting applications in December 2016, with 41 young researchers accepted into the January 2017 programme. Further rounds occurred in July 2017 (31 admissions), April 2018 (44 admissions) and June 2019 (48 admissions). Selection criteria include: age (under 40 years old), affiliation (need to be affiliated with an academic programme either as a student or as a young faculty), endorsement (must be endorsed by academic supervisor or head of department/graduate school), and research subject (DRR and its link to broader environment and development issues). Their research proposals in particular are requested to be integrated, innovative and serve to Sendai Framework four priorities. Since the third round, applications are reviewed by a selection panel consisting of IRDR Scientific Committee members and the IPO Executive Director and the principal of this programme. A scoring sheet is provided for evaluation (1 as not qualified to 5 as the best qualified). The applicant whose average score is 3 or above will be accepted as the new IRDR young scientists.

The 164 IRDR young scientists come from 46 countries. Among them, 45 are female researchers, and 50 were students at the time they applied. Their fields of study cover a wide range of subjects, including Disaster Risk Reduction, Disaster Management, Physical Geography, Human Geography, Geology, Environmental Science, Environmental Planning, Environmental Anthropology, Environmental Health, Environmental Engineering, Geotechnics Engineering, Civil Engineering, Seismic Engineering, Climate Change Mitigation and Adaption, Public Health, Hydrology, Watershed Management, Humanitarian, Ecology, RS and GIS, Law, Agricultural Economics, Architecture, Political Science, Anthropology, Statistics, Communication studies, Economics, Urban Planning, Sustainable Development, Physics, Crisis Management, Disaster Nursing, Rural Development and Administration, Development

Figure 2-62: IRDR young scientists contributed greatly to DRR researches toward Sendai Framework combined with IRDR objectives.

Policy, Glaciology, Earth and Atmospheric Science, Biology, Computer Science, Social Science, and more.

More than 40 young scientists have participated in IRDR-related training programmes hosted by IRDR ICoEs, IRDR Flagship Projects and IRDR Partners such as ICoE-Taipei and ICoE-CCOUC in Hong Kong, and by IRDR partnership with the Digital Belt and Road (DBAR) programme of CAS. The training courses provide cutting-edge courses and research training on comprehensive/individual disaster risk assessment, humanitarian and emergency response, risk communication, science and policy interface and other DRR methodology, theories, and practices.

The IRDR young scientists also participated in DRR training programmes in their regions while acting as IRDR ambassadors, seeking further academic communication and cooperation. For example, in 2017, programme participants Ximena Roncancio (Colombia), Armand Kablam (Cote D 'Ivoire), Khalid Bahaudin (Bangladesh) and Antonethe Castaneda (Guatemala), participated in the event "Climate Change: Scientific basis, adaptation, vulnerability and mitigation" organized by the São Paulo School of Advanced Science.

A brief selection of works from the broad range of research work the Young Scientists undertook is listed below:

Godfrey Chiabuotu Onuwa from Nigeria conducted research focusing on IRDR objectives 1.1, 2.2 and 3.2 and Sendai Target E, looking at for the Vegetable farmers' perceptions of climate change and adaptation practices in Bassa, Plateau State, Nigeria. The research was presented at the 27th Annual congress of the Rural Sociological Association of Nigeria (RuSAN), Zaria, in 2018.

Olufemi Adetunji from Nigeria focused on addressing IRDR objective 2.3 and Sendai Target G, looking at rethinking the roles of local non-governmental organisations (LNGO) in managing disaster risks in historic neighbourhoods in the city of Lagos, Nigeria. The result revealed that the interventions implemented by the LNGOs were not contributing to the preparedness of historic neighbourhood's disaster risk but rather are mere reactive actions during and post disaster.

Tesfahun Asmamaw Kasie from Ethiopia analysed the impact of the 2015 El Niño-induced drought on household consumption, contributing to IRDR objective 1.1 and Target 3. Followed a quasi-experimental approach based on the Difference in Difference (DID) method, the result confirmed that consumption at the 25th percentile declined significantly as a result of the drought – indicating that the drought impact was largely driven from the lower tail of the consumption distribution. From these results, the paper concluded that there is need for an integrated development & emergency management program to address the long-term vulnerabilities that cause inequalities in shock resilience between the poor and the better-off rural households, while also addressing transitory food needs during drought periods.

Dahan Kueshi Sémanou from Côte d'Ivoire focused on fire, vegetation cover dynamics and climate change in forest-savanna contact area through looking at a case in the Toumodi Department (located in the centre of the country). The research contributed to IRDR objective 2.3 and Sendai Target G. In a context of climate change, this study aimed to improve knowledge on the recurrence of fires for the sustainable management of plant biodiversity in the Toumodi department, a forest-savanna transition area.

Spyros Schismenos from Greece gained significant recognition, acting as advisor to the UNESCO Chair on Conservation and Ecotourism of Riparian and Deltaic Ecosystems (CONEECT) with his expertise. His integrated research on Hydropower for Disaster Resilience Applications (HYDRA), which covered most IRDR objectives, further contributed to Sendai Target A, B, C and D as they deal with community vulnerability challenges and water-based disaster risks. HYDRA is an innovative humanitarian engineering solution that promotes low-cost, localised hydropower to support remote community socio-economic growth and disaster risk reduction. HYDRA investigates the development of a pilot product - a portable, DIY (do-it-yourself), EDO (easy-to deploy-and-operate) micro-hydropower generator connected with outdoor flood warning systems designed to operate at the local level. A project team has used this approach to measure important vulnerability and capability factors by comparing communities with different capabilities for coping with water-based disasters (WD). A key goal of this analysis is the development of a universal community capability assessment (UCCA) suitable for comparing two or more communities in a simple, evidence-informed assessment. Finally, HYDRA also accords with the SDGs promoting environmental and socio-economic sustainability, and hazard resilience. Recent research results can be found in the 2nd Special Edition of UNMGCY Youth Science Policy Interface Publication.

Antonethe Castaneda from Guatemala contributed to IRDR objectives 2.3 and Sendai Target E with research on evidence and scientific advice in developing the Policy and Framework Law on Climate Change in Guatemala. Tracking the intersectoral participatory process through the effort of the advisors of the Climate Change Tables, he concluded that the scientific and academic community must get out of its comfort zone and begin to influence other issues with decision-makers. Citizen participation should not just be about voting and or running for office and being elected, but also participating actively in the processes that affect our environment.

Tingxi Liu from China focused on IRDR objectives 2.1 and 2.2 and Sendai Target D. She analyzed post-disaster community resilience and tourism development after Wenchuan earthquake in China (Figure 2-63). In this study, a comparative sequence and timing of recovery provided a calendar of historical experience against which to gauge progress in reconstruction. The research also traced post-disaster tourism development in the town of Shuimo, which has undergone a complete transformation from industry-led economy to tourism-led economy as part of its reconstruction since the mega-earthquake. This exploration and the practical observations enriched the relevant domains of developing resilience of critical infrastructure, health and educational facilities, and provide a channel for further theoretical work on post-disaster tourism recovery.

Figure 2-63: The phases from the emergency response to reconstruction in Wenchuan.

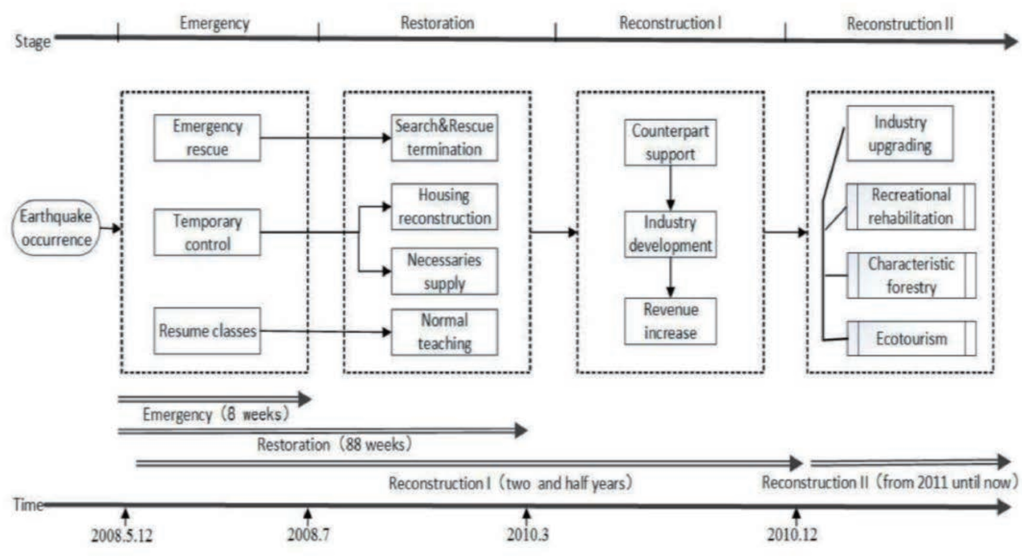
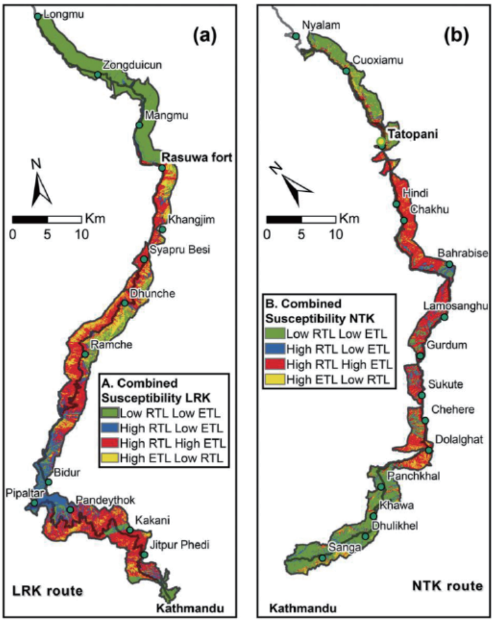


Figure 2-64: Combined rainfall and earthquake triggered landslides susceptibility maps for the two important China-Nepal economic highway road corridors (LRK and NRK).



Zubaria Andlib from Pakistan conducted DRR research focused on IRDR objectives 1.1 and Sendai Target C, E, F, and G, looking to assess the impact of natural disasters on human capital accumulation in selected Asia-Pacific countries including China, Japan, South Korea, Indonesia, Thailand, Malaysia, Philippines, Pakistan, Bangladesh, India, Sri Lanka, and New Zealand. The prime objective of this study was to analyse the impacts of natural disasters on human capital accumulation in these countries, whereas human capital is defined by secondary school enrollment rate, maternal mortality and infant mortality.

Shah Nawaz Khan from Pakistan conducted research on risk assessment of flash floods along Budhni Nullah,District Peshawar, Pakistan, contributing to IRDR objective 1 and Sendai Target C and D. This study was an attempt to identify level of vulnerability, exposure of elements at risk, flood risk and cost of damages for 5-, 10-, 50- and 100-year return period floods. The maps developed by this study reveal the areas of high risk. The research also found that in the study area the indigenous (local) knowledge was often ignored in planning processes despite the importance of utilizing such local knowledge by involving the community's people in each step of flood risk assessment and management.

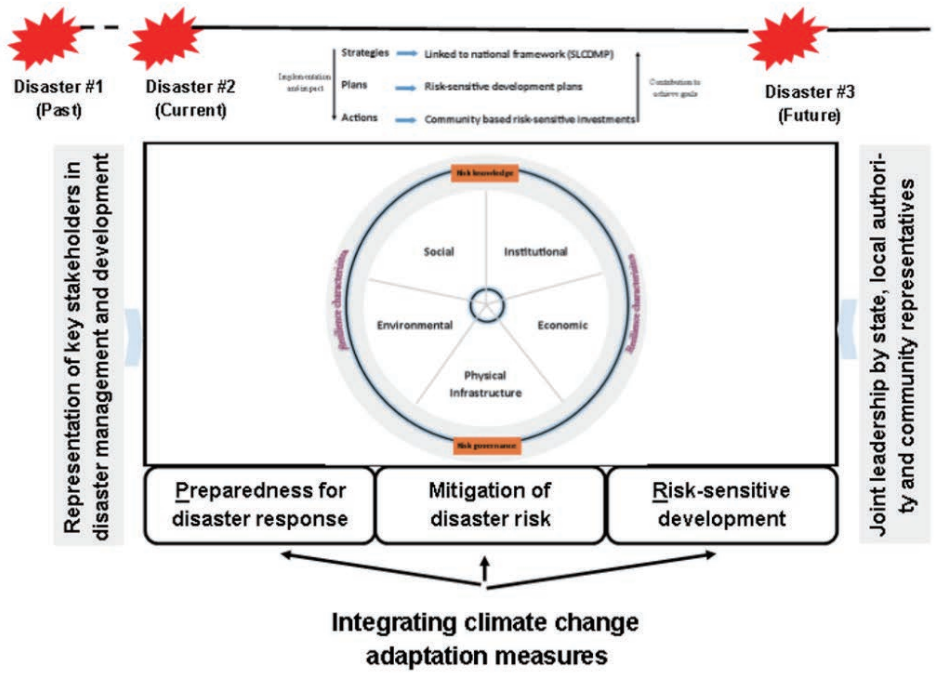
Kaushal Raj Gnyawali from Nepal contributed to the IRDR objectives 1.1, 1.2 and 3.1 and Sendai Target D and F, undertaking a comprehensive mapping of areas susceptible to landslides along the China-Nepal highway corridors, and with both transboundary and infrastructure risks addressed (Figure 2-64). The work is also collaborative research project involving scientists from four countries: Nepal, China, Germany and South Korea. As a developing nation, Nepal received great collaboration from scientists and institutions from the other three nations to support this research work in Nepal.

Charlotte Kendra Gotangco from the Philippines explored a Systems Approach to urban resilience, contributing to IRDR objectives 1.3 and 2.1 and Sendai Target B and D. The main objective of the project is to explore the application of systems thinking approaches to framing, understanding and addressing the issue of resilience of urban centers, particularly to flooding hazards with the following four goals:

1. To review frameworks for resilience, map existing definitions and tools.
2. To design and implement workshops for local government units (LGUs) using systems thinking tools to mainstream resilience measures into development planning;
3. To develop a system dynamics model for dynamically quantifying resilience of cities to flooding over time;
4. To discuss the value, utility and specific applications of modelling resilience drawing from insights derived from the local government unit (LGU) workshops and from the case studies.

A.M. Aslam Saja from Sri Lanka attempted to create an approach using risk-sensitive development plans to build resilient communities, contributing to IRDR objective 1.2, 2.2, and 3.2 and Sendai Target E. Using case studies, Saja developed an Integrated Disaster Resilience Framework (IDRF) from the consultation with key DRR and development practitioners in Sri Lanka (Figure 2-65).

Figure 2-65: An integrated Disaster Resilience Framework (IDRF) proposed for Sri Lanka (Saja et.al 2020).



Farman Ullah from Thailand contributed to IRDR objective 1.2 and Sendai Target F, with research on assessing flood risks in rural areas of Khyber Pakhtunkhwa, Pakistan. The research aimed to achieve the following objectives: 1) To find out flood risk assessment and flood risk perception of rural households.2) To study the preparedness level to floods among the rural households. 3) To assess the adaptive capacity of the flood prone rural household for future floods. He concludes that the current course of action in DRR related activities is insufficient and lacking serious planning and implementation, and that there is significant need for a comprehensive strategy against disaster risk in these rural areas. This comprehensive strategy should be an inclusive approach.

Nargis Shabnam from India contributed to IRDR objectives 1.1 and 1.2 and Sendai Target G, attempting to estimate future changes in landslide risk for the several locations in Himalayan terrain which have a long history of serious climatic extreme events. The study generates a comprehensive landslide atlas, which incorporate both shallow and deep-seated origin. This is especially important in developing nations, where no existing records of landslide inventory is available at present in the public domain.

Sangeeta from India conducted research on earthquake-induced landslide hazard assessment in the Indian Himalayas, contributing to IRDR objectives 1.1 and 1.2 and Sendai Priority 1. He explored the methodologies on landslide susceptibility zonation (LSZ) mapping by considering different factors and found that the map considering pre-earthquake landslide inventory with seismic factor is the ideal one with overall excellent success rate and validation accuracies for spatial prediction of both pre- and post-earthquake landslide zones.

Shruthi Dakey from India contributed to IRDR objectives 1.3, 2.1, and 2.3 and Sendai Priority 2 with a study on applying Socio-Ecological Systems perspective for gaining resilience in coastal rural communities of India. The model can assist in understanding the complexities in the system. Fuzzy cognitive mapping helps in understanding conceptual changes in the socio-ecological system components and thereby assists decision-makers. The study gives general recommendations that are supposedly applicable for the selected case study areas, hopefully a stepping stone towards broader reframing the management of socio-ecological systems that are exposed to climatic related risks.

Several IRDR young scientists have won awards for their work. For example, IRDR young scientist Emmanuel Raju, Assistant Professor of the Faculty of Law & Global Health Section, Copenhagen Centre for Disaster Research, University of Copenhagen, recently was awarded as Outstanding Reviewer for Disaster Prevention and Management: An International Journal in the 2018 Emerald Literati Awards. Emmanuel was selected by the editorial team based on his contribution to the Journal in 2017. IRDR young scientist Dr. Basanta Raj Adhikari has been nominated for the prestigious "Young Affiliates" by The World Academy of Sciences (TWAS) for 5 years, receiving the award from TWAS President Prof. Dr. Bai Chunli at the 28th TWAS annual meeting held in Trieste, Italy, for his outstanding contribution in the field of natural science.

The IRDR Young Scientists Programme establishes a network for the capacity building of a new generation of DRR specialists and researchers. These individuals are not only active in their respective research fields, but they also contribute to the sharing and promoting of DRR knowledge to local communities. For example, two IRDR young scientists, Dr. Basanta Raj Adhikari of Tribhuvan University and Mr. Ranit Chatterjee of Kyoto University jointly conducted an awareness generation program with the National Youth Alliance for Reconstruction, a youth group focused on strengthening youth leadership and promoting community-led reconstruction process in 14 earthquake affected districts of Nepal. As a part of the event titled "Youth Action in Disaster Risk Management", Dr. Adhikari and Mr. Chatterjee made respective presentations and engaged the participants in active discussion to engage students in disaster management activities. IRDR strongly encourages such outreach, as well as encourages young scientists to promote and continue to build regional and national DRR young scientists networks.

Finally, as an effort to address challenges and future interdisciplinary and intergenerational capacities in disaster risk reduction, UNESCO Regional Sciences Bureau for Asia and the Pacific, jointly with the International Centre for Interdisciplinary and Advanced Research of the Indonesian Institute of Sciences (ICIAR LIPI), UNDRR, facilitated the birth of U-INSPIRE. The workshops on Strengthening, Empowering, and Mobilizing Youth and Young Professionals in Science, Engineering, Technology and Innovation (SETI) for Disaster Risk Reduction (DRR) in 2018 and 2019, which were organised by UNESCO, LIPI, IRDR, and IDRM of Sichuan University, witnessed the declaration of U-INSPIRE missions and the launching of national chapters. IRDR Young Scientists played leading roles on organizing the national chapters of U-INSPIRE such as Indonesia, Pakistan, Nepal, Malaysia, and India.

Table 2-18. List of Young Scientists

No.	Name	Nationality	Research Proposal Topic
1	Angelo Paolo L. TRIAS	Philippines	Connecting the actors, discovering the ties: Exploring the organizational networks of disaster risk reduction (DRR) interventions and projects in Asia and the Pacific
2	Anissa SARAH	Indonesia	Regular Socialization of Public Awareness on the Importance of Emergency Response to the Disaster
3	Armand KABLAN	Côte d'Ivoire	Open and green spaces in African urban areas: An assessment of the opportunity and challenges in risk reduction context
4	Ayesha SIDDIQI	Pakistani	How do conflict affected communities in LMICs experience and construct disasters, especially politically?
5	Barrett RISTROPH	USA/Russia	How Alaska Native Villages (ANVs) are adapting to flooding, erosion, and species shifts, how laws can help or hinder adaptation processes, and the correlation between community characteristics, vulnerability, and disaster declarations.
6	Basanta Raj Adhikari	Nepalese	Land degradation and community-based disaster risk reduction plan in the Himalayas: A case study of Rupa lake Watershed, Kaski, Nepal
7	Behrooz Balaei	Iranian	Measuring water supply system resilience to earthquakes
8	Chekwemboi Christine	Ugandan	Adaptation to climate change risks in the Lake Kyoga Basin
9	CHIAN Siau Chen	Singaporean	Catastrophe modelling, landslide and underground lifelines.
10	Dao Nguyen-Khoi	Vietnam	Impacts of climate change and land-use change on hydro-meteorological and agricultural droughts in the Central Highlands of Vietnam
11	Doris Jimena Roncancio Benitez	Colombia	Health risk assessment relating to the variability of extreme air temperatures in Colombia for the planning of mitigation and adaptation strategies to face climate change.
12	Edris ALAM	Bangladeshi	Climate change perceptions, impacts and adaptation of Bangladeshi coastal communities
13	Elisha Anne Pei Yi TEO	Malaysian	Digging for lost rivers in Thailand: Reconstructing historical channel shifts in the Chiang Mai Intermontane Basin
14	Fátima Antonethe Castaneda Mena	Guatemalan	Management and Restoration of Forest Ecosystem for purposes of Food Security and Energy in Central America
15	Flavio Lopes Ribeiro	Brazilian	Individual and Community Responsibility for Water Management as a Strategy to Mitigate the Impact of Drought in the Semiarid Region of Brazil
16	Geoffrey Mwangi Wambugu	Kenyan	Agro-Pastoralists and Drought: Exploring Climate-smart Mitigation Strategies among Women in the ASALs
17	Givemore Munashe Makonya	Zimbabwean	Thermotolerance genotypes for sustainable Chickpea production in South Africa
18	Glenn Fernandez	Philippines	Empirical Research on Earthquake Risk Perception and Housing Reconstruction in Kathmandu, Nepal and on Earthquake, Cyclone, and Fire Risk Perception and Housing Safety in Yangon, Myanmar
19	Harold Aquino	Philippines	Developing storm resilience through building code upgrades and its impact on affordability of houses in the Philippines
20	Indrajit Pal	Indian	Investigating Critical Factors for Social Resilience and Risk Governance for Flood Adaptation in Ayeyearwady Delta, Myanmar
21	JIA Yang	Chinese	Influence of Climate Change on the Formation of Various Mountain Hazards in the Central and Eastern Himalayas

No.	Name	Nationality	Research Proposal Topic
22	Gabriel Kojo Frimpong	Ghanaian	Use gamma radiation to decontaminate and preserve freshly harvested and dried pepper fruits
23	LEI Yu	Singapore	A quantitative risk assessment method of human settlements subject to debris flow impact
24	LIU Tingxi	Chinese	Post-disaster community resilience and tourism development: The case ofWenchuan earthquake areas in China
25	Marie Delalay	Swiss	Flood risk assessment under different scenarios of climate change, urban expansion, and economic exposure: A probabilistic analysis of the Upper Seti River Watershed in Nepal
26	Masahiko Haraguchi	Japanese	Innovations towards Climate induced Disaster Risk Assessment and Response
27	Md. Shamsuzzoha	Bangladeshi	Strengthening economic security through social capital: Households' adaptation to cyclone risk in Bangladesh
28	Oluwatosin Adejoke Oyedele	Nigerian	Dynamics of food insecurity in nigeria
29	Poorna Sandakantha YAHAMPATH	Sri Lankan	Approaching multi-proxy analysis for review Quaternary palaeo-climate reconstruction in Ratnapura and Sri Lanka
30	Ranit CHATTERJEE	Indian	Recovery Process of Micro Small and Medium Scale Businesses in Backdrop of 2015 Nepal Earthquake
31	Saadia Majeed	Australia and Bangladesh	Comprehensive Framework for Disaster Risk Management (CFDRM) Application Programme
32	Sameer Deshkar	Indian	Prioritizing Disaster Risk Resilience Strategies and Locations for their Implementation through Local Community Participation in Urban-Rural Transect Areas
33	Sandra Delali Kemeh	Ghanaian	Exploration of Potential Benefits of the landscape approach in Drought Risk Reduction: A case study of Masongaleni, Kibuwezi in Maukueni County, Kenya.
34	Sarah Hasan	Pakistani	Investigation of Geomorphology of Northern Pakistan and surrounding regions: Insides from Remote Sensing and GIS
35	Sarah Lindbergh	Brazilian	The role of infrastructure vulnerability assessment in natural disaster response planning
36	Shan Nawaz Khan	Pakistani	Application of GIS/RS in assessment of flood hazard, vulnerability and risk
37	Spyros Schismenos	Greek	Preparedness, resilience & education against torrents (predator)
38	TAN Chunping	Chinese	Drought Disaster Risk and Its Projection Under RCP Scenarios in the Silk Road Economic Belt of China
39	WANG Guanghui	Chinese	Comprehensive Risk Assessment of Coastal Cities through Sea Level Rise in China and America: A social development perspective
40	WANG Jiao	Chinese	Study on failure mechanism and criterion of moraine deposits under climate change
41	CUI Yan	Chinese	Overview of disaster risk governance and regulatory system in China
42	Abhinav Walia	Indian	Managing Urban Flooding in the era of Changing Climate: Way forward for smart Governance
43	Akvan Gajanayake	Sri Lankan	Measuring social, environmental and economic impacts of road failure due to natural disasters
44	Avirut Puttiwongrak	Thai	Preliminary Assessment of Seawater Intrusion Problem in Phuket Island, Thailand

No.	Name	Nationality	Research Proposal Topic
45	Brennan Vogel	Canadian	Analysis of the social, political and cultural dimensions that impact climate change policy and practice, with an applied focus on the governance context of Canada's coastal First Nations and municipalities.
46	Chow Ming Fai	Malaysia	The potential of parameter estimation through regionalization for flood simulations in ungauged mesoscale catchments
47	Débora A. Swistun	Argentina	The determinants of housing, health and environmental policies in the Matanza-Riachuelo river's basin (Buenos Aires, Argentina) and the ways in which they impact on the neighbourhoods settled in environmental risk areas
48	Emmanuel Raju	Indian	Increasing Stakeholder Diversity in Disasters - Lessons for Disaster Risk Management
49	Florian Roth	German	A Context-Specific Framework for Integrating Social Vulnerablity in Mapping
50	Idowu Ajibade	Nigerian	Building resilient cities: a proposal for 'transformative and just adaptation' in the Global south.
51	Ignatius Gutsa	Zimbabwean	Examining the importance of everyday local level sources of reading the weather and seasons in rural Zimbabwe for disaster risk reduction in the face of climate change
52	Imon Chowdhooree	Bangladeshi	Impacts of structural mitigation measures on perceptions of community flood resilience: experiences from HAOR communities of Bangladesh
53	Jose Areekadan	Canadian	Sichuan Business Continuity Assessment during Earthquakes and Natural Disaster
54	Karen McNamara	Australian	Are we 'building back better'? Exploring disaster response efforts in the Asia-Pacific region
55	Khalid Md. Bahauddin	Bangladeshi	Coastal Floods in Bangladesh: How people's Interpretation of Personal, Social and Institutional Resources Influence Flooding Preparedness
56	Md. Abdus Sattar	Bangladeshi	Forecasting of cyclone risk for coastal community and exploring risk reduction strategies in Bangladesh
57	Mizan Bustanul Fuady Bisri	Indonesia	The Networked-Politics of Science and Policy Interface on Disaster Risk Reduction in Southeast Asia: A Comparative Perspective
58	Mohammad Aminur Rahman	Australian	Impact of structural development projects on vulnerability of coastal communities to disaster
59	Mohan Kumar Bera	Indian	Collective Efforts of People to Reduce Natural Disasters: A Study of Sundarban Islands
60	Mortuza ahmmed	Bangladeshi	Factors Associated with Safe Delivery Practice in Bangladesh
61	Richard Adu	Ghanaian	Flood control management in monrovia: a sustainable way to a resilient and livable city
62	Saja Aslam A.M.	Sri Lankan	An approach to develop risk-sensitive development plans to build resilient communities
63	Sandra M. Carrasco M.	Peru	Self-help transformations of post-disaster housing and community empowerment in Asia-Pacific
64	Saswata Sanyal	Indian	Assess how social capital helps in preparedness and response towards natural disasters among communities in this high risk area
65	Shyamli Singh	Indian	Community-centric Disaster Risk Reduction: An Instrument for Climate Risk Management

No.	Name	Nationality	Research Proposal Topic
66	Suraj Gautam	Nepalese	Preparation of Landslide Susceptibility Mapping focusing on Landslide Risk Assessment and Risk Perception in the Sindhupalchowk district
67	Tanwa Arpornthip	Thai	Disaster ratio analysis for Flood Risk Assessment of Thailand's Andaman Region
68	Tinsaye Tamerat	Ethiopia	Africanizing Sendai framework with special emphasis on "Green Famine" resilience in the Horn of Africa
69	Vivien How	Malaysia	Integrating Science-based Knowledge into Innovation Action for Community-based Disaster Risk Reduction (DRR) Program
70	Xianlin Jin	Chinese	Impact of Health Consciousness on Response to Haze Warning Messages: A Test of the Extended Paraller Process Model in an Enviornmental Health Risk Context
71	Yan Yan	Chinese	Monitoring and early warning system for debris flow and debris flow monitoring
72	Zubaria Andlib	Pakistani	An Assessment of Women's Vulnerabilities and Adaptation Strategies to Climate Change Hazards in Coastal Area of Balochistan, Pakistan
73	Abayineh Amare Woldeamanuel	Ethiopian	Index-Based Livestock Insurance: New options to manage climate risks in Ethiopia
74	Amrit Prasad Sharma	Nepali	Watershed based climate and disaster risk assessment in Riu-Khola Sub Watershed, Maadi, Chitwan, Nepal.
75	Anna Barra	Italian	Sentinel-1 for geohazard monitoring and risk management
76	Anne Simiyu	Kenyan	Green water Management for Food Security and Sustainable livelihoods in drylands-A case of Ukambani Region in Kenya
77	Bikram Manandhar	Nepali	Hydrological characterization of an ungauged or limited precipitation monitoring data basin for flood risk assessment and water resource management- learning and sharing knowledge across the region
78	Chandra Laxmi Hada	Nepali	Rethinking Participatory Approach in the preparation of Risk Sensitive Land Use Planning (RSLUP) for emerging Nepali Towns
79	Fajar Shidiq Suwarno	Indonesian	Urban Community Empowerment Strategy for Preventing House Fires in Dense Settlements in Jakarta, Case Study: Cipinang Besar Utara Urban Village
80	Frederick Dapilah	Ghanaian	Coproducing knowledge for flood risk resilience and urban sustainability in Sub-Sahara Africa: The case of Accra, Ghana
81	Gosaye Degu Belay	Ethiopian	Estimating the household resilience for drought driven food insecurity using system dynamics model: the case of afar national regional state of ethiopia
82	Hastoro Dwinantoaji	Indonesian	Effectiveness of Snakes and Ladders Game on Flood Disaster Risk Education and Health Education on Basic First Aid Management for Children in Indonesia
83	Hendy Irawan	Indonesian	Data Fusion for Detection and Parameterization of Earthquake Sources
84	Hugues Yénoukoumè HANGNON	Beninese	The future of Ouagadougou by 2030 against the risk of flooding
85	Ifedotun Victor Aina	Nigerian	Analysis of climate change resiliency through index insurance among smallhodler farmers in southern guinea savannah of nigerian
86	Irfan Ahmad Rana	Pakistani	Community Resilience and Multi-Hazard Risks in Urban Areas of Pakistan

No.	Name	Nationality	Research Proposal Topic
87	Jahir Anicama Diaz	Peru	The impact of hydro meteorological information systems in agriculture sector in Peru and Chile against to floods and droughts
88	Jaime Angelo Victor	Filipino	Development of a rapid assessment method for shallow landslide susceptibility, hazard and risk – calibrated for localized application
89	Johnrev Guilaran	Filipino	Work and Interpersonal Relationships among Emergency First
90	Kamran Azam	Pakistani	Mainstreaming the Coping Capacities for Risk Reduction and Resilience through Community Centered Trans-Durand Diplomacy: A Case of Kabul River Basin
91	Kripa Shrestha	Nepali	Landslide risk assessment of Chepe river corridor, west Nepal
92	Kristoffer Berse	Filipino	Science advice for disaster risk reduction: a scoping study on the policy-science interface of disaster governance in the philippines
93	Kumbirai Ivyne Mateva	Zimbabwean	What functional strategies drive drought survival and recovery in bambara groundnut (Vigna subterranea (L.) Verdc.)?
94	Ma. Brida Lea D. Diola	Filipino	Disaster Waste Management in The Philippines: Assessment and Recommendations
95	Marina Drazba	USA	Managing the risk, not the disaster. Building community resilience in the face of Landslide Risk. Case Studies: Mexico; Fiji; Bangladesh
96	Mayeda Rashid	Bangladeshi	Teacher-delivered, child participatory disaster resilience education program for children
97	Michael Boyland	UK	Transforming Development and Disaster Risk in the Mekong Region: An Integrated and Trans-disciplinary Research Plan to the IRDR Young Scientists Programme
98	Monica Cardarilli	Italian	Spatio-temporal variability analysis of territorial resistance and resilience to risk assessment
99	Mouloud Hamidatou	Algerian	Capturing the uncertainty of seismic activity rates in probabilistic seismic hazard assessments
100	Mujiburrahman	Indonesian	Governance and decentralization of multi hazard early warning system in Indonesia
101	Ngwa Kester Azibo	Cameroonian	A gender analyses of the determinants for the adoption of disaster management mechanisms in Sub-Saharan Africa: A Multiple Case Study Analyses
102	Paul Andrés Muñoz Pauta	Ecuadorian	Flash flood forecasting in a mountain catchment based on the Random Forest algorithm: A strategy for disaster reduction in mountain areas
103	Raju Chauhan	Nepali	Reliability and Effectiveness of Flood Early Warning System in Nepal
104	Rita Thakuri	Nepali	Empowerment of Women Mason in Gorkha Earthquake Reconstruction: Facts and Challenges
105	Robert Šakić Trogrlić	Croatian	The role of local knowledge in community-based flood risk management in Malawi
106	Rodrigo Rudge Ramos Ribeiro	Brazilian	Climate risks in rural areas and adaptation processes: a national vision of Portugal
107	Sandeeka Mannakkara	New Zealand	Development of the “Build Back Better Tool” to Implement Sendai Framework Priority 4
108	Shabir Ahmad Kabirzad	Afghan	Assessing Sendai Framework Execution in Afghanistan Context
109	Shakeel Ahmed Khan	Pakistani	Assessing Geohazard Mitigation and Linking Disaster Risk Perception to Preparedness for Resilient Communities: A case study of Attabad landslide dam.

No.	Name	Nationality	Research Proposal Topic
110	Sharad Wagle	Nepali	2015 Gorkha Earthquak reconstruction initiative in rural area of Nepal and its challenges
111	Simon Wagner	German	Assessing institutional capacities of municipal urban planning departments to integrate future-oriented vulnerability information in the context of rapid urbanization into public infrastructure planning by city size
112	Somana Riaz	Pakistani	Sustainable Socio-Economic Aspects of CPEC
113	Supriya Krishnan	Indian	The Future Ground Urban planning under long-term climate uncertainty
114	Suresh Chaudhary	Nepali	Continuity and Transformation of Community Resilience against earthquake in Nepalese cities
115	Sushila Khatri	Nepali	Increment of soil cohesion by Thysanolaena maxima to mitigate shallow landslide in Simbari watershed, Sindhuli
116	Syed Zulfiqar Ali Shah	Pakistani	Diverting Disasters: A Multi-Method Analysis of Flood Management and its Conflict Implications in Pakistan
117	Md. Abul Kalam Azad	Bangladeshi	Role of Disaster Governance in Health Risk Management during Humanitarian Crisis: A Case Study on Coastal Communities of Bangladesh
118	Siswani Sari	Indonesian	The Roles of Aceh Government to Sustain Disaster Risk Reduction in Aceh Province, Indonesia
119	Charlotte Kendra de Zuñiga GOTANGCO	Filipino	A systems approach to urban resilience
120	Khamarrul Azahari Razak	Malaysian	Disaster Risk Repository and Mainstreaming DRR into Development Planning: A transdisciplinary approach
121	Mira Khadka	Nepalese	Projection of Future Flood Scenarios Integrating Glacio-hydrological and Hydraulic Modelling in Koshi River Basin, Nepal
122	Qurban Rahim	Pakistani	Avalanche and Debris Flow Mitigations
123	Shruthi Dakey	Indian	Applying Socio-Ecological Systems perspective for gaining resilience in coastal rural communities of India
124	Tesfahun Kasie	Ethiopian	Modeling Drought Extreme Events – Testing Resilience Properties of Food Emergency Response Systems in Africa.
125	Farman Ullah	Pakistani	Assessing Flood Risk in Rural Areas of Khyber Pakhtunkhwa, Pakistan
126	Ghani Rahman	Pakistani	Analysis of Climatic Variability and Its Impact on Drought Reoccurrences, Intensity and Trend Prediction Using Multi-Indices in Khyber Pakhtunkhwa, Pakistan
127	Godfrey Chiabuotu Onuwa	Nigeria	Climate change perceptions and adaptation practices among food crop farmers in north central Nigeria
128	Kaushal Raj Gnyawali	Nepalese	Application of free and open-source software in detection, initiation and runout dynamics of large landslides in China and Nepal
129	Sangeeta Prajapati	Indian	Earthquake Induced Landslide Assessment focusing on Hazard and Risk Perception in the Chamoli District Uttarakhand, India
130	Suman Chapagain	Nepalese	The study of trends of hazards and people's perception towards risk due to urbanization: a comparative study of Kathmandu metropolitan city and Biratnagar metropolitan city of Nepal
131	Chioma Nwakanma	Nigeria	Assessment of Ecosystem Diversity, Economic and Health Implications of Climate Variability on Rural Dwellers in the Riverrine Areas of Abia State

No.	Name	Nationality	Research Proposal Topic
132	Jeevan Madapala	Indian	Urban Flood Resilience: A Case Study of Gurugram
133	Kanchan Kumar	Indian	Drought and Farm Loans: A study of Financial Institution's Compensatory Government Expenditure
134	Mbiafeu Nfonbeu Marlene Francine	Cameroonian	Climate Change and Food Security in Cameroon: A comparative Economic Analysis of Resilience and Adaptation in Different Agro-ecologies
135	Muhammad Yaseen	Pakistani	Valuation of the Landslides along the Dargai–Malakand Road, Khyber Pakhtunkhwa part of CPEC Pakistan: Implication from geological aspect of slope failure and mitigation approach for future disaster risk reduction
136	Nargis Shabnam	Indian	Estimating Future Changes in Landslide Risk for Himalayan Terrain
137	Reza Bakhshoode	Iran	Nature-based solutions for urban blue and grey water under changing climate
138	Samuel Weniga Anuga	Ghana	Climate change and mental health risks of smallholder farmers in Northern Ghana
139	Sasmita Poudel Adhikari	Nepalese	A study on nutritional status of children under five years of age in earthquake affected areas of Nepal
140	Sheeba Farooq	Pakistani	Building communitie's resilience to manage natural disasters
141	Sitotaw Haile Erena	Ethiopian	Understanding the type, nature, causes, frequency and driving forces of flooding in Dire Dawa city, Ethiopia
142	Su Li	Chinese	Does Resilience Policies in Post-Disaster Period Worsen Air Quality of the Disaster Affected Areas and Their Neighboring Areas? A Research on the 2008 Wenchuan Earthquake
143	Tantely Sarah Randriamparany	MALAGASY	Gender and resilience to disaster risks in the urban environment: antananarivo
144	Ivan Taslim	Indonesian	Manufacture of Conblock Materials by Utilizing Clay Sediments for Flood Risk Reduction in Coastal Lake Limboto
145	Sabrina Zaman	Bangladeshi	Gendered Culture and Water Security: an exploratory study in coastal region of Bangladesh
146	Shengnan Wu	Chinese	Study on the Risk Communication in the Emergency Response from the Perspective of Discourse Analysis
147	Sushila Paudel	Nepalese	Participatory Action Research in Community-Based Health Education Program for Disaster Preparedness
148	Typson Dahan	Togolese	Fires, vegetable dynamics and climate change in contact area forest-savanna: case of the department of Toumodi in ivory coast center
149	Adnan Arshad	Pakistani	Impact Assessment of Regional Climate Warming and Extreme Weather Events to Natural Resource Management
150	Akinola Olalekan	Nigeria	Risk assessments survey of urban trees in the Nigerian selected cities (port Harcourt and Ibadan)
151	Ali Said	Tanzanian	The role of mangrove forests in reducing the impacts of climate change-related disasters in west b district, Zanzibar
152	Nformi Tarshi Lesly	Cameroonian	Investigating the impact of climate on crops production
153	Nirdesh Nepal	Nepalese	Landslide risk management along highways connecting China and Nepal
154	Rina Suryani Oktari	Indonesian	SECI-based Knowledge Creation in Enhancing Community Resilience towards Disaster Risk and Climate Change
155	Shakeel Mahmood	Pakistani	Flood Risk Modelling and Management in Panjkora Basin, Eastern Hindu Kush, Pakistan

No.	Name	Nationality	Research Proposal Topic
156	Subeg M Bijukchhen	Nepalese	Use of ambient seismic noise to estimate velocity structure of Bhaktapur, Nepal
157	Yifei Cui	Chinese	Investigation of Internal Erosion of Wide Grading Loose Soil
158	Isaac A. OYEKOLA	Nigeria	Social Health Insurance and Attainment of Sustainable Health Financing among Older
159	Olufemi Adetunji	Nigeria	Social Participation Framework for Climate Change Adaptation in Public Built Heritage in Nigeria
160	Oluwafemi A. Sarumi	Nigeria	Development of a predictive model to mitigate the effects of flood occurrences in sub-Saharan Africa
161	Repaul Kanji	Indian	Development of an easy-to-use tool to empower residents to assess their vulnerabilities to disaster risk: Building a comprehensive methodology in the Indian context
162	Sebleweng Ayichew Megerrssa	Ethiopian	Risk assessment of emerging arboviruses of public health significance for reducing risk of disasters with integrated interdisciplinary approach in Ethiopia
163	Zaw Ko Latt	Myanmar	Restoration of Soil Fertility in Cyclone Nargis Affected Areas in Myanmar
164	Zerihun Yohannes	Ethiopian	Myths and realities of gender and climate shock vulnerability

References

Ahsan, M. N., Khatun, A., Islam, M. S., Vink, K., Ohara, M., & Fakhruddin, B. S. (2020). Preferences for improved early warning services among coastal communities at risk in cyclone prone south-west region of Bangladesh. *Progress in Disaster Science*, 5, 100065.

Ajibade, I., & McBean, G. (2014). Climate extremes and housing rights: a political ecology of impacts, early warning and adaptation constraints in slum communities. *Geoforum*, 55, 76-86.

Amini-Hosseini, K., & Izadkhah, Y. O. (2020). From "Earthquake and safety" school drills to "safe school-resilient communities": A continuous attempt for promoting community-based disaster risk management in Iran. *International Journal of Disaster Risk Reduction*, 45, 101512.

Anderson-Berry, L., Achilles, T., Panchuk, S., Mackie, B., Canterford, S., Leck, A., & Bird, D. K. (2018). Sending a message: How significant events have influenced the warnings landscape in Australia. *International Journal of Disaster Risk Reduction*, 30, 5-17.

Anderson, C. C., Hagenlocher, M., Renaud, F. G., Sebesvari, Z., Emrich, C. T., & Cutter, S. L. (2019). Comparing index-based vulnerability assessments in the Mississippi Delta: Implications of contrasting theories, indicators, and methodologies. *International Journal of Disaster Risk Reduction*, 39.

Armaș, I., & Gavriș, A. (2013). Social vulnerability assessment using spatial multi-criteria analysis (SEVI model) and the Social Vulnerability Index (SoVI model) – a case study for Bucharest, Romania. *Natural Hazards and Earth System Sciences*, 13(6), 1481-1499.

Atrachali, M., Ghafory-Ashtiany, M., Amini-Hosseini, K., & Arian-Moghaddam, S. (2019). Toward quantification of seismic resilience in Iran: Developing an integrated indicator system. *International Journal of Disaster Risk Reduction*, 39, 101231.

Azadegan, S. (2018). *Dimensions of Vulnerability, Resilience*, and *Social Justice in a Low-Income Hispanic Neighborhood During Disaster Recovery*. Retrieved from Natural Hazards Center Quick Response Grant Report Series, 293. Boulder, CO: Natural Hazards Center, University of Colorado Boulder: https://hazards.colorado.edu/quick-response-report/dimensions-of-vulnerability-resilience-and-social-justice-in-a-low-income-hispanic-neighborhood-during-disaster-recovery

Basyal, G. K. (2018). The First 100 Hours: Emergency Response to the Gorkha Earthquake. In B. L., A. R. H., & R. T. (Eds.), *Evolving Narratives of Hazard and Risk*. Palgrave Macmillan, Cham.

Bates, J. (2020). *Cascading extreme weather beyond our experience: are we ready?* Retrieved from 12th Australasian Natural Hazards Management Conference https://www.bnhcrc.com.au/publications/biblio/bnh-6743

Bebbington, M. (2015). *First Steps to a National Volcano Hazard Model* Retrieved from Natural Hazards Research Platform Contest 2015: https://www.naturalhazards.org.nz/NHRP/Funding/Contest-2015-2012/Contest-2015/Contest-2015-Final-Reports

Becker, J., & Johnston, D. (2018). *10 Years Societal Resilience Research and Its Impact over the Past Decade*. Retrieved from Natural Hazards 2018: https://www.naturalhazards.org.nz/NHRP/Publications/Natural-Hazards-Issues

Bednar, D., Henstra, D., & McBean, G. (2019). The governance of climate change adaptation: are networks to blame for the implementation deficit? *Journal of Environmental Policy & Planning*, 21(6), 702-717.

Blaikie, P., Cannon, T., Davis, I., & Wisner, B. (1994). *Disaster pressure and release model*. London [etc.]: Routledge.

Boyland, M., Ensor, J., Johnson, K., Salamanca, A., Thomalla, F., & Tuhkanen, H. (2019). *A framework for transforming the relationship between development and disaster risk*. Retrieved from IRDR Working Paper Series: https://www.sei.org/publications/a-framework-for-transforming-the-relationship-between-development-and-disaster-risk/

Burby, R. J. (2006). Hurricane Katrina and the Paradoxes of Government Disaster Policy: Bringing About Wise Governmental Decisions for Hazardous Areas. 604(1), 171-191.

Chen, F., Guo, H., & Shirazi, Z. (2019). *Disaster risks and response strategies in process of urbanization in China*. Retrieved from Contributing Paper to GAR 2019: https://www.undrr.org/publication/disaster-risks-and-response-strategies-process-urbanization-china

Cheng, X., Wan, H., Huang, S., Li, C., & Zhang, H. (2018). Lessons learned from the 2016 Yangtze River flood in Anhui province, China. *International Journal of River Basin Management*, 16(3), 307-314.

Coco, G., & Bryan, K. (2018). *New tools for assessing climate change impacts on coastal hazards*. Retrieved from Natural Hazards 2018: https://www.naturalhazards.org.nz/NHRP/Publications/Natural-Hazards-Issues

Collins, J., Ersing, R., Polen, A., & Saunders, M. (2017). *Evacuation Behavior Measured During an Evacuation Order - An Assessment of the Effects of Social Connections on the Decision to Evacuate*. Retrieved from Natural Hazards Center Quick Response Grant Report Series, 293. Boulder, CO: Natural Hazards Center, University of Colorado Boulder: https://hazards.colorado.edu/quick-response-report/evacuation-behavior-measured-during-an-evacuation-order

Cui, P., Deep, R. A., Zou, Q., Lei, Y., Chen, X., & Cheng, D. (2017). *Natural Hazards and Disaster Risk in One Belt One Road Corridors*. Paper presented at the Advancing Culture of Living with Landslides, Cham.

Cui, P., Hu, K., Chen, H., & Zou, Q. (2018). Risks along the Silk Road Economic Belt owing to natural hazards and construction of major projects. 63(0023-074X), 989.

Cutter, S. L. (2018). Linkages between vulnerability and resilience. In S. Fuchs & T. Thaler (Eds.), *Vulnerability and Resilience to Natural Hazards* (pp. 257-270). Cambridge, England: Cambridge University Press.

Cutter, S. L., & Derakhshan, S. (2020). Temporal and spatial change in disaster resilience in US counties, 2010–2015. *Environmental Hazards*, 19(1), 10-29.

Cutter, S. L., & Gall, M. (2015). Sendai targets at risk. *Nature Climate Change*, 5 707-709.

Cutter, S. L., Ismail-Zadeh, A., Alcántara-Ayala, I., Altan, O., Baker, D. N., Briceño, S., Gupta, H., Holloway, A., Johnston, D., McBean, G. A., Ogawa, Y., Paton, D., Porio, E., Silbereisen, R. K., Takeuchi, K., Valsecchi, G. B., Vogel, C., & Wu, G. (2015). Pool knowledge to stem losses from disasters. *Nature*, 522, 277-279.

de Oliveira Mendes, J. M. (2009). Social vulnerability indexes as planning tools: beyond the preparedness paradigm. *Journal of Risk Research*, 12(1), 43-58.

Dellow, S., & Massey, C. (2018). *10 Years Lessons from New Zealand Landslides and Rockfall*. Retrieved from Natural Hazards 2018: https://www.naturalhazards.org.nz/NHRP/Publications/Natural-Hazards-Issues

Dittmar, M. (2014). Development towards sustainability: How to judge past and proposed policies? *Science of The Total Environment*, 472, 282-288.

Doyle, E. E. H., Becker, J. S., Neely, D. P., Johnston, D. M., & Pepperell, B. (2015). Knowledge transfer between communities, practitioners, and researchers: A case study for community resilience in Wellington, New Zealand. *Australasian Journal of Disaster Trauma Studies*, 19(2), 55-66.

Doyle, E. E. H., Khan, S., Adler, C., Alaniz, R. C., Athayde, S., Lin, K. H., Saunders, W., Schenk, T., SosaRodriguez, F., & Sword-Daniels, V. (2014). Reporting on the seminar-risk interpretation and action (RIA): decision making under conditions of uncertainty.

Du, S., Cheng, X., Huang, Q., Chen, R., Ward, P. J., & Aerts, J. C. J. H. (2019). Brief communication: Rethinking the 1998 China floods to prepare for a nonstationary future. *Nat. Hazards Earth Syst. Sci.*, 19(3), 715-719.

Duan, Y., Wan, Q., Huang, J., Zhao, K., Yu, H., Wang, Y., Zhao, D., Feng, J., Tang, J., Chen, P., Lu, X., Wang, Y., Liang, J., Wu, L., Cui, X., Xu, J., & Chan, P.-W. (2019). Landfalling Tropical Cyclone Research Project (LTCRP) in China. *Bulletin of the American Meteorological Society*, 100(12), ES447-ES472.

European Commission. (2015). *Risk Management Capability Assessment Guidelines* (2015/C261/03). Retrieved from https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52015XC0808(01)&from=EN

Fakharuddin, B., Tonkin+Taylor, I., Bostrom, A., Cui, P., Yu, L., Zou, Q., Sillman, J., Johnston, D., Jimenez, V., Chan, E. Y. Y., Chan, G. K. W., Hung, H., Huang, Z., Wong, C. K. P., Lim, C. S., Tajul Anuar, J., & Ibrahim, K. (2019). *Integrated Research on Disaster Risk (IRDR)*. Retrieved from Contributing paper to GAR 2019: https://www.preventionweb.net/files/65873_f301fahkruddinintegratedresearchond.pdf

Fakhruddin, B. S., & Chivakidakarn, Y. (2014). A case study for early warning and disaster management in Thailand. *International Journal of Disaster Risk Reduction*, 9, 159-180.

Fakhruddin, B. S., Murray, V., & Maini, R. (2017). *Disaster loss data in monitoring the implementation of Sendai Framework*: ICSU policy document. Retrieved from https://council.science/wp-content/uploads/2019/05/ISC_Disaster-Loss-Data-In-Monitoring-The-Implementation-Of-The-Sendai-Framework_May-2019.pdf

Fakhruddin, B. S., & Schick, L. (2019). Benefits of economic assessment of cyclone early warning systems-a case study on Cyclone Evan in Samoa. *Progress in Disaster Science*, 2, 100034.

Fan, X., Scaringi, G., Tanyas, H., Hales, T., Jibson, R., Allstadt, K., Zhang, L., Evans, S., Li, G., Pei, X., Korup, O., West, A., Westen, C. J., Hovius, N., & Xu, C. (2019). *Supporting Information for: Earthquake induced chains of geologic hazards: patterns, mechanisms, and impacts.*

Fan, X., van Westen, C. J., Xu, Q., Gorum, T., & Dai, F. (2012). Analysis of landslide dams induced by the 2008 Wenchuan earthquake. *Journal of Asian Earth Sciences*, 57, 25-37.

Gall, M. (2015). The suitability of disaster loss databases to measure loss and damage from climate change. *International Journal of Global Warming*, 8(2), 170-190.

Gall, M., & Cutter, S. L. (2016). Understanding disaster risk through loss data. *Solving the puzzle: Where to invest to understand risk, written contributions*, 70-73.

Gall, M., Cutter, S. L., & Nguyen, K. (2014a). *Governance in Disaster Risk Management*. Retrieved from IRDR AIRDR: http://www.irdrinternational.org/wp-content/uploads/2015/01/AIRDR-Project-Report-No.-3-WEB-6MB.pdf

Gall, M., Cutter, S. L., & Nguyen, K. (2014b). *Incentives for Disaster Risk Management* Retrieved from IRDR AIRDR: http://www.irdrinternational.org/wp-content/uploads/2015/01/AIRDR-Project-Report-No.-2-WEB-8MB.pdf

Gall, M., Cutter, S. L., & Nguyen, K. (2014c). *Transformative Development and Disaster Risk Management*. Retrieved from IRDR AIRDR: http://www.irdrinternational.org/wp-content/uploads/2015/01/AIRDR-Project-Report-No.-4-WEB-7MB.pdf

Gall, M., Emrich, C. T., & Cutter, S. L. (2014). Vulnerability and loss. In *Understanding risk in an evolving world: Emerging best practices* in natural disaster risk assessment. Washington D.C.: Global Facility for Disaster Reduction and Recovery, The World Bank.

Gall, M., Nguyen, K. H., & Cutter, S. L. (2015). IRDR: Is it really integrated? . *International Journal of Disaster Risk Reduction*, 12, 255-267.

Gao, W., Zhao, F., Hu, Z., & Feng, X. (2011). A two-moment bulk microphysics coupled with a mesoscale model WRF: Model description and first results. *Advances in Atmospheric Sciences*, 28(5), 1184.

German Committee for Disaster Reduction (DKKV e.V.). (2018). *Enhancing Synergies for Disaster Prevention in the European Union*. Retrieved from http://www.espressoproject.eu/

Ghaffarian, S., Rezaie Farhadabad, A., & Kerle, N. (2020). Post-Disaster Recovery Monitoring with Google Earth Engine. 10(13), 4574.

Ghafory-Ashtiany, M. (2014). Earthquake risk and risk reduction capacity building in Iran. In A. Ismail-Zadeh, A. Kijko, I. Zaliapin, J. Urrutia Fucugauchi, & K. Takeuchi (Eds.), *Extreme Natural Hazards, Disaster Risks and Societal Implications* (pp. 267-278). Cambridge: Cambridge University Press.

Golnaraghi, M. (2012). *Institutional partnerships in multi-hazard early warning systems: a compilation of seven national good practices and guiding principles*: Springer Science & Business Media.

Guillard-Gonçalves, C., Cutter, S. L., Emrich, C. T., & Zêzere, J. L. (2015). Application of Social Vulnerability Index (SoVI) and delineation of natural risk zones in Greater Lisbon, Portugal. *Journal of Risk Research*, 18(5), 651-674.

Hadorn, G. H., Hoffmann-Riem, H., Biber-Klemm, S., Grossenbacher-Mansuy, W., Joye, D., Pohl, C., Wiesmann, U., & Zemp, E. (2008). *Handbook of transdisciplinary research* (Vol. 10): Springer.

Hayashi, H., Shaw, R., & Doherty, B. (2018). Exploring the possibility of an online synthesis system for disaster risk reduction as a tool to promote “Consilience” of knowledge and practice. *Journal of Disaster Research*, 13(7), 1213-1221.

Holand, I. S., Lujala, P., & Rød, J. K. (2011). Social vulnerability assessment for Norway: A quantitative approach. *Norsk Geografisk Tidsskrift - Norwegian Journal of Geography*, 65(1), 1-17.

Holloway, A. (2015). Strategic mobilisation of higher education institutions in disaster risk reduction capacity building: Experience of Periperi U. *Global Assessment Report on Disaster Risk Reduction*, 49-72.

Holloway, A., & Fortune, G. (2019). *Beyond fragility: Advancing skilled human capital for disaster risk reduction and resilience in Africa.* Retrieved from Contributing Paper to GAR 2019: https://www.preventionweb.net/publications/view/65971

Institute for Catastrophic Loss Reduction. (2019). Focus on Flood mapping in Canada. Retrieved from https://www.iclr.org/wp-content/uploads/2019/09/ICLR_Flood-mapping_2019.pdf

IRDR. (2014). *Peril classification and hazard glossary* Retrieved from IRDR DATA: http://www.irdrinternational.org/wp-content/uploads/2014/04/IRDR_DATA-Project-Report-No.-1.pdf

IRDR. (2015). *Guidelines on Measuring losses from disasters - human and economic impact indicators*. Retrieved from IRDR DATA: http://www.irdrinternational.org/wp-content/uploads/2015/03/DATA-Project-Report-No.-2-WEB-7MB.pdf

IPCC. (2013). Climate Change 2013: The Physical Science Basis. In T. F. Stocker, D. Qin, G.-K. Plattner, M. Tignor, S. K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex, & P. M. Midgley (Eds.), *Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change.* Cambridge, United Kingdom and New York, NY, USA: Cambridge University Press.

IPCC. (2018). Summary for Policymakers. In V. Masson-Delmotte, P. Zhai, H.-O. Pörtner,

D. Roberts, J. Skea, P. R. Shukla, A. Pirani, W. Moufouma-Okia, C. Péan, R. Pidcock, S. Connors, J. B. R. Matthews, Y. Chen, X. Zhou, M. I. Gomis, E. Lonnoy, T. Maycock, M. Tignor, & T. Waterfield (Eds.), *Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty* (pp. 32). Geneva, Switzerland: World Meteorological Organization.

Ismail-Zadeh, A., Cutter, S. L., Takeuchi, K., & Paton, D. (2017). Forging a paradigm shift in disaster science. *Natural Hazards* 86(2), 969-988.

Izumi, T., Shaw, R., Ishiwatari, M., Djalante, R., & Komino, T. (2019). Thirty Innovations for Disaster Risk Reduction. Retrieved from https://apru.org/wp-content/uploads/2019/03/30-Innovations-for-Disaster-Risk-Reduction_final.pdf

Kenney, C. K., & Phibbs, S. (2015). A Māori love story: Community-led disaster management in response to the Ōtautahi (Christchurch) earthquakes as a framework for action. *International Journal of Disaster Risk Reduction*, 14, 46-55.

Kesik, T. (2015). Best practices guide: Management of inflow and infiltration in new urban developments. Retrieved from https://www.iclr.org/wp-content/uploads/PDFS/best-practices-guide-management-of-inflow-infiltration-in-new-urban-developments.pdf

Kilvington, M., & Saunders, W. (2019). Gaining public input on natural hazard risk and land-use planning: A case study from New Zealand. *Disaster Prevention and Management: An International Journal*, 28(2), 228-244.

Kovacs, P. (2020). *Climate Risks: Implications for the Insurance Industry in Canada.* Retrieved from https://www.insuranceinstitute.ca/en/resources/insights-research/Climate-risks-report

Kuscahyadi, F., Meilano, I., & Riqqi, A. (2017). *Spatial modelling of disaster resilience using infrastructure components of baseline resilience indicators for communities (BRIC) in special region of Yogyakarta*. Paper presented at the AIP Conference Proceedings.

Kwok, A. H., Becker, J., Paton, D., Hudson-Doyle, E., & Johnston, D. (2019). Stakeholders' perspectives of social capital in informing the development of neighborhood-based disaster resilience measurements. *Journal of Applied Social Science*, 13, 26-57.

Kwok, A. H., Doyle, E. E. H., Becker, J., Johnston, D., & Paton, D. (2016). What is 'social resilience'? Perspectives of disaster researchers, emergency management practitioners, and policymakers in New Zealand. *International Journal of Disaster Risk Reduction*, 19, 197-211.

Kyriazis, J., Zizzo, L., & Sandink, D. (2017). *Assessing local mandatory measures to reduce flood risk and inflow & infiltration in existing homes*. Retrieved from https://www.iclr.org/wp-content/uploads/PDFS/assessing-local-mandatory-measures-to-reduce-flood-fisk-and-inflow-infiltration-in-existing-homes.pdf

Lambie, E. S., Wilson, T. M., Brogt, E., Johnston, D. M., Ardagh, M., Deely, J., Jensen, S., & Feldmann-Jensen, S. (2017). Closed Circuit Television (CCTV) Earthquake Behaviour Coding Methodology: analysis of Christchurch Public Hospital video data from the 22 February Christchurch earthquake event. *Natural Hazards*, 86(3), 1175-1192.

Lauta, K. C., Albris, K., Zuccaro, G., & Grandjean, G. (2018). *ESPREssO Enhancing Risk Management Capabilities Guidelines*. Retrieved from www.espressoproject.eu

Layton, J. B., Li, W., Yuan, J., Gilman, J. P., Horton, D. B., & Setoguchi, S. (2020). Heatwaves, medications, and heat-related hospitalization in older Medicare beneficiaries with chronic conditions. *PLoS one*, 15(12), e0243665.

Lei, Y., Cui, P., Deep, R. A., Virginia, M., Alessandro, P., Giacomo, T., Muhammad, S., & Tilak, P. D. G. (2018). An international program on Silk Road Disaster Risk Reduction–a Belt and Road initiative (2016–2020). *Journal of Mountain Science*, 15(7), 1383-1396.

Li, D., Yuan, J., & Kopp, R. E. (2020). Escalating global exposure to compound heat-humidity extremes with warming. *Environmental Research Letters*, 15(6), 064003.

Li, Y., & Zhai, G. (2017). China's urban disaster resilience evaluation and promotion. *Planners*.

Liu, H., Wang, Y., Xu, J., & Duan, Y. (2018). A Dynamical Initialization Scheme for Tropical Cyclones under the Influence of Terrain. *Weather and Forecasting*, 33(3), 641-659.

Liu, Y., Ning, Z., Chen, Y., Guo, M., Liu, Y., Gali, N. K., Sun, L., Duan, Y., Cai, J., & Westerdahl, D. (2020). Aerodynamic analysis of SARS-CoV-2 in two Wuhan hospitals. *Nature*, 582(7813), 557-560.

Marx, S., Barbeito, G., Fleming, K., Petrovic, B., Pickl, S., Thieken, A., & Zeidler, M. (2017). Synthesis Report on Disaster Risk Reduction and Climate Change Adaptation in Germany. *DKKV-Schriftreihe*, 56, 75.

Matin, N., Forrester, J., & Ensor, J. (2018). What is equitable resilience? . *World Development*, 109, 197-205.

Mitchell, J. (2000). Crucibles of Hazard: Mega-Cities and Disasters in Transition. *Journal of Government Information*, 27.

Moe, T. L., & Pathranarakul, P. (2006). An integrated approach to natural disaster management. *Disaster Prevention Management: An International Journal*, 15(3), 396-413.

Morgan, J., Begg, A., Beaven, S., Schluter, P., Jamieson, K., Johal, S., Johnston, D., & Sparrow, M. (2015). Monitoring wellbeing during recovery from the 2010–2011 Canterbury earthquakes: The CERA wellbeing survey. *International Journal of Disaster Risk Reduction*, 14, 96-103.

Munene, M. B., Swartling, Å. G., & Thomalla, F. (2018). Adaptive governance as a catalyst for transforming the relationship between development and disaster risk through the Sendai Framework? *International Journal of Disaster Risk Reduction*, 28, 653-663.

National Disaster Resilience Strategy. (2019). *National Disaster Resilience Strategy - Rautaki ā-Motu Manawaroa Aituā,* . Retrieved from https://www.civildefence.govt.nz/assets/Uploads/publications/National-Disaster-Resilience-Strategy/National-Disaster-Resilience-Strategy-10-April-2019.pdf

NHRP. (2018). *10 years engineering and infrastructure research*. Retrieved from Natural Hazards 2018: https://www.naturalhazards.org.nz/NHRP/Publications/Natural-Hazards-Issues

Niles, S., & Contreras, S. (2019). *Social Vulnerability and the Role of Puerto Rico's Healthcare Workers after Hurricane Maria*. Retrieved from Natural Hazards Center Quick Response Grant Report Series, 293. Boulder, CO: Natural Hazards Center, University of Colorado Boulder: https://hazards.colorado.edu/quick-response-report/social-vulnerability-and-the-role-of-puerto-ricos-healthcare-workers-after-hurricane-maria

NSET. (2017). *Safer Society*. Retrieved from Annual Report 2017: https://www.nset.org.np/nset2012/images/publicationfile/Safer%20Society_Annual%20Report_FINAL_Small_1.pdf

Oliver-Smith, A., Alcántara-Ayala, I., Burton, I., & Lavell, A. (2016). *Forensic Investigations of Disasters (FORIN): a conceptual framework and guide to research*. Retrieved from IRDR FORIN: http://www.irdrinternational.org/wp-content/uploads/2016/01/FORIN-2-29022016.pdf

Oliver-Smith, A., Alcántara-Ayala, I., Burton, I., & Lavell, A. (2017). The social construction of disaster risk: Seeking root causes. *International journal of disaster risk reduction*, 22, 469-474.

Oulahen, G., McBean, G., Shrubsole, D., & Chang, S. (2018). Production of risk:

Multiple interacting exposures and unequal vulnerability in coastal communities. *Regional Environmental Change*, 19(3), 867-877.

Pan, J., Yao, Y., Liu, Z., Meng, X., Ji, J. S., Qiu, Y., Wang, W., Zhang, L., Wang, W., & Kan, H. (2021). Warmer weather unlikely to reduce the COVID-19 transmission: An ecological study in 202 locations in 8 countries. *Science of The Total Environment*, 753, 142272.

Parsizadeh, F., & Ghafory - Ashtiany, M. (2010). Iran public education and awareness program and its achievements. *Disaster Prevention and Management: An International Journal*, 19(1), 32-47.

Pelling, M. (2014). Transformation: A Renewed Window on Development Responsibility for Risk Management. 01(01), 1402003.

Pereira, J. J., & Hunt, J. C. R. (2019). Climate Science & Technology in Asia: Current Status and Future Needs. *Report of the Workshop on Status of Climate Science and Technology in Asia*.

Pereira, J. J., Muhamad, N., Lim, C. S., Aziz, S., & Hunt, J. (2019). *Making Cities Disaster Resilient in a Changing Climate: The Case of Kuala Lumpur, Malaysia*. Retrieved from IRDR Working Paper Series: https://www.preventionweb.net/publications/view/65393

Pereira, J. J., Pulhin, J. M., Nyda, C., Tran, D. T., & Satari, S. K. (2019). Appraising slow onset hazards for loss and damage: Case studies in Southeast Asia. *APN Science Bulletin*, 9(1), 45-51.

Pérez-Molina, E., Sliuzas, R., Flacke, J., & Jetten, V. (2017). Developing a cellular automata model of urban growth to inform spatial policy for flood mitigation: A case study in Kampala, Uganda. *Computers, Environment and Urban Systems*, 65, 53-65.

Porter, K., & Scawthorn, C. (2020). *Estimating the benefits of Climate Resilient Buildings and Core Public Infrastructure (CRBCPI)*. Retrieved from https://www.iclr.org/wp-content/uploads/2020/03/SPA-Climate-resiliency-book.pdf

Raikes, J., & McBean, G. (2017). Natural Disaster Management: Behaviour and Response in the City of Vancouver and District of Maple Ridge, British Columbia, Canada. . *Regional Environmental Change*.

Sandink, D., Kopp, G., Stevenson, S., & Dale, N. (2019). Increasing high wind safety for Canadian homes: A foundational document for low-rise residential and small buildings. Retrieved from https://www.iclr.org/wp-content/uploads/2019/04/ICLR-Western-SCC-Increasing-High-Wind-Safety-2019_EN.pdf

Sandink, D., Kovacs, P., Oulahen, G., & Shrubsole, D. (2016). Public relief and insurance for residential flood losses in Canada: Current status and commentary. *Canadian Water Resources Journal*, 41(1-2), 220-237.

Scherzer, S., Lujala, P., & Rød, J. K. (2019). A community resilience index for Norway: An adaptation of the Baseline Resilience Indicators for Communities (BRIC). *International Journal of Disaster Risk Reduction*, 36, 101107.

Sharma, A., Shaw, R., & Chen, F. (2017). *Strengthening Science Capacities for Sustainable Development and Disaster Risk Reduction: Regional Research Strategy*. Retrieved from Beijing China: https://rajibshaw.org/wpRS/wp-content/uploads/2018/09/DBAR-Disaster-Theme-Regional-Research-Strategy.pdf

Simmons, K. M., & Kovacs, P. (2018). Real estate market response to enhanced building codes in Moore, OK. *International Journal of Disaster Risk Reduction*, 27, 85-93.

Simonovic, S. (2020). Intensity-Duration-Frequency Curves under Climate Change (IDFCC). Retrieved from https://www.idf-cc-uwo.ca/

Singh-Peterson, L., Salmon, P., Goode, N., & Gallina, J. (2014). Translation and evaluation of the baseline resilience indicators for communities on the Sunshine Coast, Queensland Australia. *International Journal of Disaster Risk Reduction*, 10, 116-126.

Stockholm Environment Institute. (2018). Enabling an ambitious agenda for transformation in development and disaster risk. Retrieved from https://www.sei.org/publications/enabling-ambitious-agenda-transformation-development-disaster-risk/

Tamura, K., Rafliana, I., & Kovacs, P. (2018). Formalizing the concept of “build back better” based on the global forum on science and technology for disaster resilience 2017 WG4. *Journal of Disaster Research*, 13(7), 1187-1192.

Thomalla, F., Lebel, L., Boyland, M., Marks, D., Kimkong, H., Tan, S. B., & Nugroho, A. (2018). Long-term recovery narratives following major disasters in Southeast Asia. *Regional Environmental Change*, 18(4), 1211-1222.

Tiampo, K. F., Shcherbakov, R., & Kovacs, P. (2017). Probability Gain from Seismicity-Based Earthquake Models. In G. Michel (Ed.), *Risk Modeling for Hazards and Disasters* (Vol. 175). 2017: Elsevier.

Tuhkanen, H., Boyland, M., Han, G., Patel, A., Johnson, K., Rosemarin, A., & Lim Mangada, L. (2018). A Typology Framework for Trade-Offs in Development and Disaster Risk Reduction: A Case Study of Typhoon Haiyan Recovery in Tacloban, Philippines. *Sustainability*, 10(6), 1924.

Tuhkanen, H., Johnson, K., & Ensor, J. (2020). Guidelines for planning equitable disaster resilient development. Retrieved from https://www.sei.org/publications/guidelines-for-planning-equitable-disaster-resilient-development/

Van Den Bout, B., Van Asch, T. W. J., Hu, W., Tang, C., Mavrouli, O., Jetten, V. G., & Van Westen, C. J. (2020). Towards a model for structured mass movements: the OpenLISEM Hazard model 2.0 a. *Geoscientific Model Development Discussions*, 1-31.

Van Westen, C. J. (2019). District Disaster Risk Profile – Sughd Region: Multi-hazard Risk Assessment at District Level in Tajikistan. *A report submitted to UNDP in partial fulfillment of services under Contract ref.*: 43-2018-RFP-UNDP-DRMP.

Van Westen, C. J., Bakker, W., Andrejchenko, V., Zhang, K., Berlin, J., Cristal, I., & Olyazadeh, R. (2014). *RiskChanges: a Spatial Decision Support System for analysing changing hydrometeorological risk*. Paper presented at the Proceedings of the international conference on analysis and management of changing risks for natural hazards.

Villagra, P. (2019). Drivers of community resilience to natural hazards: The experience of Southern Chile. *Environment: Science and Policy for Sustainable Development*, 61(4), 4-17.

Vogel, B., Henstra, D., & McBean, G. (2020). Sub-national government efforts to activate and motivate local climate change adaptation: Nova Scotia, Canada. *Environment, Development and Sustainability*, 22(2), 1633-1653.

Wang, R., Xiong, Y., Xing, X., Yang, R., Li, J., Wang, Y., Cao, J., Balkanski, Y., Peñuelas, J., & Ciais, P. (2020). Daily CO2 emission reduction indicates the control of activities to contain COVID-19 in China. *The Innovation*, 1(3), 100062.

Wang, X., & Zhang, R. (2020). How Did Air Pollution Change during the COVID-19 Outbreak in China? *Bulletin of the American Meteorological Society*, 101(10), E1645-E1652.

Ward, P. J., Jongman, B., Aerts, J. C. J. H., Bates, P. D., Botzen, W. J. W., Diaz Loaiza, A., Hallegatte, S., Kind, J. M., Kwadijk, J., Scussolini, P., & Winsemius, H. C. (2017). A global framework for future costs and benefits of river-flood protection in urban areas. *Nature Climate Change*, 7(9), 642-646.

Woods, R. (2018). *Riskscape 2.0 - What is coming next*? Retrieved from Natural Hazards 2018: https://www.naturalhazards.org.nz/NHRP/Publications/Natural-Hazards-Issues

Yao, Y., Pan, J., Liu, Z., Meng, X., Wang, W., Kan, H., & Wang, W. (2020). No association of COVID-19 transmission with temperature or UV radiation in Chinese cities. *European Respiratory Journal*, 55(5).

Yao, Y., Pan, J., Wang, W., Liu, Z., Kan, H., Qiu, Y., Meng, X., & Wang, W. (2020). Association of particulate matter pollution and case fatality rate of COVID-19 in 49 Chinese cities. *Science of The Total Environment*, 741, 140396.

Yuan, J., Stein, M. L., & Kopp, R. E. (2020). The evolving distribution of relative humidity conditional upon daily maximum temperature in a warming climate. *Journal of Geophysical Research: Atmospheres*, 125(19), e2019JD032100.

Zhang, C., Wang, Y., & Xue, M. (2020). Evaluation of an E–ε and Three Other Boundary Layer Parameterization Schemes in the WRF Model over the Southeast Pacific and the Southern Great Plains. *Monthly Weather Review*, 148(3), 1121-1145.

Zhang, L., Pathak, A., & Ganapati, N. E. (2019). *Stakeholder Values in Hurricane Michael: Understanding How Value Dynamics Contribute to Collaborative Decision Making in Disasters*. Retrieved from Natural Hazards Center Quick Response Grant Report Series, 293. Boulder, CO: Natural Hazards Center, University of Colorado Boulder: https://hazards.colorado.edu/quick-response-report/stakeholder-values-in-hurricane-michael

Zuccaro, G., Leone, M. F., Martucci, C., Grandjean, G., Lauta, K. C., & (Eds.). (2018). *ESPREssO Vision Paper on future research strategies following the Sendai Framework for DRR* 2015-2030. . Retrieved from http://www.espressoproject.eu/

Chapter 3. Advancing international scientific cooperation and dialogue

As an international scientific programme, IRDR has an overall role in promoting scientific exchange and cooperation and science-policy dialogue. To this end, IRDR has endeavoured to provide different platforms for engagement and as well as knowledge products for policy improvement. IRDR's relevance and significance in this aspect is reviewed in this chapter, as we look back briefly on IRDR's major international scientific conferences and outputs, main policy recommendations and papers, and key research partnerships. Individual perspectives from IRDR members are also provided.

3.1 The global position of IRDR in DRR

The 2008 IRDR Science Plan noted that there was neither an established and ongoing scientific assessment process, like the IPCC, nor an internationally planned and coordinated scientific research programme. The UNFCCC had benefited from four scientific assessments of climate change by the IPCC, which had been able to draw upon the internationally-planned and coordinated scientific research programmes of the World Climate Research Programme (sponsored by WMO, ICSU and the IOC of UNESCO), the International Geosphere-Biosphere Programme (sponsored by ICSU) and other international and national programmes. IRDR was created with the hope that it would take a similar role in the coordination of the scientific research programmes in DRR and fill the gaps.

With its Scientific Committee to collect and integrate individual expertise in specific domains, National Committees to facilitate national research and application, International Centres of Excellence to enhance the knowledge production and sharing, Working Groups to focus on frontier scientific questions, and Young Scientist Programme to support the young generation, IRDR did become a programme which successfully mobilized the international research capacity, creating new methodologies and new conceptions, and building bridges for science and policy dialogue in DRR.

Over its ten years of operation, IRDR has witnessed the international consensus shift from disaster management to risk management and risk reduction. IRDR played an important role in the context framing of this process, not only through its direct contributions to the formulation of the Sendai Framework, but also through advocating this concept in the implementation of the global agenda. To this end, IRDR kept "integrated" and "interdisciplinary" as the criteria in all its DRR activities. This systematic approach is reflected for example in the evaluation criteria of ICoE nominations and IRDR Young Scientist applications. The "integrated approach" is a firm requirement for all the application proposals from both ICoEs and Young Scientists. This interdisciplinarity can also been seen with the diverse stakeholders engaged in the IRDR community, with multi-agencies collaboration the norm in the IRDR projects.

Under the co-sponsorship of ISC and UNDRR, IRDR has been, to some extent, acting as a scientific representative of ISC and UNDRR in addressing issues in the field of DRR. IRDR has spearheaded efforts to facilitate and contextualize the implementation of Sendai Framework and other related UN agenda at national and local levels. IRDR also acts as an international platform for the regional and national projects to present their work and achievements, and to outreach to other stakeholders. Finally, IRDR facilitates the visualization, teaching, and spreading of good practices though its meetings, workshops and internet portals.

To understand how international and regional institutions and programmes are positioned and engaged in the global DRR endeavour through the Sendai Framework, a mapping of typical DRR institutions using web-based accessible information has been carried out in an IRDR Working Paper[48]. 32 active institutions were selected and analysed by looking through respective institutional nature, goals and missions, products and services, and more perspectives. The results indicate that these DRR institutions and programmes have covered a good spectrum of actions, including: a) monitoring, analysing, and coordinating the implementation of Sendai Framework; b) developing global platform for disaster risk reduction; c) promoting multi-disciplinary and integrated disaster science research; d) establishing disaster monitoring and early warning networks; e) applying disaster prevention and mitigation engineering and information technology; f) establishing data, information and knowledge services; and g) improving multi-scale disaster reduction practices. This mapping clearly demonstrates the important role IRDR plays in promoting multi-disciplinary and integrated disaster science research, science-policy interface, institutional capacity building, and the fostering young professionals in the field of disaster prevention and mitigation.

As a new initiative, IRDR inevitably had weaknesses and shortcomings in operation. The team in the IPO of IRDR has proved too small, and resources have been proved too limited compared to the tremendous needs and requirements. These include, for example, the resources needed to facilitate international science-policy dialogues; to develop new norms, standards, and research methodologies; to draw up and successfully and effectively communicate achievements and lessons learnt to various stakeholders; and to provide sufficient support to research communities in their integrated search initiatives. Additionally, there has also been a visible unbalance of IRDR work between different regions.

◆ Roles and relevance of IRDR as seen by IRDR SC members and Executive Directors

The former IRDR SC members and Executive Directors were invited to provide views, evidences and suggestions regarding the roles and relevance of IRDR and its impacts.

48 Wang, J.L., Han, Q.L., Wu, Y.X., Zhang, M., Lian, F.(2020). Mapping Disaster Risk Reduction Institutions Using Web-based Accessible Information. *IRDR Working Paper Series*, 16 pages. doi: 10.24948/2020.08

Sálvano Briceño

IRDR Scientific Committee Chair (2011-2013), Member (2013 – 2017)

Despite not having impacted the international policy settings as it was expected in its inception, with disaster risk increasing rather than reducing in the world, the IRDR has nevertheless made some substantive contributions both to international policy organs, UNISDR and ISC notably, and to academic and scientific institutions working in this field and aiming at reducing the risk of disasters. IRDR's value and relevance remain intact, with greater necessity given the rapidly increasing urban, climate and inequality risks. Its most important activities, in my view, the FORIN and RIA methodologies, as well as the DATA and international centres of excellence networks, provide a formidable basis to support and guide further work on reducing disaster risk, assuming, of course, that the IPO and Scientific Committee manage to influence and work closely together with the most relevant policy actors at international as well as national, local and academic levels, facilitating a team effort to make greater impact in changing institutional and personal practices and behaviours for increased and more effective risk reduction and management at all levels.

Rajib Shaw

Executive Director (2016-2017), Member (2017-onwards)

The key achievement of IRDR as an international scientific program lies in its research networks. The SC members (both past and present) brings a great knowledge and human resource network. The institutions (ICoEs), and committees (regional and national) are considered as the engine of the network. Thematic ICoEs spread over both developed and developing countries were the key footprint of innovative research of IRDR. The last part was the new generation researchers (young scientist network), which has also expanded the program to bring it to a wider audience, especially for the benefit of science in the global south. Collaboration (both formal through MOU and informal) with other research programs like WWRP of WMO, Belmont Forum, Future Earth, Urban Health Wellbeing etc. have been found beneficial to all, enabling programs to learn from each other. Thus, IRDR's performance can be seen through: 1) new innovative research product (like FORIN), 2) institutional network (ICoE / RC/ NC), 3) human resources (SC members), 4) developing new generation researchers (young scientists) and 5) partnership (with other science programs).

Jane Rovins

First Executive Director (2010-2013)

IRDR was instrumental in the years leading up to the Sendai Framework to get the inclusion of science and research into the regional statements and ultimately the Sendai Framework. This was a significant and key accomplishment of IRDR.

The FORIN project seems to be active and contributing to scientific knowledge. It is not clear were RIA, DATA and AIRDR are or the contribution beyond the initial reports and activities. Several of the IRDR projects seemed to end when the member left the Science Committee even if there was a need or opportunity for the work to continue.

IRDR should take a larger role in activities like the GAR, IPCC, SDGs and other global reports. This would be an opportunity to make significant impacts in the DRR research going forward.
On a smaller scale IRDR was able to bring together natural and social scientists to work together and begin to have conversations about the interconnectedness of disaster research. This may be the single most important thing that IRDR has accomplished.

Shuaib Lwasa

IRDR SC Member (2013-2018), Vice-Chair (2014-2016), Chair (2016-2018)

My opinion about IRDR is that despite the challenges over the program period, as a network of professionals in DRR, it has achieved a lot in context of the challenges it faced. IRDR has enabled a build-up of a network of senior professionals organized in working groups of its structure with a role to advance disaster science manifesting inform of journal articles and reports that have been published. Through its structures of working groups, the Early (Young) Career Scientists, IRDR had demonstrated its relevance in the DRR space. IRDR has had impact on young professional in various countries and universities who are not only developing skills and knowledge base but also advancing the frameworks developed. The national committees as part of its structure have also been very critical in advancing the discourse of DRR in governance circles happening at national but also regional/continental levels. IRDR has been impactful on the global level with the involvement of its members/associates in UNDRR global discussions on solutions but also enabling the framing of UNSFDRR. Having had Scientific Committee members representing most sectors including private sector, the programs out of IRDR and the publications have impactfully shaped the understanding of risk with its science plan objectives squarely replicated in the UNSFDRR. Further getting into the Science and Technology Road map for implementation of UNSFDRR. This illustrates a key achievement of IRDR.

3.2

IRDR as the science and policy interface

3.2.1 Dialogues through meetings and conferences

◆ IRDR Conference

The IRDR Conferences in 2011 and 2014 were two international and high-level scientific gatherings on the challenges of implementing integrated disaster risk research, inter-organisational collaboration and policy, as well as the interaction with global discourses on sustainable development. The sessions provided by the IRDR Conferences addressed the range of environmental hazards, vulnerability, and sustainability at both global and local scales. It included key discussions on the influence of science in the Hyogo Framework for Action (HFA2) in preparation for the 2015 World Conference on Disaster Risk Reduction (WCDRR) in Sendai, Japan.

The IRDR 2011 Conference was held from 31 October-2 November 2011, at the Beijing International Convention Center. It was organized by the IRDR IPO and the CAST. The conference, titled “Disaster Risk: Integrating Science and Practice”, aimed to advance new comprehensive approaches to natural hazards research and disaster risk reduction that investigated the root causes of disasters and incorporated input from scientists, decision-makers, and the public. Sessions revolved around three main topics:

characterization of hazards, vulnerability and risk; understanding decision-making in complex and changing risk contexts; and reducing risk and curbing losses through knowledge-based actions. Attendees included ICSU President and Nobel Laureate Yuan Tseh Lee, UNESCO Special Envoy for Haiti and Former Governor General of Canada Michaëlle Jean, as well as state officials from around the world.

The 2011 Beijing Declaration on IRDR

The 300+ participants at the inaugural IRDR Conference organized by IRDR and the China Association of Science and Technology (CAST) and held in Beijing, China from 31October to 2 November 2011, acknowledge that to address disaster events requires a more strategic integrated approach of all scientists and engineers with policy makers, the insurance industry and the mass media to make disaster risk reduction a reality. The impacts of disasters triggered by natural hazards continue to grow and reduce the capacity for countries of the World to move towards sustainable development. The Conference provided a platform from which to launch trans-disciplinary, multi-sectorial alliances for the advancement of disaster risk research. Individual Conference events facilitated information sharing and knowledge transfer between researchers, practitioners and policy makers.

The 2011 Beijing Declaration on IRDR:

- recognizing the IRDR Science Plan and the outcomes of this Conference and the valuable contributions made by participants; and，
- being fully aware of the international policy guidance provided by the HFA (2005-2015): Building the Resilience of Nations and Communities to Disasters, and other major policy and technical initiatives;
- calls for commitments to:

1. RESEARCH: Promote and advance research on natural, social, engineering and technology aspects of disaster risk in an integrated environment and enhance team efforts in hazard and disaster risk research, building on existing research networks and initiatives, and integrating various stakeholder needs at all levels
2. INTEGRATION: Ensure that disaster risk research programmes and policies are integrated across disciplines, and contribute to enhancing policy-making and capacity building for reducing risk in the face of natural hazards
3. GLOBAL STANDARDS: Develop and coordinate globally standardized open source information, disaster loss data, event documentation and analysis procedures, guidelines and frameworks for integrated and effective disaster risk management
4. AWARENESS RAISING: Raise awareness of decision-makers and the public by promoting effective, integrated, demand-driven, evidence-based disaster risk initiatives and increased advocacy
5. EDUCATION: Promote a holistic approach in natural hazards and disasters risk education and training by promoting integration of risk into various curricula
6. INCREASE FUNDING: Motivate funding sources (public, private, humanitarian, development, scientific, etc.) to allocate priority funding to address the urgent need for applied integrated research on disaster risks
7. AND specifically for the:

- Promotion of Forensic Investigations of Disasters (FORIN) by scientists, politicians and decision makers for a sound integrated disaster risk reduction through the development of a series of case studies with partners.
- Advancement of better integration of social sciences into disaster risk research, especially with regard to decision-making leading to Risk Interpretation to Action (RIA) research projects.
- A concise analysis of existing and applied methodologies of disaster data collection and impact assessment leading to standardized and transparent data collaboration under the Disaster Impact and Loss Assessment Data (DATA) project.
- Establishment of an Assessment of Integrated Research on Disaster Risk (AIRDR), a first systematic and critical global assessment of research on disaster risks.
- Enhanced and focused interaction between scientists, politicians and policy-makers, by introducing as project's input the search of success by political actors.
- Contributions to the dissemination and implementation of recommendations stemming from the IPCC's Special Report on Managing the Risk of Extreme Events (SREX), and the preparation of the 2013 UN Global Assessment Report on Disaster Risk Reduction.

The IRDR 2014 Conference, titled "Integrated Disaster Risk Science: A Tool for Sustainability," was designed to emphasize the importance of science as a tool to address hazard risks and issues of sustainable development. It took place from 7-9 June 2014 in Beijing. Once more, it was held at the Beijing International Convention Center and was organized by the IRDR IPO and CAST. Through a series of plenaries and break-out sessions dealing with the challenges of implementing integrated disaster risk research, inter-organisational collaboration, and interaction with policy-makers, as well as the coordination with activities aimed at promoting sustainable development and climate change adaptation, sessions addressed the full range of environmental hazards, vulnerability, and sustainability, in both global and local contexts. The IRDR Conference 2014 brought together some 200 leading experts and some of the best of an emerging cohort of young researchers in the field of disaster risk reduction from all academic and professional backgrounds to help create a "global IRDR community," and bring continued worldwide attention to the IRDR programme. The output of the 2014 Conference together with the follow up actions by IRDR Scientific Committee and individual experts of IRDR, as well as the active participation of many of them at the Sendai Conference 2015, ensured the IRDR's contribution to the formulation of the Sendai Framework.

The 2014 IRDR Conference report are can be found at: 2nd IRDR Conference – Integrated Disaster Risk Science: A tool for sustainability. In: Planet@Risk, 2(5), Special Issue for the Post-2015 Framework for DRR: p. 332-336, Global Risk Forum GRF Davos, Davos.

Tokyo Conferences

The Tokyo Conference on International Study for Disaster Risk Reduction and Resilience which took place between 14-16 January, 2015 was co-organized by IRDR, the Science Council of Japan (SCJ), the United Nations International Strategy for Disaster Reduction (UNISDR) and Tokyo University. His Imperial Highness, the Crown Prince of Japan, attended the opening ceremony of the three-day conference which brought together nearly 400 attendees from 37 countries.

In his keynote speech, ICSU President Gordon McBean outlined the ICSU's role coordinating the global Science and Technology community through IRDR, and highlighted the need to strengthen coordination and cooperation across scientific and research organizations, and institutions and networks currently delivering scientific information on disaster risk reduction, and to connect them to policy-makers and practitioners. This approach, called the Science and Technology Partnership for DRR, was proposed by the Science & Technology Major Group led by ICSU/IRDR during the preparatory work for the 3rd World Conference on Disaster Risk Reduction, held in Sendai, Japan, from 14-18 March 2015. A four-part strategy, it consists of a synthesis of the knowledge, assessment, monitoring and review.

Presentations and discussions during the three days of the conference provided input into the revision of the Tokyo Statement 2015 and the draft Tokyo Action Agenda presented on January 16.

The **Tokyo Statement 2015** called for:

- More awareness on the part of policymakers and practitioners of the latest scientific knowledge on disasters
- Greater empowerment of national platforms to incorporate science and technology into real practice
- Increased importance of science in disaster risk reduction through the development of collaborative frameworks with Earth environmental sciences and global Earth observations, thus promoting inter- and trans-disciplinary approaches for human well-being

The **Global Forum on Science and Technology for Disaster Resilience 2017**, held in Tokyo from 23-25 November 2017, was co-organised by SCJ, ICSU, UNISDR and IRDR. The declaration addressed science and technology action for a disaster-resilient world and committed to join and led efforts by the science and technology community to work closely with stakeholders and partners at local, national, regional and global levels towards the achievement of a disaster resilient world where nobody is left behind.

Tokyo Statement

◆ Science and technology action for a disaster-resilient world

With this declaration, we, the participants at the Global Forum on Science and Technology for Disaster Resilience 2017, held in Tokyo from 23-25 November 2017, commit to join and lead efforts by the science and technology community to work closely with stakeholders and partners at local, national, regional and global levels towards the achievement of a disaster resilient world where nobody is left behind.

A new era on disaster risk reduction has begun. The Sendai Framework for Disaster Risk Reduction 2015-2030 emphasizes the importance of a scientific basis for risk-informed development and investment. It highlights the important linkages and mutual reinforcement for disaster risk reduction with the 2030 agendas: the SDGs, the Paris Agreement on Climate Change, the Addis Ababa Action Agenda (AAAA) for financing and the New Urban Agenda. The importance of a science-based risk-informed planning and decision-making has been pronounced more than ever before.

The 2017 Global Forum builds on the outcomes of the First Science and Technology Conference in January 2016, namely the Science and Technology Roadmap to Support the Implementation of the Sendai Framework for Disaster Risk Reduction 2015-2030 and accompanying Science and Technology Partnership. The outcomes of the 2017 Global Forum should be incorporated in the 6th Session of the Global Platform for Disaster Risk Reduction in Geneva, Switzerland, in May 2019.

In support of the implementation of the Science and Technology Roadmap, we identify the following needs under the four priorities for action of the Sendai Framework:

1) We need to contribute to knowledge on disaster risk. Through enhancement and extension of the existing research programs we need to develop a system for collection, archiving, management, analysis, modelling, and use data concerning root causes, risk drivers, disaster risk and disaster damage and losses. In support of policy makers and practice, establish and use reliable scientific frameworks and networks for evaluating disaster risk on a regular basis, as a function of the identification and assessment of hazards, vulnerability, and exposure including single and cascading events. The use of scientific tools, including geospatial information and earth observation systems, should be promoted to provide and share disaster risk information at different scales before, during and after disasters. In addition, participatory research methods involving grassroots and indigenous communities and systematically organized education for improving disaster literacy should be encouraged.

2) We need to contribute to strengthening disaster risk governance and accountability. Promote dialogue in local languages on disaster risk reduction between scientific sectors and policy makers; facilitate networking between them; create and implement a systematic framework in which disaster risk assessment is used to make decisions for planning and development based on scientific evidence; improve data collection in proper ways and share them for research which could discover root causes of vulnerabilities; and gain the necessary trust to ensure collaboration among all actors in the reduction of risk by co-design of projects and co-production of solutions.

3) We need to encourage investment in disaster risk reduction and adaptation for resilience. Develop and implement tailor-made methods to assess disaster risks and share those among relevant Government agencies and key stakeholders including international financial institutions and the private sector at large as the main investor in all countries; propose policies that are highly effective as ex-ante investment and technologies that deliver a high return on the investment; create and provide incentives for investment in human capital; develop application criteria for each disaster prevention measure; propose reasonable plans for the develop methods for an optimal, risk-based allocation of limited resources; monitor the effectiveness of investments in DRR; and strengthen the capacity of scientific and technological disaster research and education in particular. Also we need to support implementation of sustainable observation infrastructure.

4) We need to promote "Build Back Better" in recovery, rehabilitation and reconstruction. Take actions for sharing common paradigms including “rebuilding lives”, "rebuilding livelihoods", "rebuilding economy" and "rebuilding regional communities"; developing indicators and guidelines based on scientific evidence; and make plans for disaster recovery, rehabilitation and intelligent reconstruction processes. To implement these effectively, support the development of legislation and procedures, based on enhanced scientific evidence, prior to disasters and based on scientific scenarios for possible disaster damage. We urge to actively invest in research with long vision.

Successful disaster risk reduction depends on innovation and interdisciplinary approaches. The Science and Technology Community has a responsibility in this effort to co-create and co-implement new types of science and technology in society.

1) We need to promote and implement interdisciplinary and transdisciplinary collaboration. To assess the full spectrum of disaster risks, including those associated with natural hazards and vulnerability as well as anthropogenic and technological risks, we should develop innovative, integrated approaches and technologies for risk assessment that embrace all science, including citizens’ health and mental conditions, as well as other relevant stakeholder groups. Specifically, this should include efforts to advance intergenerational collaboration. The risks of highly complex mega or widespread small and medium-size disasters should be addressed seamlessly through collaboration among all stakeholders. The definition and usage of existing terminology should be clearly confirmed to avoid misunderstandings.

2) We need to produce periodic synthesis reports on the state of science and technology for risk-sensitive development and investment. To understand and measure the status and progress of science and technology, we propose producing an online synthesis system with periodic reports incorporating "cognizing" science and "designing" science in a transdisciplinary way. The online and participatory report system would be multi-layered (from global to local), with diversity in language, user group (policy makers to practitioners) and age group (including the young scientists). A specific science communication and maintenance strategy will be developed at the inception stage of the synthesis report. Enhance resilience by promoting science and evidence-based policies and practices for disaster risk reduction that clearly factor in prediction, prevention and response strategies.

3) We need to contribute to national platforms for more effective use of science and technology. Reflecting the call for an all-of-society approach in The Sendai Framework, a wide range of knowledge and expertise available within the national science and technology community should be effectively integrated into national platform activities, where policy makers and practitioners may indicate their specific needs regarding science and technology. Contributions from science and technology should include: translating the Sendai Framework into local languages; providing appropriate scientific advice for the collection, assessment and analysis/archiving of annual disaster records; assisting the national platform in compilation and publication of case studies on interactive dialogue between local authorities and scientists & engineers which led to successful disaster risk reduction, for replication in the country and for sharing internationally; and assisting the Government in compiling and publishing their national reports on disasters, including Sendai Framework Monitoring.

As a first step to pursue steady implementation of these actions, we commit to work closely with relevant stakeholders to develop and implement the following documents:

1) Guidelines for strengthening national platforms for DRR and coordination mechanisms through enhanced contribution of science and technology.

2) Periodic synthesis reports on the state of science and technology for reducing disaster risk.

International research programs and alliances commit to implementing the outcomes of this meeting of experts to focus their research priorities and strengthen their contributions to the Sendai Framework to enhance the understanding of disaster risk, supporting governance and prioritizing investments in disaster risk reduction, and enhancing disaster preparedness for effective response. Particular focus must be placed on the engagement and harnessing of the potential of grassroots communities, women and youth, as well as other groups such as persons with disabilities.

Increased disaster risk demands an urgent response. Inaction is no longer an option. The support of all stakeholders is necessary.

◆ 2016 UNISDR Science and Technology Conference on the Implementation of the Sendai Framework for Disaster Risk Reduction 2015–2030

The UNISDR Science and Technology Conference on the Implementation of the Sendai Framework for Disaster Risk Reduction 2015–2030 was held in January 2016 to discuss the role of science and technology in implementing the Sendai Framework for Disaster Risk Reduction 2015–2030. This is the first international conference for the post-2015 United Nations landmark agreements. IRDR was one of the co-organisers.

The conference successfully launched the Science and Technology Partnership, and crystalized an agenda for the science and policy community to support the implementation of the Sendai Framework. The latter is reflected in the Global Science and Technology Road Map. Other notable outcomes included the proposal to launch a Women in DRR Science platform supported by UN Women, UNISDR, and UNESCO; and the launch of the Young Scientists in DRR platform that is coordinated by the UN Major Group for Children and Youth. The official conference outcomes are summarized on the conference website[49].

◆ Science and Policy Forum of 2019 Global Platform for DRR

The Science and Policy Forum for the Implementation of Sendai Framework for Disaster Risk Reduction was organised by United UNDRR Science and Technology Advisory Group (STAG), International Science Council (ISC) and IRDR (IRDR), and took place from 13-14 May 2019, at Assembly Hall, Palais des Nations, Geneva. The Forum was one of the major pre-events of the 2019 Global Platform for Disaster Risk Reduction (GP2019).

The one-and-half day Science & Policy Forum brought together some three hundred experts from the Member States, policy making bodies, research institutions, civil society organizations, enterprises and other relevant sectors. The Forum provided an open place for experts to share and review progress in global, regional, national and local implementation of science-based policy making and risk-informed development, and to identify knowledge gaps and opportunities to strengthen a comprehensive and interdisciplinary science base for the implementation of the Sendai Framework. The dialogue and exchange through the Forum sessions helped enhance the engagement between science and policy for risk-informed decision making across the 2030 Agenda.

Notably, the Science & Policy Forum launched the contextualized Global Science and Technology Road Map, an important instrument for coherent science and technology backed actions in DRR, which opened the dialogue on the need to review hazard terminology and enhance interdisciplinary cooperation, discussed the best way forward for better DRR data, looked at the roles of technology in DRR (in terms of both opportunities for solutions as well as factors of new uncertainties), and deliberated the overall roles of science and technology for resilience.

◆ 3rd Huangshan Dialogue on UNESCO Sites and Sustainable Development

At the 3rd Huangshan Dialogue on UNESCO Sites and Sustainable Development, which took place from 31 October-3 November 2018, UNESCO, its International Centre on Space Technologies and Cultural Heritage (HIST), and IRDR co-organised the session Disaster Risk Assessment and Mitigation for UNESCO Sites. This concerns three categories of internationally-designated areas, namely, Biosphere Reserves, Global Geoparks and World Heritage sites, and together comprise more than two thousand sites. The technical panel discussion resulted in an outcome document in which UNESCO and IRDR proposed several actions for consideration at the 2019 Global Platform for Disaster Risk Reduction:

49 https://www.unisdr.org/partners/academia-research/conference/2016/

Passage from Outcome Document

The following recommendations and key discussion points were made during the session:

1) The use of remote sensing and related technologies for hazard risk assessment and early warning has significant potential for further application.

2) An integrated, comprehensive global database on the application of remote sensing and related technologies for disaster risk reduction would be of considerable value.

3) Engineering solutions to mitigate disaster risk must be designed so as to be appropriate in the context of local conditions, with standards aligned with trends in hazard intensities.

4) The comprehensive, recently completed DRR survey among UNESCO-designated sites has yielded important data and results with the potential to serve as the basis for decision- and policy-making.

5) Existing levels of site-to-site and other modalities of international cooperation do not reach their full potential –considerable benefits could be derived from increased and intensified cooperation.

6) Local and traditional knowledge of cultural and natural heritage – ranging from knowledge of techniques, materials, landscape ecology, agriculture and more – are essential components in reducing and mitigating disaster risk and should be given full consideration.

Towards the implementation of DRR at UNESCO-designated sites, the following actions were recommended by the participants of the session.

1) Consider the establishment of an international task group on DRR for IDAs. This task group could be composed of committed DRR organizations such as IRDR, IDMR and ICL, under the overall guidance of UNESCO. First understanding on the modality of such a group would be discussed between UNESCO and IRDR in the upcoming year.

2) Continue the discussion on DRR for IDAs started at the Huangshan Dialogue, with particular attention to relevant indicators under international frameworks (Sendai, 2030 Agenda and the SDGs, Paris Agreements, New Urban Agenda, SAMOA Pathway, etc.)

3) Identify and promote concrete DRR actions at IDAs through the design and implementation of field projects and research cooperation, with focus on sites affected by recent major natural hazards such as Jiuzhaigou Biosphere Reserve/World Heritage and Kathmandu Valley as demonstration cases.

4) Through UNESCO and IRDR, bring the issue of DRR for IDAs to the attention of the 2019 Global Platform for Disaster Risk Reduction.

◆ Asia Science and Technology Conference for DRR

The Asia Science and Technology Conference for DRR is a serial conference organized by UNDRR AP-STAG, UNDRR AP Regional Office, and the national DRR departments regarding the host countries, with IRDR as a co-organizer.

The **1st Asian Science and Technology Conference on DRR** was held on 23-24 August 2016 in Bangkok. The Conference brought together more than 300 senior policy-makers, practitioners, researchers and academics, civil society and the private sector in the realm of disaster risk reduction from across Asia (and beyond) to discuss how to strengthen science based DRR policy development in support of the implementation of the Sendai Framework in Asia. The conference came up with recommendations for 12 Actions for Science and Technology-based DRR in Asia. The outcomes of the conference were further intended to feed into the deliberations in the then upcoming Asian Ministerial Conference on Disaster Risk Reduction (AMCDRR), which later took place from 2-5 November 2016 in New Delhi.

In addition, it was at this conference that the Asia Science Technology Status for Disaster Risk Reduction was published. This publication was developed by a group of individuals from the Asia Science Technology Academia Advisory Group (ASTAAG), with support from researchers, scientists from different countries. It includes a total of 28 case studies on 13 countries and 4 cross-cutting cases on the application of science and technology for disaster risk reduction.

After the Conference, IRDR conducted a survey to collect feedback about the twelve actions from a wide range of stakeholders. The survey consisted of 2 sections: (I) General Information (II) The twelve actions based on the 4 priority areas of the Sendai Framework. The analyses of the survey were presented at the 2016 AMCDRR. The survey for organizations was designed based on the twelve recommended actions among the four priorities of the Sendai Framework. In part I, information about organizations and networks were collected, including names, websites and contact details. In part II, respondents selected their top four actions from the twelve for the short (in the next 2 years), medium (5 years) and long-term (10 years) that they felt most relevant to their organizations. The final part of the survey asked about the means of implementation for the top four priority actions in the short-term. The survey was circulated to a wide range of stakeholders from 27 September 2016 to 26 October 2016. The survey received 15 completed responses, including 8 from universities, 2 from international organizations and 5 from national research institutes, and represent institutions in charge of disaster risk reduction in 12 Asian countries. A crucial result of the individual questionnaire analysed which actions in each priority are the most relevant to the respondents and what kind of resources (technical resources, government/ legal resources, human resources and financial resources) are most essential to each action. The results were as Figure 3-1 and Table 3-1.

Figure 3-1: The most relevant action in each priority in 2016

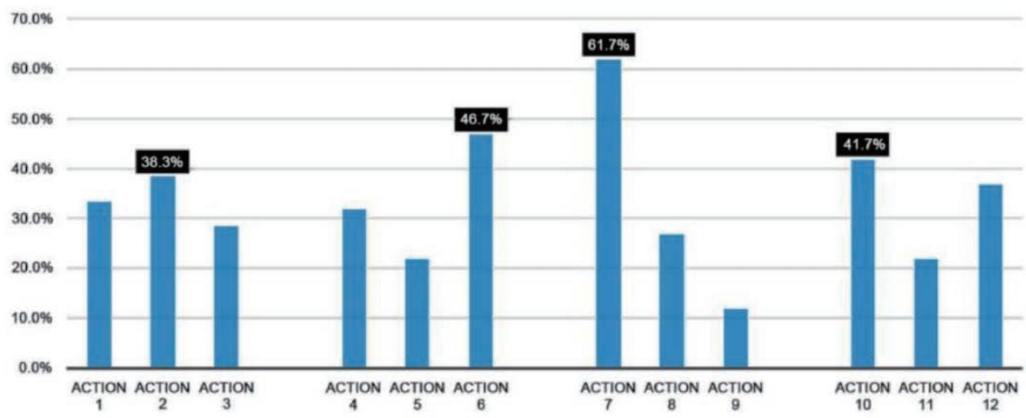


Table 3-1. **The most necessary resource for each action in 2016**

	Technical Resources	Government/ legal Resources	Human Resources	Financial Resources
Priority 1	Action 2	Action 3	Action 1	
Priority 2		Action 4, Action 5	Action 6	
Priority 3		Action 7	Action 9	Action 8
Priority 4	Action 10	Action 11		Action 12

The **2nd Asian Science and Technology Conference for Disaster Risk Reduction**, which took place on 17-18 April 2018, was organised by UNISDR with support from IRDR and other partners. Its aim was to renew the commitment to the accelerated implementation of the Sendai Framework for Disaster Risk Reduction 2015-2030 as the pivotal means to achieve the goals of sustainable development and resilience. The conference generated an outcome document, which reaffirmed the importance of the twelve actions identified in the First Asian Science and Technology Conference for Disaster Risk Deduction in 2016, and added two more actions which emerged from this conference.

Figure 3-2: **The most relevant action in each priority in 2018**

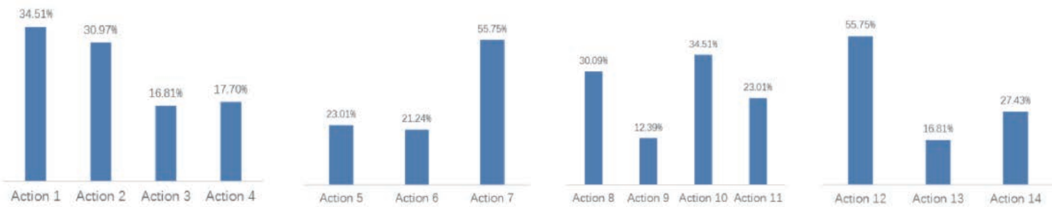


Table 3-2. **The most necessary resource for each action in 2018 compared to 2016**

2018	Technical Resources	Government/legal Resources	Human Resources	Financial Resources
Priority 1	Action 2	Action 1 Action 3 Action 4		
Priority 2	Action 6(5)	Action 5(4) Action 7(6)		
Priority 3			Action 8 (7) Action 10(9)	Action 9(8)
Priority 4	Action 12(10) Action 13(11)	Action 14(12)		

Note: Action 6(5) means Action 6 in 2018 is Action 5 in 2016; the action highlighted in red means the most necessary resource has been changed according to the respondents' answers.

In the Conference, Science & Technology into action: Disaster risk reduction perspectives from Asia was published. This publication “takes forward the 12 action points, adopted at the First Asian Science and Technology Conference for Disaster Risk Reduction as contribution to the global ‘Science and Technology Roadmap’. The publication identifies examples and good practices of implementation for these action points, as well as emphasizing the role of science and technology in each. This unique way of bridging the gap between science and policy was introduced by Ms. Loretta Hieber Girardet, chief of UNISDR Asia and Pacific Region.

After the Conference, IRDR conducted the same aforementioned survey to collect feedback about the 14 actions from a wide range of stakeholders. Significant differences were found when comparing results from the 2016 and 2018 surveys (Figure 3-2 and Table 3-2), and analyses of the survey were presented at the Asian Ministerial Conference on Disaster Risk Reduction on 03- 06 July 2018, in Ulaanbaatar, Mongolia.

The 3rd **Asia Pacific Science and Technology Conference for Disaster Risk Reduction (APSTCDRR)** was scheduled to take place on 16-17 March 2020, in Kuala Lumpur, Malaysia. As a result of the COVID-19 pandemic, this did not happen, with the Conference organized by IRDR ICoE-SEADPRI UKM finally taking place virtually on 15 October 2020. This conference covered the entire Pacific Region, with APSTCDRR’s goal to provide an opportunity for the science, technology, and academic community in Asia and the Pacific to continue the much-needed science-policy dialogue to ensure that the implementation of DRR measures is based on reliable science, technology, and innovation (STI). Focus was placed on the application of STI for local and inclusive action to build disaster resilience in the face of growing disaster risks and a changing climate, and the application of STI in the development or revision of national and local strategies to meet Target E of the Sendai Framework highlighted. Finally, numerous opportunities were provided to various organisations and stakeholders, in particular young scientists, to learn and share about different innovation measures.

Figure 3-3: Outcome-wise Progress in Implementation

Before the Conference, IRDR together with APSTAAG conducted a survey to track the progress of the Asia and Pacific regional implementation of the Sendai Framework Science Technology Roadmap from a wide range of stakeholders. The results (Figure 3-3) were presented at the Conference and published as a report, “Science and Technology Status for Disaster Risk Reduction in Asia-Pacific. The other key report launched at the Conference was the “Asia-Pacific Regional Framework for NATECH Risk Management”.

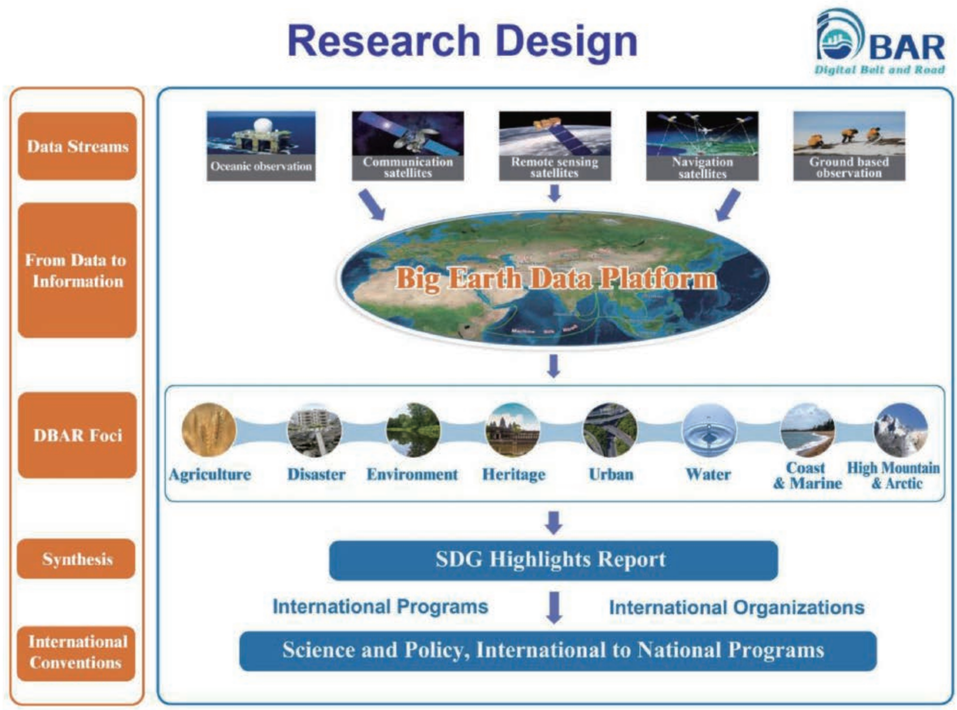
All the outcomes of this Conference will be included in the 2020 Asia-Pacific Ministerial Conference on Disaster Risk Reduction (APMCDRR), which has yet to be rescheduled.

◆ DBAR Conference

DBAR was initiated in May 2016 during the International Symposium on Earth Observation for One Belt and One Road (EOBAR). This large-scale international science program uses space-based observation to scientifically understand the Silk Road Economic Belt and the 21st-Century Maritime Silk Road (abbreviated as the "Belt and Road") regions, and is designed to provide scientific, open, and cooperative information to support decision-making for sustainable development along the Belt and Road. As breakthrough global initiative, this ambitious programme is long-term, involves numerous fields and large, complex geographic areas, making this a highly arduous long-term project. With Earth observation technologies now able to quickly and accurately detect changes on the surface of Earth at the macroscopic level, they can be used systematically to carry out large-scale and multi-scale, long-term, seamless, and continuous observations, providing real-time evidence and scientific support for decisions relating to the sustainable construction of the Belt and Road for its member countries. As Prof. Huadong Guo (PI of DBAR programme) stressed, DBAR is a scientific, open, cooperative Earth observation program, and will benefit all countries along the Belt and Road. DBAR has embarked on an ambitious journey to build a digital Silk Road for sustainable development through five priority areas: 1 enhancing infrastructure, 2 promoting data sharing and interoperability, 3 extending applications to more people, 4 identifying research opportunities and 5 strengthening international collaboration[50].

IRDR is one of the founding partners of DBAR and its DRR WG. IRDR co-organized the serial DBAR conferences and the DRR sessions. The 1st Digital Belt and Road (DBAR) Conference was held in Beijing from 6-7 December 2016. Nearly 100 experts and scholars from China, the Netherlands, India, Pakistan, Laos, Tunisia, Morocco and other countries and international organizations attended the meeting. Their goal was to discuss and formulate a DBAR Science Plan, establish a DBAR Science Committee and WGs, consider the strength of DBAR in 2017, and explore better scientific approaches to serve sustainable

Figure 3-4: The DBAR structure



50 Guo, H. (2018). Steps to the digital Silk Road. Nature, 554, 25-27.

development along the "Belt and Road". The 2nd DBAR Conference, which took place in December 2017, officially launched the DBAR Science Plan. The 3rd DBAR Conference, which took place in December 2018, in turn marked the beginning of the critical first implementation phase of the DBAR Science Plan after more than two years of consultations with the Earth observation community in a series of meetings in Asia and Africa. The DBAR Science Plan has already successfully completed all of it objectives in the Preparatory Phase, including formation of a reputed, international Science Committee to overlook DBAR, and the establishment of an international secretariat. The DBAR has also successfully established 7 Working Groups and 2 Task Forces with growing international memberships, and a network of 6 out of 8 International Centers of Excellence. Finally, the 4th DBAR Conference, convened in Shenzhen on December 17, 2019, with the theme “Digital Belt and Road Facilitates Sustainable Development”, aimed to promote communication and cooperation between experts and scholars from all around the world on the issues related to selection and demonstration of SDGs most relevant to the “Belt and Road” region, mechanisms to aggregate and share Big Earth Data within the “Belt and Road” countries, means to enhance the capability of scientific discovery and decision-making related to Big Earth Data, and promotion of the sustainable development process by using Big Earth Data.

◆ Silk Road Conference for DRR and Sustainable Development 2019

The International Conference on Silk-Roads Disaster Risk Reduction and Sustainable Development (SiDRR Conference 2019) took place in Beijing from 11-12 May 2019 and was jointly hosted by the CAS, the CAST, the United Nations Environment Programme, the United Nations Office for Disaster Risk Reduction, and international scientific partners including IRDR. The theme was “Towards Safe, Green, and Resilient Silk Roads”.

IRDR organized two sessions at this Conference. In the session titled “Mobilization of International Science and Technology Collaboration on Disaster Risk Reduction (DRR)”, the following topics were addressed: International integrated disaster research and its possible contributions; international platforms for DRR data/knowledge sharing; university alliances and young scientists networks for DRR capacity building; and international collaboration on investment for DRR related research and technologies. In the session titled “Improving Policy and Science & Technology (S&T) Interface in Disaster Risk Reduction (DRR)”, the objectives were to: share the good practices of science-based decision-making for DRR; further analyse the gaps and challenges in implementing science-based decision-making on DRR; promote the co-designs of national/local DRR strategies by multi-stakeholders; and identify policy support required by S&T communities in disaster science and the development of DRR application technologies. During the Conference, IRDR contributed to the establishment of the Alliance of International Science Organizations on Disaster Risk Reduction (acting as the supporting organization) and the establishment of Geoscience Youth Network of the Belt and Road (acting as Co-sponsor).

3.2.2 IRDR Policy Briefs

◆ Integrated Science for Sendai Framework Implementation, 2016

This Issue Brief[51] was prepared for the UNISDR Science and Technology Conference on the Implementation of the Sendai Framework for Disaster Risk Reduction 2015-2030, held from 27-29 January 2016 in Geneva, Switzerland. It was prepared by Mark Pelling, Amy Donovan and Emma Visman of the IRDR International Centre of Excellence – Risk Information to Action, hosted by

51 http://www.irdrinternational.org/wp-content/uploads/2016/01/IRDR_-Science-Road-Map-Conference-brief_final.pdf

King's College London.

The main premise of the brief is that implementation of the Sendai Framework will benefit from a broad but clear understanding of the range of knowledge services science can provide. The science and technology communities are diverse and dynamic. The need for some knowledge services is well established in policy and practice – for example monitoring and evaluation and technical risk assessments, though gaps in application remain; other services, such as decision analysis or risk root cause analysis are only beginning to be developed and applied. Despite our growing understanding of risk, losses continue to increase. This supports ongoing calls for science to be evaluated, and re-organised to enter a new level of conversation with policy, practice and those at risk. Policy and practice actors also have to reflect on their relationship with science if the breadth of science-action relationships, from service to critical friend and catalyst, are to be valued and fostered. This is Sendai's call to science and science users.

◆ Five Policy Briefs for 2017 Global Platform for DRR[52]

As discussed during the 16th IRDR Scientific Committee Meeting, IRDR and ICSU proposed to prepare policy briefs for the 2017 Global Platform for Disaster Risk Reduction, with the aim to contribute scientific inputs into critical issues for the implementation and monitoring of the Sendai Framework, as well as highlight IRDR's products that are of direct relevance. The following five policy briefs were then prepared:

- Coherence between the Sendai Framework, the SDGs, the Climate Agreement, New Urban Agenda and World Humanitarian Summit, and the role of science in their implementation (by Virginia Murray, Rishma Maini, Lorcan Clarke, Nuha Eltinay)
- Assessing country-level science and technology capacities for implementing the Sendai Framework (by Rajib Shaw)
- Disaster loss data in monitoring the implementation of the Sendai Framework (by Bapon Fakhruddin, Virginia Murray, and Rishma Maini)
- Forensic Investigations of Disaster (FORIN): towards the understanding of root causes of disasters (by Anthony Oliver-Smith, Irasema Alcántara-Ayala, Ian Burton and Allan Lavell)
- Cities and Disaster Risk Reduction (by Mark Pelling, Donald Brown and Fang Chen)

◆ Two Policy Briefs for 2019 Global Platform for DRR

The policy briefs were presented at the Science and Policy Forum on 13 and 14 May 2019 in Geneva, providing insights from disaster risk reduction experts to science partners, Ministries of Science, scientific advisors and stakeholders, to enhance their understanding of the Sendai Framework and its connections to the SDGs and other agreements.

These policy briefs also highlight as the importance of ensuring disaster data archives are standardised to maximise the valuable opportunities to acquire better information about the health, economic, ecological and social costs of disasters.

- Disaster Loss Data in Monitoring the Implementation Of The Sendai Framework[53] (Bapon Fakhruddin, Virginia Murray and Fernando Gouvea-Reis)
- Achieving Risk Reduction Across Sendai, Paris And the SDGs[54] (by John Handmer; Anne-Sophie Stevance, Lauren Rickards, and Johanna Nalau)

52 https://council.science/publications/disaster-risk-reduction-policy-briefs-2017/

53 https://council.science/publications/disaster-loss-data-in-monitoring-the-implementation-of-the-sendai-framework/

54 https://council.science/publications/achieving-risk-reduction-across-sendai-paris-and-the-sdgs/

3.2.3 IRDR Working Paper Series

The **Working Paper Series** is a new publication of IRDR following the decision of the IRDR Scientific Committee in April 2019 to act to 'Expand IRDR Network and Scientific Output' (No. 5 of the IRDR Action Plan 2018-2020).

This Working Paper Series is thus specially made to facilitate the dissemination of the work of IRDR NCs, ICoEs, YS and institutions and individual experts that IRDR considers relevant to its mission and research agenda, and is of important value for a much broader audience working in DRR domains. We note that all working papers in this series are anchored their relevance and contributions of their work toward SFDRR, IRDR, SDGs and Paris Agreement on climate change. It is the hope of the authors of the working papers and IRDR that this working paper series will not only bring new knowledge, experience and information toward disaster risk reduction, but also help build better coherence between DRR and the UN's mainstream agenda toward inclusive, resilient and sustainable human societies. A quick list of the two batches of published papers is included below for reference purposes.

1st Batch:

- A Framework for Transforming the Relationship Between Development and Disaster Risk
- Emergency and Disaster Management Programs in disaster prone, resource deficit context
- Making Cities Disaster Resilient in a Changing Climate
- Socio-ecological Resilience as a Sustainable Development Strategy for Remote Rural Settlements in Different Geo-climatic Zones of India
- Silk Road Disaster Risk Reduction
- Extraction and Analysis of Earthquake Events Information based on Web Text
- Disaster Metadata Management System Based on pycsw and Its Application

2nd Batch

- The Biosafety - Biosecurity Culture Interface in Life Sciences Research
- Understanding the Geological Environmental Risks of Permafrost Degradation -Environmental and engineering geology in permafrost area in Northeast China
- Sustainable Infrastructure Development, Risk Perception and Vulnerability Assessment in Indian Himalayan Region
- Mapping Disaster Risk Reduction Institutions Using Web-based Accessible Information

3.3

Cooperation with IRDR partners

3.3.1 Within ISC community

IRDR collaborates with other ISC Interdisciplinary Bodies (IBs), members, and regional offices on numerous DRR activities.

Committee on Data of the International Science Council (CODATA)

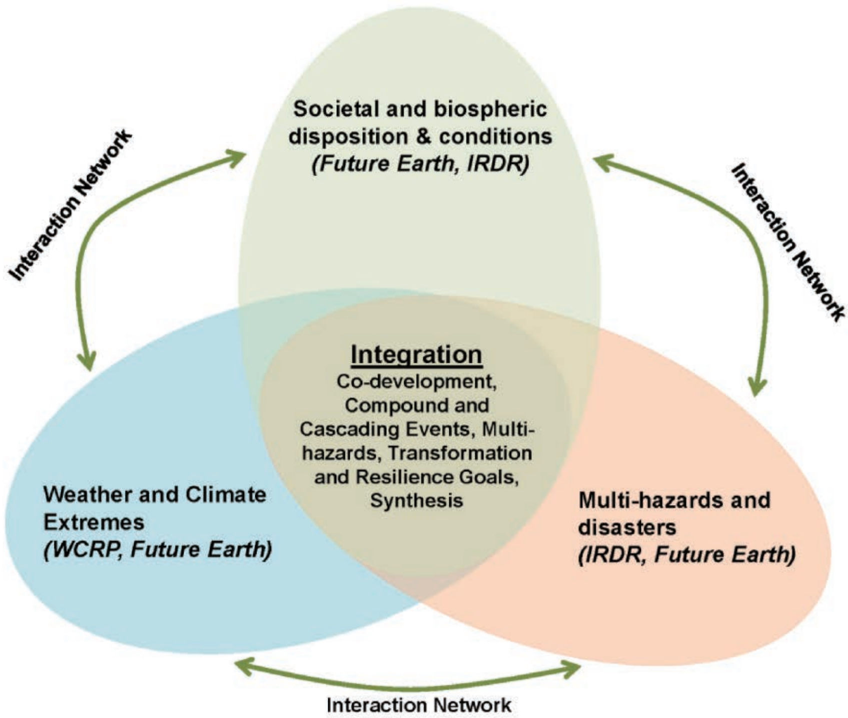
There is a close and long-term collaboration between IRDR and CODATA through the IRDR DATA Working Group and CODATA Task Group on Linked Open Data for Global Disaster Risk Research. A large number of policy briefs, webinars, workshops on the DRR data issues have been developed in collaboration. The white papers and reports have so far focused on disaster data protocols. The recent publications include *Next Generation Disaster Data Infrastructure (2019), Gap analysis on open data interconnectivity for disaster risk research (2017), Disaster Loss Data: Raising the Standard*

(2017), etc. In addition, since August 2018, IRDR together with CODATA, Public Health England, Sustainable Development Solutions Network, and Tonkin+Taylor, have published the monthly newsletter Disaster Risk Reduction and Open Data. The newsletter consists of three parts: DRR and data in news, Publications on DRR and data, Upcoming DRR and data events.

IRDR also hosted sessions and participated in the CODATA series conferences. At *CODATA 2012: Open Data and Information for a Changing Planet*, IRDR DATA WG hosted a session focusing on disaster loss data to address the data landscape and database development. At CODATA 2019: Towards Next-Generation Data-Driven Science, IRDR together with GEO and Tokin+Taylor organized a session to discuss the linked open data for global DRR with emphasis on big data application.

CODATA and IRDR contributed to the disaster responses by providing scientific evidence for decision makers. In November 2016 for example, New Zealand was hit by a 7.8 magnitude earthquake in Kaikoura. The New Zealand government has expressed thanks to IRDR and CODATA for their timely and free provision of satellite data that helped with damage and loss estimation following the disaster. The New Zealand Minister of Civil Defence, Gerry Brownlee, wrote in February 2017 to Professor Li Guoqing of the CODATA task group, saying: "In the immediate aftermath of natural disasters, accurate information on the nature and extent of damage is critically important for the efficient use of scarce resources. The New Zealand Government is very appreciative of the assistance that you and your organization provided in our time of need."

Figure 3-5: Conceptual illustration of the idea and scope of the Emergent Risks and Extreme Events KAN as the overlapping and integration platform of the core areas of Future Earth, IRDR and WCRP and the opportunity for building wider networks between all communities.



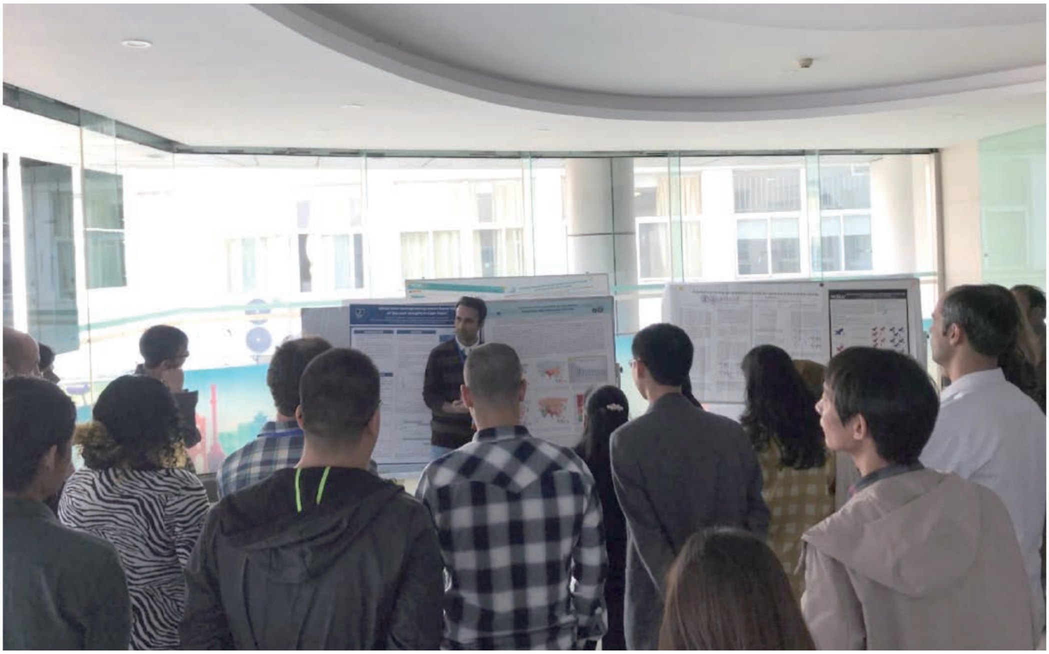
◆ Knowledge Action Network on Emergent Risk and Extreme Events (Risk KAN)

IRDR, Future Earth and World Climate Research Programme (WCRP) have been involved in the discussions that led to the creation of the Knowledge Action Network on Emergent Risk and Extreme Events since 2017 (Figure 3-5). Some IRDR scientists are involved as the members of Development Team and co-chairs of Working Groups.

◆ World Climate Research Programme (WCRP)

IRDR and WCRP signed a letter of cooperation in 2010 on the following area: 1) WCRP would assist with the characterization of climate-related hazards and input to the IRDR objectives; 2) IRDR would assist WCRP in focusing the scientific questions for climate extremes research through the identification of specific vulnerabilities and risk and how these lead to the identification of climate-extreme critical research questions include the social as well as natural sciences; 3) IRDR and WCRP would work together in the provision of scientific information to and interactions with relevant international bodies, conventions, etc., where climate-related extremes pose important hazards towards the objectives of disaster risk reduction and climate change adaptation. One example of joint activities between IRDR and WCRP was the offering of 2-week advanced course entitled "Institute of Advanced Studies in Climate Extremes and Risk Management" for 39 young researchers from 17 countries in November 2019 (Figure 3-6).

Figure 3-6: Poster presentation during the Institute of Advanced Studies in Climate Extremes and Risk Management



◆ Future Earth

IRDR has worked closely with IRG-Project under the Future Earth Programme on the regional science and technology implementation for DRR. The two programmes cooperated on a series of reports of science and technology status for DRR in the Asia-Pacific region, on organizing some side events during the AMCDRR and Asian Science and Technology Conference for Disaster Risk Reduction (ASTDCRR), sessions at the Qianhai International Symposiums and more. IRG also translated the FORIN report into Chinese as reading material for DRR education.

In ICRC-CORDEX 2019: International Conference on Regional Climate, a side event on future risk and future Earth was co-organised by the Chinese National Committee for Future Earth (CNCFE), IRDR, Monsoon Asia Integrated Research for Sustainability (MAIRS-FE), Integrated Risk Governance Project (IRG-FE), and WCRP. This session provides an open platform for scientific communities from across science disciplines on extreme events, disaster risk reduction and governance to exchange information, knowledge and explore to potential opportunities in collaborative research activities.

◆ ISC Regional Offices

IRDR SC members and ICoEs have worked with the DRR working groups of ISC regional offices in Latin America, the Caribbean, and Asia=Pacific on several projects and events. In particular, IRDR and ISC ROAP successfully helped 12 countries in this region to develop a Science Technology Plan for Disaster Risk Reduction to implement the Sendai Framework.

3.3.2 With UN agencies and programmes

◆ Science and Technology Advisory Group (STAG) of UNDRR

As co-sponsor, UNDRR worked closely with IRDR through UNDRR regional offices, STAG and regional STAGs, and Science and Technology Major Group. IRDR was heavily involved in the regional DRR conferences organised by UNDRR as representative for science and technology stakeholders. In particular, IRDR organised the Science and Technology Stakeholder Consultation with Asian-STAG and other science and technology groups as the pre-event for every AMCDRR. IRDR SC members are also involved in the STAG and Science and Technology Major Group as members.

◆ United Nations Educational, Scientific and Cultural Organization (UNESCO)

IRDR has worked closely with UNESCO, in particular on DRR for UNESCO heritage sites, and in the networking for young DRR professionals. Apart from the consensus reached at the 3rd Huangshan Dialogue, IRDR also cooperated with UNESCO-HIST to create a Community Activity within the GEO Work Programme in the field of Climate Change and Impacts on World Heritage Cities. IRDR and UNESCO also helped facilitate the establishment of U-INSPIRE, as organisers of the workshop at which the U-INSPIRE initiative was proposed. This occurred at the November 2018 Regional Workshop on SETI in DRR in Asia and the Pacific. Titled “Strengthening, Empowering, and Mobilizing Youth and Young Professionals in SETI for DRR”, it was organized by UNESCO, LIPI (IRDR NC Indonesia) and UNISDR, and took place in Serpong between 1-4 November 2018. The objective of U-Inspire is to mobilize and increase awareness for disaster risk reduction among youth and young professionals in science, engineering, technology and innovation, and to facilitate their collaboration with other stakeholders. The IRDR young scientists played important roles in the establishment of the national chapters of U-INSPIRE. Meanwhile, IRDR ICoE-SEADPRI-UKM hosted the U-INSPIRE Malaysia. During the COVID-19 Pandemic, U-INSPIRE organised serial webinars to discuss the role of youth. Finally, IRDR and the Disaster Risk Reduction Knowledge Service Sub-Platform (DRRKS), International Knowledge Centre for

Engineering Sciences and Technology under the Auspices of UNESCO signed a MoU to promote DRR data and knowledge sharing.

◆ United Nations Major Group for Children and Youth (UNMGCY)

IRDR also collaborated with the United Nations Major Group for Children and Youth (UNMGCY) Working Group. IRDR contributed to the design of The Disaster Risk Reduction Edition of the Youth Science-Policy Interface Publication. This report captures and promotes the role of young people in sharing knowledge of evidence-informed best practices, science and technology, emerging trends, challenges, and solutions in the implementation, monitoring, follow-up, and review of intergovernmental frameworks on sustainable development, especifically in disaster-related contexts. This initiative is part of the UNMGCY Youth Science-Policy Interface Platform and coordinated by the UNMGCY. Launched in May 2017, it is meant to feed into the discussions of the Global Platform for Disaster Risk Reduction, specifically around the SPI mandate, in order to showcase the contributions of young scientists, engineers, practitioners, and students in strengthening the science-policy interface, further linking policy and practice for a sustainable society. It seeks to build coherence between the Sendai Framework for Disaster Risk Reduction (2015-2030) and the DRR-dimensions of other intergovernmental agreed upon sustainable development agendas (e.g. 2030 Agenda, New Urban Agenda, etc.). IRDR young scientists have contributed the following three articles:

- Assessment of Coordination Mechanism in 2015 Nepal Earthquake, Kathmandu District (Indrajit Pal, Ranit Chatterjee)
- Business recovery after Gorkha earthquake 2015 in Nepal (Ranit Chatterjee, Basanta Raj Adhikari)
- Anthropocentric principles for effective early warning systems (Spyros Schismenos)

3.3.3 Global or regional partners beyond ISC and UN community

◆ World Weather Research Programme (WWRP)

IRDR signed a MoU in 2012 with WWRP to cooperate in the following areas:

1. WWRP will assist IRDR with the characterization, understanding, and prediction of weather-related hazards (i.e., floods, storms, and typhoons) whose physical aspects manifest themselves at nowcasting through to sub-seasonal scales, thus contributing to IRDR Programme Objective 1—the characterization of hazards, vulnerability and risk.
2. IRDR will assist WWRP in defining and exploring critical natural and social science research questions based on an understanding of disaster risk and the implications of extreme weather or climate events for society and economy, thus contributing to the implementation of the WWRP Strategic Plan.
3. WWRP and IRDR will jointly support the activities of the Working Group on Societal and Economic Research and Applications (SERA) of the WWRP for which the research priorities include:

- Estimation of the societal (including economic) value of weather and disaster risk reduction information;
- Understanding and improving the use of weather-related hazard information in decision making;
- Understanding and improving the communication of weather-related hazard information and forecast uncertainty;
- Development of user-relevant verification methods; and
- Development of decision support systems and tools.

4. IRDR and WWRP will collaborate in the provision of scientific information, guidance, and associated interactions with relevant international bodies, conventions, protocols, and agreements, concerning weather-related hazards and their role in disaster risk management.

◆ Joint Research Centre of the European Commission (JRC)

A Memorandum of Understanding (MoU, No.: 32228) between the Joint Research Centre of the European Commission and IRDR was signed in 2011. The mission of JRC is to provide customer-driven scientific and technical support for the conception, development, implementation and monitoring of European Union policies. Through its thematic areas “Security and Crisis Management” and “Sustainable Management of Natural Resources”, the JRC conducts research in the fields of disaster risk reduction, early warning, post-disaster damage analysis, and crisis management technologies.

The scope of the collaboration relates to research within the fields of:

- Characterisation of hazards, vulnerability and risk
- Post-disaster investigations focusing on natural hazards and human-induced environmental hazards.

For the first area, JRC acts a member of IRDR Risk Interpretation and Action (RIA) Working Group, contributing to:

- Enhanced capacity for identifying and assessing the level of hazards and for disaster forecasting and early warning
- Dynamic modelling of risk and elaboration of potential prevention plans (risk reduction)
- Consistent methods for the evaluation of vulnerability, including that of physical urban infrastructure, in disaster hot spots at a variety of spatial and temporal scales.

For the second, JRC takes an active part working with the FORIN project Working Group on case studies that aim at testing methods and approaches for post-disaster investigative analysis and the analysis of crises or disasters caused by natural phenomena from which lessons can be learnt in order to contribute to the production of new understanding and insights that would permit more effective disaster risk reduction. The results of this collaboration help identify major future research needs in the field. In particular, the collaboration focuses on:

- The organization of coordinated joint post-disaster field reconnaissance missions for the generation of new information and data and for the training of young researchers
- Methods for the classification, archiving, retrieval and metadata of photographic records and other data gathered from field missions
- Establishing a common exchange platform for easy access and use of archived data

World Vision

World Vision International is a relief, development and advocacy organization devoted to serving children, their families and their communities in impoverished regions. Currently, World Vision is working in about 100 countries and regions across the world. IRDR’s cooperation with World Vision extends to the following World Vision programmes, which goals intersect with IRDR’s: Information Management Workshops, Asia-Pacific Region DRR, Co-designed Research, Urban Resilience, Youth Group.

IRDR supported and participated in World Vision’s regional proposal for ECHO ERC, specifically the Action titled “Using Pre-crisis Information Management for responsive Decision Making in Emergencies”. IRDR’s young scientist Dr. Poorna Yahampath was invited to participate in the World Vision's Humanitarian Leaders' Meeting on May 21 - 22, 2018 in Colombo, Sri Lanka to introduce the role of science and technology in the DRR to the Humanitarian Emergency Affairs (HEA) directors from country levels.

◆ SysTem for Analysis, Research and Training Int. (START Inc.)

START Inc. is an internationally recognized independent international nongovernmental organization affiliated with the global environmental change related programmes of the ICSU. It is focused on capacity building activities to empower developing countries with scientific capabilities to motivate and inform societal action to manage risks and address opportunities of global environmental change and sustainable development. START Inc. is actively engaged in the DRR activities of IRDR ICoE-Taipei’s Advanced Institute and provided seed funds for young researchers participating therein.


3

Chapter 4. Programme Governance, Operational Mechanism and Management

A justified scientific mission does not guarantee success in implementation. For an international scientific programme like IRDR to be successful, apart from its well-crafted scientific plan, it depends also on how the programme is governed, operated, and managed. Over last ten years, IRDR's governance, operations and management have evolved along with the implementation of its work. From the operational aspect, IRDR's strengths are its Scientific Committee (SC), Working Groups (WGs), National Committees (NCs), International Centres of Excellence (ICoEs), YSP, and broad partnership with others working in the field of DRR. However, gaps and shortcomings are also well documented.

4.1 Structure of the IRDR Community[55]

IRDR is co-sponsored by the International Science Council (ISC, which was created in 2018 as the result of a merger between the ICSU and the ISSC) and the United Nations Office for Disaster Risk Reduction (UNDRR, former acronym UNISDR). The execution of IRDR programme, including promotion, coordination and related functions is undertaken by the IRDR IPO. The IPO is located in Beijing, China and is hosted by the Aerospace Information Research Institute (AIR) of the CAS. Funding is provided by the CAST.

IRDR SC

IRDR is governed by a SC set up by and on behalf of the Co-Sponsors. In the past ten years, IRDR SC has included in total 41 outstanding experts from a diverse range of disciplines, taking into account regional and gender balance. The responsibilities IRDR SC are to define, develop and prioritise actions for the IRDR, guide its programming, budgeting and implementation, establish a mechanism for the oversight of programme activities, and disseminate and publicize its results on behalf of the co-sponsors[56].

55 The IRDR current organigram was built in 2018, as part of the response of the 2016 Mid-term Review to improve the management and governance.

56 IRDR SC is the 'central brain' of IRDR programme. The original scope of its responsibilities proved tobe over balance between programme management and scientific direction. This issue was addressed by the 2016 mid-term review, resulting in the current amended list of responsibilities.

The specific tasks of the IRDR-SC

(a) To further define the inter-disciplinary scientific strategy and determine its specific objectives and priorities; this will involve, through an extensive consultation process, the continued identification and exploration of the major programmes and projects that exist in the field of natural and human-induced hazards and disasters and, where appropriate, the conclusion of agreements as to how they might become components of IRDR.

(b) To develop, and keep under continuous review, an implementation plan for the Programme in close consultation with potential research partners, and to ensure that the plan develops in such a way as to make optimal use of available resources;

(c) To establish and implement a mechanism for the design, guidance, development and oversight of the Programme;

(d) To facilitate the exchange of information among the scientists participating in the Programme and the natural and human-induced hazards and disaster community in general, as well as relevant scientific institutions and agencies at the national and international levels;

(e) To promote the goal and objectives of the Programme, its deliberations and achievements through development of capacity building and outreach programmes in order to attract and form a new generation of individuals at all levels that can address natural and human-induced hazard and disaster issues, and to capture the interest of the general public and decision-makers in the importance of risk reduction for human well-being and sustainable development;

(f) To work with appropriate organizations, including the Global Terrestrial and Ocean Observing Systems (GTOS and GOOS) and the Group on Earth Observations (GEO) of the Global Earth Observation System of Systems (GEOSS) to ensure the development of sustained monitoring and enable continuous observations relating to natural and human-induced hazards;

(g) To convene sessions of an Open Consultative Forum to which all stakeholders will be invited. The Forum will serve as a consultative process for expressions of views on the Programme development, as a platform for dialogue among the various stakeholders and as a venue for exchange of information on Programme implementation. The Forum shall be convened at least once per year, preferably in conjunction with a major international disaster and risk event;

(h) To raise additional funds for the planning and coordination activities, including activities of any working groups that the SC-IRDR may wish to set up, and to assist in convincing national and international funding bodies to fully support the research activities of the Programme; and,

(i) To provide oversight and guidance to the activities of the IPO of IRDR.

◆ Outcomes of SC meetings[57]

The Scientific Committee meeting convenes twice a year. The overall objectives of the SC meeting are to make decisions on actions and plans and to review the progress of implementation of such.

[SC1] 12-13 May 2009 (Bergen, Norway)

The 1st IRDR Scientific Committee meeting mainly examined the Term of References for IRDR SC, discussed the establishment of IRDR IPO and the funding mechanism; recognized the co-sponsorship by ICSU, ISSC and UNISDR; acknowledged the role of ISDR Scientific and Technical Committee in providing "strategic guidance on research needs" for disaster risk reduction and oversight of progress"; and agreed that a mechanism was needed to be put in place to ensure strong collaboration and exchange. The meeting set forth five actions for Working Groups and Task Teams, four actions for Partner and joint activities, and two actions for the whole IRDR community.

[SC2] 21-23 October 2009 (Paris, France)

The 2nd IRDR SC meeting provided updates on the case studies and demonstration projects; explored cooperation with UNISDR systems and articulation with ICSU regional programmes on hazards and disasters; proposed the concept of International Centres and National Committees for IRDR; prepared Memoranda of Understanding with identified partners; published the announcement for the recruiting of IRDR IPO staff especially the Executive Director; and discussed the promotion of IRDR and its objectives.

[SC3] 14-16 April 2010 (Paris, France)

The 3rd IRDR SC meeting announced the appointment of the first Executive Director and the establishment of the IPO at the Center for Earth Observation and Digital Earth (CEODE) of CAS in Beijing; nominated three Vice Chairs of SC and created the Executive Committee; provided updates on the collaborations with partners; advanced the establishment of IRDR Working Groups, National Committees and International Centres of Excellence; and discussed the preparation of the IRDR Conference.

[SC4] 15-17 November 2010 (Beijing, China)

The 4th IRDR SC meeting was the first meeting hosted by the IPO. In this meeting, the IRDR Constitution was signed by the Sponsors, namely ICSU, ISSC and UNISDR. UNISDR agreed that IRDR would be the body helping it convene and coordinate the Science Forum at the 4th session of the 2013 Global Platform for Disaster Risk Reduction. IPO provided an outline of the IRDR Work Plan. Four NCs were launched (China, Japan, France, Canada). The application of ICoE-Taipei was approved. The Terms of Reference of NC and ICoE were fixed and approved. The meeting further provided updates on the activities and research plans of Working Groups (RIA, Disaster Loss Data, FORIN, Disaster Assessment). Finally, preparation work for the IRDR Conference was initiated.

[SC5] 27-29 April 2011 (Paris, France)

The fifth IRDR SC meeting welcomed three new SC members; appointed the new Chair; launched the Annual Report and the official website; and provided updates on the activities of the IPO, WGs, NCs and ICoEs.

[SC6] 28-29 Oct. & 3 Nov. 2011 (Beijing, China)

The 6th IRDR SC meeting provided updates on

57 The documents of all SC meetings are available at IRDR website.

the activities of the IPO, WGs, NCs and ICoEs; announced confirmed partnerships with WCRP, START, EC/JRC, and WWRP; developed the selection process and criteria for NCs and ICoEs; and reported the wrap-up and after action of IRDR Conference 2011.

[SC7] 09-12 May 2012 (Ravello, Italy)

The 7th IRDR SC meeting submitted the Annual Report 2011; discussed the IRDR Strategic Plan; provided updates on the activities of the IPO, WGs, NCs and ICoEs; and proposed new initiatives. It was further suggested that NC Colombia could be developed into an IRDR Regional Committee for Latin America; and determined that the ICSU Regional Office for Asia and the Pacific (ROAP) would be a regional network link to IRDR.

[SC8] 04-07 November 2012 (Chengdu, China)

The 8th IRDR SC meeting reported on the activities of the IPO and WGs aligned with the goals of IRDR Strategic Plan; embraced the new SC member and new Chair; provided updates on the activities of NCs and ICoEs; and planned the IRDR Conference 2014. The ICSU presented the launch of the Future Earth programme, encouraging IRDR to communicate with the regional offices of Future Earth on DRR. ISSC suggested IRDR to submit a panel. UNISDR encouraged IRDR to conduct a session at its 2013 Global Platform (GP) GP2013 to illustrate the role of integrated sciences in policy and practice. Finally, to better reflect ongoing institutional changes, IRDR host CEODE adopted the new name of Institute of Remote Sensing and Digital Earth, CAS.

[SC9] 18-20 May 2013 (Geneva, Switzerland)

The 9th IRDR SC meeting approved the 2012 Annual Report and IRDR Strategic Plan 2013-2017. The contributions from the IRDR community to the ICSU's International Scientific Unions, World Social Science Report 2013, Global Assessment Report (GAR) 2013, GAR 2015, GP 2013 and CAS-TWAS Centre of Excellence on Space Technology for Disaster Mitigation were reported. Updates on the activities of WGs, NCs, ICoEs were provided. More funding opportunities and partnerships were explored.

[SC10] 12-14 November 2013 (Sanya, China)

The 10th IRDR SC meeting provided updates on the activities of the Co-sponsors, Host, IPO, WGs, NCs and ICoEs; reviewed applications from new NCs and ICoEs; discussed the appointment of a new Executive Director to the IPO; examined IRDR's participation in the ICSU ROA and ROLAC workshops; and noted IRDR's contributions to the UNISDR STAG Report, the UNISDR Terminology on DRR and the UNISDR AMCDRR. Finally, in collaboration with ICSU, IRDR submitted a briefing document to the SDGs process.

[SC11] 10-11 June 2014 (Beijing, China)

The 11th IRDR SC meeting provided updates on the activities of the Co-sponsors, Host, IPO, WGs, NCs and ICoEs. ICSU announced that there would be an evaluation of IRDR starting in mid-2015. UNISDR invited ICSU to be the Organising Partner for the science and technology (S&T) community for the process leading up to the UN WCDRR, and IRDR would play a prominent role therein. Final arrangements for IRDR Conference 2014 were made. WGs and ICoEs reported on their working plans. A number of researchers from China joined three breakout sessions for DATA, FORIN and RIA.

[SC12] 13-15 November 2014 (Paris, France)

The 12th IRDR SC meeting provided updates on the activities of the Co-sponsors, Host, IPO, WGs, NCs and ICoEs. ICSU provided an update of the scientific review of the 17 goals and 169 targets proposed by the UN Open Working Group for the SDGs on the disaster risk aspect. IRDR submitted an independent statement to the pre-zero draft of the Post-2015 Framework for Disaster Risk Reduction. Finally, the function and possibility of a “Consultative Forum” were discussed.

[SC13] 1-3 June 2015 (Qingdao, China)

The 13th IRDR SC meeting reviewed and commented upon the Action Points; highlighted the role IRDR played at the 3rd WCDRR; and looked back at the STMG statement it gave on 17 March 2015, in particular the '4 + 2' formula agreed upon by STMG leaders for the implementation of the Sendai Framework as the key overarching commitment. In addition, the London Reflections on Phase II of IRDR was compiled into paper form as the starting point for a discussion about the next phase of the programme (reviewing achievements, obstacles and opportunities). Additional partnership possibilities in China were explored, including with the Chinese Psychological Society, Beijing Normal University/Integrated Risk Governance, UNESCO-HIST, and Centre of Excellence on Space Technology for Disaster Mitigation.

[SC14] 16-18 November 2015 (West Cape, South Africa)

The 14th IRDR SC meeting provided updates on the activities of the Co-sponsors, Host, IPO, WGs, NCs and ICoEs. The major review questions for IRDR were provided by ICSU. The stakeholders agreed to postpone IRDR Conference 2016. The position of IRDR at UNISDR S&T Conference was discussed, and it was agreed that IRDR would continue to contribute on the S&T Roadmap and S&T Partnership. Four Panels were organised to addressed updates from Africa on the advances in integrated research on DRR on the continent.

[SC15] 5-6 May 2016 (Paris, France)

The 15th IRDR SC meeting briefly reflected on the programme over the past 5 years and considered this transition period with support from ICSU, ISSU and UNISDR. Issues which arose over the course of the programme thus far were examined; outcomes of the UNISDR Scientific and Technical Advisory Group (UNISDR/STAG) conference on science and technology were reported and discussed; and partnerships with SEI and Global Alliance of Disaster Research Institutes (GADRI) were explored.

[SC16]29-30 November 2016 (Sanya, China)

The 16th IRDR SC meeting welcomed the new Executive Director. In addition, the IRDR Mid-Term Review Report was presented, based on which strategic future directions were discussed, all in preparation for a new strategic plan. The meeting also established the IRDR Young Scientists Programme and approved two IRDR Flagship Projects.

[SC17]22-23 May 2017 (Cancun, Mexico)

The 17th IRDR SC meeting focused on the IPO’s updated efforts to support science and technology plan at national level; the presentation and review of the IRDR Strategic Plan of Action; and a discussion of the collaboration mechanism of ICoEs. A concept note would be drafted.

[SC18]20-21 November 2017 (Tokyo, Japan)

The 18th IRDR SC meeting welcomed the new Executive Director. ICSU reported the merger between ICSU and ISSC, which was finalized at 32nd ICSU General Assembly, and made clear its expectations for a vital collaboration among IRDR, Future Earth, WCRP and Urban Health and Wellbeing. The meeting also discussed the concept of Risk Knowledge Action Network (KAN); and reviewed the IRDR Communication Strategy presented, looking at improving ICoE regular meetings and communications. A special issue as the IRDR legacy was proposed. This meeting directly piggybacked upon the Global Forum on Science and Technology for Disaster Resilience 2017.

[SC19]15-16 April 2018 (Beijing, China)

The 19th IRDR SC meeting took place prior the 2nd Asian Science and Technology Conference for Disaster Risk Reduction (ASTCDRR 2018). Before this session of IRDR SC meeting, a Coordination Meeting between IRDR Co-sponsors, the host, the Chair of IRDR SC and IRDR IPO was held in Paris as a follow-up of 2016 Mid-term Review, and in particular to examine the Action Plan 2018-2020 proposed by IPO. The SC meeting noted the expectation from the co-sponsors to IRDR to improve the coherence and mutual reinforcement between the Sendai Framework, the SDGs and the Paris Agreement. The SC meeting approved IRDR Action Plan 2018-2020, and actively participated ASTCDRR 2018, and anticipated its roles in the Asian Ministerial Conference for Disaster Risk Reduction (AMCDRR 2018) and UNESCO Youth Forum.

[SC20]15-18 October 2018 (Chengdu, China)

The 20th IRDR SC meeting looked at the progress made in the implementation of IRDR Action Plan 2018-2020. The meeting concurred with the Co-sponsors on five priority areas for actions: coherence between the Sendai Framework, SDGs and Paris Agreement at national, local and community levels, urgency in reaching the Sendai Framework deadline of 2020 on Target E, expansion of scope of risk, improvement of capacity on data disaggregation, science policy interface and youth engagement. The meeting also discussed IRDR's organization of pre-event and specific sessions at GP2019 as well as the future of IRDR more broadly. The meeting noted the official merging of the IRDR host institution with other CAS institutions and renamed as The Aerospace Information Research Institute (AIR). This meeting was in conjunction with a UNDRR meeting mainly focused on the review of the S&T Roadmap. A field trip to investigate the recovery and resilience strategies of cultural heritage sites in Chengdu area was organized.

[SC21]14 May 2019 (Geneva, Switzerland)

The 21st IRDR SC meeting took place after the Science-Policy Forum of GP2019, which IRDR organized together with ISC and UNDRR. It was a half-day meeting reviewed the effort t and contributions of IRDR to GP2019, particularly to the Science-Policy Forum. The concept of the IRDR Compilation 2010-2020 was proposed by IPO and was approved. A book titled IRDR: Contributions from IRDR Young Scientists proposed by two SC members was approved. The meeting confirmed that there would be an IRDR Conference in 2020. The concept of the IRDR Compilation was proposed and approved, and the IRDR Handbook and previously mentioned special issue were updated.

[SC22]8-10 October 2019 (Xiamen, China)

The 22nd IRDR SC meeting's overall objective was to put together ideas from the IRDR community for a DRR integrated research agenda towards 2030, as it looks to the future of IRDR. To this end, the ISC's new Action Plan 'Science as a global public good' and GAR2019 were presented; the IRDR contribution to GP2019, especially the contribution to S&T Roadmap was introduced; an update on the development of Risk KAN was provided; and a seminar to review the draft Hazard Terminology and Classification was organised. A new science plan on risk science and to guide IRDR 2.0 was expected to be prepared in 2010.

[SC23]15 June 2020 (Online)

The 23rd IRDR SC meeting was held in virtual format due the COVID-19 Pandemic. As a result of the delays arising therefrom, ISC announced the extension of the IRDR programme to 2021 to complete its planned tasks for 2020. Updates were provided on the main tasks of IRDR, namely the IRDR Compilation, IRDR Conference 2020 and the Global Research Agenda on DRR. The Hazard Terminology and Classification Technical Report was presented, in which IRDR's contributions were noted and appreciated.

[SC24]10 November 2020 (Online)

The 24th IRDR SC meeting presented the draft Executive Summary of the IRDR Compilation; conducted brainstorming session to obtain comments and suggestions from the IRDR Community on its updated Research Agenda. Finally, the meeting agreed to postpone the IRDR Conference to 2021 and confirmed that it would be organised in a virtual format.

◆ IRDR National Committees (NCs) and Regional Committee (RC)

Over time, a total of 13 IRDR National Committees (NCs) and one Regional Committee (RC) have been established to support and supplement IRDR's research initiatives, and help to establish or further develop crucial links between national disaster risk reduction programmes and activities within an international framework. NCs and RC helped foster the much-needed interdisciplinary approach to disaster risk reduction within national scientific and policy-making communities, and served as important national focal points between disciplinary scientific unions and associations. The First Consultative Forum of IRDR National Committees, hosted by UK Collaborative on Development Sciences (UKCDS), was held on 11-12 November 2014 at Wellcome Trust, London, UK.

The objectives of NCs/RCs include: First, IRDR NCs/RCs are encouraged to act as mechanisms to mainstream integrated research into disaster risk reduction efforts at national and regional on an institutionalized basis, to enhance the coordination and cooperation among multi-stakeholders for the sustainability of the integrated research, and to improve the capacity of countries and regions in the field of disaster risk reduction. Second, IRDR NCs/RCs are to serve as focal point to promote IRDR-related research initiatives of host countries, and to enhance the links between national and international disaster risk research programmes and activities. Third, IRDR NCs/RCs are to, in conjunction with IRDR SC, IPO and IRDR partners in pursuit of IRDR objectives, identify research priorities, develop research plans, and implement programmes and other activities to achieve IRDR goals.

In support of IRDR's SC, IRDR NCs/RCs are expected to undertake the following activities:

- Foster and support participation in IRDR on the part of institutions and individual scientists;
- Serve as the national or regional focal point for IRDR;
- Foster networking and collaboration among domestic, regional and international disaster risk reduction science and technology activities;
- Improve scientific knowledge and enhance the integration of science in disaster risk reduction planning, policies and programmes domestically, regionally and internationally;
- Support efforts to update and report on national and regional disaster risk reduction activities aligned with the Hyogo Framework of Action's strategic priorities, with emphasis on the science and technology activities and engage in the discussions for the post-2015 regime on disaster risk reduction and contribute to the national or regional discussions for other relevant global negotiations (climate change adaptation, earth systems, etc.);
- Provide scientific advice to policy-makers, taking into consideration on national and regional disaster risk reduction initiatives;
- Assist in fundraising for IRDR activities and projects.

Current NCs

IRDR Australia
Home Institution: Bushfire & Natural Hazards Cooperative Research Centre (BNH CRC)

IRDR Canada
Home Institution: Science and Technology Working Group, Canada's Platform for Disaster Risk Reduction

IRDR China
Home Institution: CAST

IRDR Colombia
Home Institution: National Committee of Disaster Risk Knowledge, National Unit for Disaster Risk Management of the Presidency of the Republic of Colombia (Unidad Nacional de Gestión del Riesgo de Desastres, UNGRD)

IRDR France
Home Institution: Scientific Council, Association Française Pour la Prevention des Catastrophes Naturelles (AFPCN)

IRDR Germany
Home Institution: German Committee for Disaster Reduction (Deutsches Komitee Katastrophenvorsorge e.V. – DKKV)

IRDR Indonesia
Home Institution: Indonesia Institute of Sciences (LIPI)

IRDR Iran
Home Institution: International Institute of Earthquake Engineering and Seismology (IIEES)
*IRDR Iran is a group of eight Iranian research institutes and scientific associations. These are the:

- International Institute of Earthquake Engineering and Seismology (IIEES) – coordinating institute for IRDR Iran
- Iranian Earthquake Engineering Association (IEEA)
- Disaster Management Research Institute of Shakhesh Pajouh (DMRISP)
- Iranian Sociological Association (ISA)
- Water Research Institute (WRI)
- Iranian Water Resource Association (IR-WRA)
- Disaster and Emergency Health Department at Tehran University of Medical Science
- Tehran Disaster Management and Mitigation Organization (TDMMO)

IRDR Japan
Home Institution: Science Council of Japan (SCJ)

IRDR Nepal
Home Institution: National Reconstruction Authority of Nepal

IRDR New Zealand
Home Institution: Natural Hazards Research Platform (NHRP)

IRDR the Republic of Korea
Home Institution: National Disaster Management Research Institute (NDMI) in Ministry of the Interior and Safety

IRDR the USA*
Home Institution: Natural Hazards Center (NHC), Institute of Behavioral Science, University of Colorado at Boulder

Note: IRDR the USA is a 'centre of centres' taking advantage of the research capacities of university-based centres that specialise in different aspects of hazards and disasters and that represent diverse disciplines.

Current RC
IRDR welcomed its first RC in 2013, in the Latin American and Caribbean (LAC) region, through the newly formed ICSU Regional Office for Latin America and Caribbean (ICSU-ROLAC) Scientific Steering Committee for IRDR in LAC.

The roles taken and contributions made as well as the challenges encountered and lessons learnt by the IRDR NCs and RC are reported in the

Chapter 2 and Chapter 3 of the Compilation. It is expected that, should IRDR be continued for another substantial duration, e.g. through 2030, IRDR NCs and RC and scientists behind would continue play their active roles. However, since the subject of IRDR programme governance and operational management are addressed in this Chapter, one need to step back and look at the overall position and roles of IRDR NCs in IRDR with a more critical eye.

The level of exchange between IRDR NCs and IRDR SC and IPO are seen as limited. Since 2015, IRDR NCs have been participating in IRDR through their attendance of IRDR SC meetings but such participation is voluntary in nature, and we have observed a reduction in the numbers of attendants therefrom. Some NCs have also raised the issue of their position at IRDR SC meetings. This is a good point: while NCs are very much encouraged to participate in all IRDR SC meetings, they are not equipped with voting power for the planning and decisions of IRDR. As an international scientific programme which has clear roles in interacting at national level for policy improvement, the position of IRDR NCs in IRDR's planning and decision making need to be further reviewed and re-considered.

IRDR is mandated and committed to bringing together DRR research communities for cooperation, but so far there is no regular mechanisms for IRDR NCs to meet and exchange among themselves, except for the limited opportunity of IRDR SC meetings. It is now clear that IRDR should have had other regular conferences (as it was during the initial years of the programme) to bring together entire IRDR community for exchange. This has also led, or at least partially contributed to, the relatively low visibility of IRDR NCs in international community, with perhaps a few exceptions. In addition, the reporting mechanism for NCs have not been effective in facilitating the information flow between NCs and IRDR SC and IPO, and this certainly has affected IRDR's scope of outreach.

IRDR ICoEs

Over last ten years, a total of 17 institutions have joined IRDR as ICoEs. They have provided regional and research foci for the IRDR programme. In particular, each established ICoE enabled regional scientific activities through geographically-focused contributions based on more localised inputs, and by being visible centres of research, motivate participation in the IRDR programme. Chapter 2 and Chapter 3 have evidenced the contributions of IRDR ICoEs as providing critical institutional research capacity, acting as producers of knowledge and important actors to advance the IRDR agenda within the Sendai Framework.

Generally, each ICoE contributes to IRDR's main principles, objectives and studying domains and to promote and disseminate widely the IRDR concepts, approaches and methodologies. ICoEs not only are committed to supporting the SC and IPO in facilitating IRDR, but also to developing a global network for IRDR knowledge, expertise and researchers. Specifically, ICoEs follow 3 objectives in their IRDR activities. Firstly, each ICoE research programme embody an integrated approach to disaster risk reduction that directly contributes to the IRDR Science Plan and its objectives: the scientific characterization of natural and human-induced environmental hazards, vulnerability and risk; the understanding of decision-making in complex and changing risk contexts; and the reduction of risk and curbing losses through knowledge-based actions. The ICoE also contributes to the cross-cutting themes: capacity building; case studies and demonstration projects; and assessment, data management and monitoring. ICoE and IRDR projects work together to contribute towards IRDR's global legacy. In particular, the ICoE enables regional scientific activities through geographically-focused contributions based on more localized inputs and, by being a visible centre of research, motivates participation in IRDR. Secondly, ICoEs support IRDR in developing and strengthening powerful partnerships with UN Agencies and organizations at international, regional and national levels working on disaster risk, which provides a reserve of intelligent and informational resources for IRDR. Thirdly, ICoEs further extend their core function as facilitators of IRDR and acts as international centres providing support for decision-making, promulgating the achievements of DRR research, and fostering senior DRR researchers and practitioners. All the above with a view of ensuring a shift of focus towards disaster risk reduction in research and policy-making.

In order to comply with the objectives of IRDR Science Plan and its own objectives, the roles of ICoEs can be broadly categorized as below:

- Conduct IRDR at local, regional, and global scale, meeting the objectives of 4 IRDR Working Groups;
- Provide specifically-designed technical cooperation on disaster risk and reduction management for policy and decision-making;
- Provide technical support for formulating regional, national or local disaster risk reduction programs based on integrated research;
- Promote IRDR research by conducting regular trainings, workshops or other activities for disaster managers, decision- makers, and junior researchers;
- Facilitate and participate in IRDR events;
- Contribute to disaster risk researchers' networks and/or platforms

◆ Current ICoEs (in order of establishment):

1. IRDR ICoE-Taipei

Home Institution: Academy of Sciences located in Taipei, China

2. IRDR ICoE in Vulnerability and Resilience Metrics (IRDR ICoE-VaRM)

Home Institution: Hazards and Vulnerability Research Institute (HVRI), Department of Geography, College of Arts and Sciences, University of South Carolina, Columbia, South Carolina, USA

3. IRDR ICoE in Community Resilience (IRDR ICoE-CR)

Home Institution: Joint Centre for Disaster Research (JCDR), Massey University, Wellington, New Zealand

4. IRDR ICoE in Understanding Risk & Safety (IRDR ICoE-UR&S)

Home Institution: Disaster Risk Management Task Force, Institute of Environmental Studies (Instituto de Estudios Ambientales – IDEA), National University of Colombia (Universidad Nacional de Colombia), Manizales City, Colombia

5. IRDR ICoE for Risk Education and Learning (IRDR ICoE-REaL)

Home Institution: Periperi U (Partners Enhancing Resilience for People Exposed to Risks) Consortium, Research Alliance for Disaster and Risk Reduction (RADAR), Department of Geography and Environmental Studies, Stellenbosch University, South Africa

6. IRDR ICoE in Risk Interpretation and Action (IRDR ICoE-RIA)

Home institution: Centre for Integrated Research on Risk and Resilience (CIRRR), Department of Geography, King's College London (KCL), London, UK

7. IRDR ICoE for Disaster Resilient Homes, Buildings and Public Infrastructure (IRDR ICoE-DRHBPI)

Home Institution: Institute for Catastrophic Loss Reduction (ICLR), Western University, Toronto, Canada

8. IRDR ICoE on Critical Infrastructures and Strategic Planning (IRDR ICoE-CI&SP)

Home Institution: Institute for Spatial and Regional Planning (IREUS), Department of Civil Engineering and Environmental Management, University of Stuttgart, Germany

9. IRDR ICoE for Collaborating Centre for Oxford University and CUHK (CCOUC) for Disaster and Medical Humanitarian Response (IRDR ICoE-CCOUC)

Home Institution: Collaborating Centre for Oxford University and CUHK (CCOUC) for Disaster and Medical Humanitarian Response

10. IRDR ICoE for Disaster Risk and Climate Extremes (IRDR ICoE-SEADPRI-UKM)

Home Institution:Southeast Asia Disaster Prevention Research Initiative (SEADPRI-UKM), the National University of Malaysia

11. IRDR ICoE for National Society for Earthquake Technology- Nepal (IRDR ICoE-NSET)

Home Institution:National Society for Earthquake Technology-Nepal

12. IRDR ICoE in Spatial Decision Support for Integrated Disaster Risk Reduction (IRDR ICoE-SDS IDRR)

Home Institution:Faculty of Geo-Information Science and Earth Observation (ITC),The University of Twente

13. IRDR ICoE on Transforming Development and Disaster Risk (IRDR ICoE-TDDR)

Home Institution:SEI Initiative on Transforming Development and Disaster Risk

14. IRDR ICoE on IRDR Science (IRDR ICoE-IRDRS)

Home Institution:Disaster Risk Science Institute, The Australian National University

15. IRDR ICoE on Resilient Communities & Settlements (IRDR ICoE-RCS)

Home Institution: Visvesvaraya National Institute of Technology (VNIT), India

16. IRDR ICoE on in Disaster and Climatic Extremes (IRDR ICoE-DCE)

Home Institution: Department of Geography, University of Peshawar, Pakistan

17. IRDR ICoE on Risk Interconnectivity and Governance on Weather/Climate Extremes Impact and Public Health (IRDR ICoE-RIG-WECEIPHE)

Home Institution: Fudan University, China

The records show that, over last five years, the level of participation of IRDR ICoEs in IRDR SC meetings are higher and more dynamic (as compared to many IRDR NCs). However, vis-a-vis programme governance, there is a similar concern to NCs, with the role of ICoEs in programme development planning and decision making unclear. This needs to be further reviewed and improved in the process of development of new global research agenda and the associated implementation mechanism(s).

◆ IRDR WG

IRDR established six Working Groups (WGs) under the IRDR SC. These WGs are organized and operated to carry out research to meet IRDR's research objectives and cross-cutting themes with a particular emphasis in formulating new methods in addressing the shortcomings of current disaster risk research. In recent year, IRDR WGs have opened for ICoEs and Young Scientists to join.

AIRDR

The AIRDR project was set up to undertake the first systematic and critical global assessment of IRDR. The enormity and complexity of disaster risk requires knowledge from the natural, social, and health sciences, as well as engineering, all operating in an integrative fashion, not as separate disciplines examining one aspect of the problem. Such a synthesis of perspectives is not easy, but is vital in producing the new understanding of disasters and their impacts and in achieving the objectives of IRDR.

Disaster Loss Data (DATA)

The Disaster Loss Data (DATA) project was set up to study issues related to the collection, storage, and dissemination of disaster loss data. Recognising the need for standards or protocols to reduce uncertainty in disaster loss data, the working group intends to establish an overall framework for disaster loss data for all providers, to establish nodes and networks for databases, and to conduct sensitivity testing among databases to ensure some level of comparability.

Forensic Investigations of Disasters (FORIN)

The Forensic Investigations of Disasters (FORIN) project's mission is to develop, disseminate and implement a radical new approach in disaster research that seeks to identify and explain the underlying causes of disasters, including the growth in magnitude and frequency of very large disaster events. It is intended that this research paradigm will lead to greater in-depth understanding and more enlightened and effective disaster risk reduction practices and policies.

Risk Interpretation and Action (RIA)

The Risk Interpretation and Action (RIA) project focuses on the question of how people — both decision-makers and ordinary citizens — make decisions, individually and collectively, in the face of risk. Decision-making under conditions of uncertainty is inadequately described by traditional models of 'rational choice'. Instead, attention needs to be paid to how people's interpretations of risks are shaped by their own experiences, personal feelings and values, cultural beliefs and interpersonal and societal dynamics.

DRR, CCA and SDGs

This working group focuses on DRR research in the coherence of the Sendai Framework, Paris Agreement and SDGs. Climate change is changing the characteristics of disasters. The world has adopted the Sendai Framework to help deal with disaster impacts through strengthened governance, better risk knowledge, resilience investment, and preparedness and recovery and reconstruction. The Paris Agreement on Climate Change is the international framework adopted to deal climate change. The are many strategies to deal with climate change, mostly through strengthening institutions, planning and implementation of strategies for adaptation. DRR has also been suggested as the 'first line of defense' for Climate Change Action (CCA), as they both advocate for vulnerability reduction, strengthening resilience, and integrations of climate risks considerations within development. In addition, the SDGs were adopted in 2015, and explicitly recognized the links between disasters and climate change, in particular in goals 11 on cities and 13 on climate change. It is important that strategies to deal with DRR and CCA also meet the SDGs strategically. While these 3 international frameworks are clear in terms of their intended outcome, the way by which the progress can be measured are still unclear. Capacity for research and scientific engagement related to DRR-CCA-Development also need to be strengthened. It is important to encourage scientific research and engagements within developing countries, in particular in Asia and Africa.

Nation's Synthesis on Disaster Risk Reduction

Supported by Science and Technology

This working group aims to promote dialogue between stakeholders and the science & technology community. The WG proposes that each country should develop an online information sharing system under international cooperation to share synthesized information of science and technology among a broad range of stakeholders. With this information infrastructure, the national platform of each country should review the status and issues of the current DRR efforts that they have implemented based on scientific knowledge. The national platform should then be used discuss how DRR should be carried out for the country, and design practical measures to be implemented from a holistic viewpoint. All these processes should contribute to the enhancement of dialogue between the two parties, which will result in the production of guidelines and synthesis reports.

◆ IRDR Young Scientists Programme

The IRDR Young Scientists Programme is an initiative started in 2016 to promote capacity building of young professionals and to encourage them to undertake innovative and needs-based research which strengthens science-policy and science-practice links. The objectives are to:

- Increase awareness among young scientists regarding implementation of the Sendai Framework and provide opportunities for further engagement through the Young Scientists Program on DRR;
- Collate existing research knowledge on DRR and identify research gaps and priorities in relation to the Sendai Framework Priorities for Action;
- Identify opportunities to fund continued multi-disciplinary research by young scientists and early-career researchers;
- Provide technical support to promising young researchers in DRR fields;
- Build and foster strong and dynamic networks among worldwide experts and institutions in DRR fields;
- Develop, over time, a community of high-quality young professionals that can provide support for policy making decisions related to DRR

With 4 rounds of the programme completed, already 162 young researchers from 46 countries have been involved, including 43 female researchers. The academic background of these young scientists ranges from traditional disciplines (such as Geography, Biology, Engineering, Computer Science, Architecture, Anthropology, Economy, and Law) to the integrated and cross-cutting disciplines (such as Disaster Risk Management, Climate Change and Adaption, Social Resilience, DRR Communications, Disaster and Emergency Health, and Disaster Nursing). The application proposals accepted by IRDR focus on the mechanisms of disaster processes, and the development of a comprehensive understanding of disaster risk, community resilience, and public awareness. Some 20 papers from IRDR YSP have been collected and will be included in this Compilation.

4.2

Institutional capacity gaps: views and comments from members of IRDR Community

The institutional capacity building in IRDR is mainly conducted through NCs and ICoEs. NCs and ICoEs are established on the basis of research institutes and organisations. They are the knowledge producers and DRR practitioners within national and reginal contexts. They serve as think tanks and meet the integrated research requests at the regional, thematic and global levels. However, the current distribution of IRDR NCs and ICoEs is lacking regional balance. In addition, there are critical research domains and subjects in DRR that current NCs and ICoEs have not yet covered. More efforts are still needed to fill these institutional capacity gaps.

The following two boxes presented the comments from NC Iran and NC Germany regarding the institutional capacity gaps at regional and national levels.

◆ IRDR NC of Iran

Disaster risk and resilience management and governance in Iran is facing very similar challenges as faced by many other regions in the world, namely: the gap between knowledge and implementation, between science and policy, which remains rooted in the risk-based decision-making process. Some of the recommendations are:

1. Integration of all DRR programs, policies, regulations, institutions, and stakeholders by creating synergy through systematic and NEXUS approach. All governments, including Iran, should form a high-level Risk and Resilience Science Advisory Body to look into the entirety of prevailing policies and start the process of integration and harmonization of such policies into an unified long-term policy and order. This process can be done gradually, in four steps: 1) creating cooperation within sectors, 2) creating synergy between sectors, 3) integrating all sectors in one system with inter-disciplinary cooperation, and ultimately 4) creating nexus integration of all sectors. This is the principal of good governance, where elements of a system should work together in order to solve the complex problems of being safe against natural disasters;
2. Optimization of DRM and Resiliency Objectives: Given that limited available resources are often distributed across too many activities and projects; and that achieving preparedness and resilience for mega-disasters is almost impossible; it is recommended that:
    - The resilience and disaster response goals should be set in a fashion that prepare the society for encountering more frequent and probably smaller disasters. At the same time, planning for less frequent and more severe events should be started. The target goals and acceptable risk level should be defined based on the IRRM; and,
    - A process for optimizing resource allocation to projects and activities that are doable and achievable should be followed. Funds and budget should be targeted to the

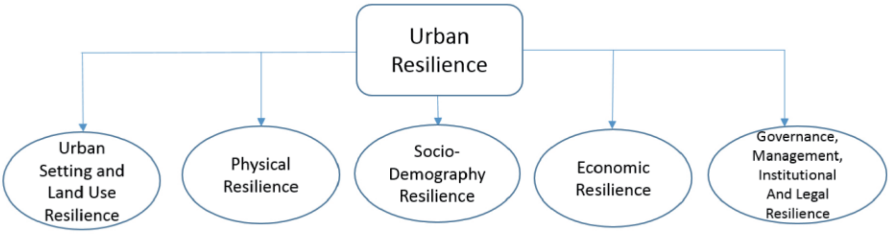
reduction projects with lower costs and higher effectiveness;

3. Creation of demand for safety by promoting risk communication: Risk communication is essential for raising awareness about disaster risk in order to achieve resilience, particularly with regards to earthquakes, fires and floods. Without opening people's eyes on the fact that they are at risk, all efforts for enhancing preparedness and taking preventive actions would barely succeed. People need reliable information from reliable sources in order to trust and cooperate with the government in risk reduction programs. Reliable hazard maps providing graphical information on the risks of disasters and information on evacuation routes, shelters, and response resources; as well as providing religious and socio-economic incentives are effective tools for raising risk awareness and public participation;

4. Formulating risk-based disaster response, recovery and reconstruction;

5. Avoiding the creation of new risk through safe and resilient planning, designing, constructing, rehabilitating and comprehensive and integrated capacity building;

6. Establishing procedures for monitoring urban resilience, evaluating the progress thereof, and for measuring improvements in the resilience of urban areas through implementation of risk reduction programs. To this point, an index-based monitoring system has been proposed based on the pertinent parts of the Sendai Framework (as the newest adopted international strategy for disaster risk reduction). An indicator system for urban resilience has also been proposed. This Indicator system has a hierarchical structure and has been extended according to a rational lookout to cover all involved parts of a city. It is based on the main contribution parameters as shown below.



◆ IRDR NC of Germany

Major gaps are found when looking at implementation on the ground. Municipalities often do not have sufficient resources to address CCA issues, even less so the complexities of bringing together CCA and DRR in a coherent manner. Both aspects need to be integrated in land use planning (such as regional plans of the federal states and urban development plans). To help local and regional actors with the harmonization of DRR and CCA, the federal government needs to invest in capacity building and awareness raising activities, especially at the local level. Finally, to enhance access to equal information on funding opportunities on CCA and DRR, information should also be made available to actors who might not belong to the CCA and/or DRR communities per se.

◆ IRDR NC of Colombia

1) National levels

Although the Technical Advisory Committee for Risk Awareness (CTACR, in Spanish) has been in operation since 2014, only until 2020 it condensed the essential information and approved the strategy. It means it is necessary the development of future projects and initiatives in the four strategic lines previously established:

- Science, technology, and innovation promotion.
- Communication of advances in science and technology.Promotion of human capital from the National System of Science, Technology, and Innovation
- National-level institutional integration

2) Regional and sub-regional

It is necessary to strengthen the collaborative work level between the National Disaster Risk Management System, the National Science, Technology and Innovation System, the National Competitiveness System, and the National Environmental System to optimize resources for developing science, technology, and innovation products at regional and sub-regional level. Such a process requires regarding academia's capacities, the scientific community, the economic sector, the technical institutions, the community, and the public sector. Finally, it has to increase synergies with the territorial level to guarantee effectiveness in implementing the risk management policies.

◆ IRDR ICoE-VaRM

Uneven institutional capacity is a key challenge for the IRDR. The lack of coordination among members of the IRDR-extended family, generally a by-product of having no centralized financial support for the ICoEs, for example, will continue to thwart the goal of an integrated science network focused on disaster risk reduction from local to national scales. Until there is some minimal amount of centralized support for the ICoEs from the IRDR IPO (or some other entity), they will continue to operate as “independent” agents with minimal collaboration among them. Without some form of matching funds, for example, true IRDR will only be aspirational, not realized.

◆ IRDR ICoE CR

New Zealand has adopted a National Resilience Strategy that aligns with the Sendai Framework. The need to enhance its global partnerships has been acknowledged at the national level. The initiative to strengthen the partnership between a number of the ICoEs is welcomed and should be furthered. Additionally, the ICoE is also well aware of the need to enhance engagement with regional partners and connect with nearby countries, communities and institutions who may have had limited connection to the IRDR efforts over the past decade.

◆ IRDR ICOE CCOUC

Institutional capacity gaps echo the backgrounding of health in the research and practice scenes. Taking China as an example, its environmental degradation and rapid urbanisation make China one of the most severely affected countries in terms of the number of disasters, human causalities and economic losses. As one of the most important indicators of disaster risk reduction, disaster-related deaths have been reduced in recent years due to the improvement of disaster management capacity. As key components of primary prevention under the Health-EDRM framework, the emergency medical and public health response and disease surveillance system have been largely strengthened. However, the health sector in China was often only involved in the later stages of disaster response. Although the newly established Ministry of Disaster Management of China has integrated the duties previously scattered in many government departments, the health sector remains not directly included in its structure. Preventive measures including primary care resilience, health infrastructure safety codes and hospital emergency plans are still not in place in many areas of the country. There is an urgent need to build a framework and mechanisms to ensure a better involvement of health in China’s disaster management system, as highlighted by the Health-EDRM framework (Chan and Shaw, 2020).

The current fight against the COVID-19 pandemic has made the need for future DRR research agenda to enhance health-related DRR abundantly clear. ICoE-CCOUC’s current work on COVID-19 is yet another attempt to put the Health-EDRM framework into use in research, practice and policy.

◆ IRDR ICoE REaL

- PERIPERI U has struggled to find and secure long-term funding contracts to support its partners and their initiatives. PERIPERI U's central funding from USAID came to an end in 2019, and with limited opportunities to replace such funding, PERIPERI U activities such as its academic programmes, research, short course strategic engagement and advocacy will be limited and potentially be forced to close.

- Despite significant growth in student enrolmentbody, a lack of student funding remainsed a major constraint, especially at post-graduate levels. Many students continued to struggle to support themselves financially, with funding obstacles delaying study completion or forcing student withdrawal from academic programmes. With limited funding available to the PERIPERI U, partners are unable to provide scholarships or financial support to their students to ensure they can continue and complete their studies.

◆ IRDR ICoE ITC

- How to effectively involve relevant stakeholders in recovery planning and execution. [often people create facts on the ground (rebuilt slums etc.) before decision makers get any planning done]

- Give risk reduction (including climate risk) more attention in spatial planning curricula and professional (life-long) learning activities

◆ IRDR ICoE-SEADPRI-UKM

Linking young scientists working on disaster risk reduction and climate change adaptation

The ICoE-SEADPRI-UKM strongly supports engagement with youth and young professionals. Early career scientists from various disciplines are involved in the crosscutting field of disaster risk reduction and climate change adaptation. The engagement of youth in science and technology is a powerful enabler for creating resilient communities. This is also conveyed in the Sendai Framework and SDGs, both of which advocate the involvement of multiple stakeholders including youth, to ensure success.

In 2017, the ICoE and Asian Network on Climate Science and Technology (ANCST) started the "Malaysia-Window-to-Cambridge at UKM" initiative with funding from the Cambridge Malaysian Education and Development Trust, in association with the Malaysian Commonwealth Studies Centre (MCSC/CMEDT). The initiative unearthed a talent pool of some 80 high-calibre "ANCST Young Scientists" in Asia, who benefitted from training workshops and events convened by ANCST in the region and are now connected through the ANCST Special Topic Group on Young Professionals in DRR and Climate Change. The young scientists of ANCST, with broader engagement from the region facilitated by the IRDR IPO, are now actively engaged in supporting the IPCC in its Sixth Assessment cycle. This has been made possible through the collaboration of the ICoE with ANCST, the Asia-Pacific Network for Global Change Research (APN), the International Science Council Regional Office for Asia and the Pacific (ISC-ROAP), as well as other partners. The collaborating agencies have convened several events in the region to increase the participation of scientists, particularly early career scientists, in the IPCC process and improve coverage of scientific information for sub-regions such as Central Asia, West Asia, Southeast Asia, Hindu-Kush Region and the Pacific Islands, which were not well covered in the Fifth Assessment Report of the IPCC (Figure 4-1).

Figure 4-1: **In 2018, ICoE-SEADPRI-UKM and ANCST partnered with APN, ISC-ROAP and other parties, to bring together young scientists working on DRR and climate change adaptation and link them to IPCC authors, at the Workshop on Status of Climate Science and Technology in Asia, held in Kuala Lumpur, Malaysia.**

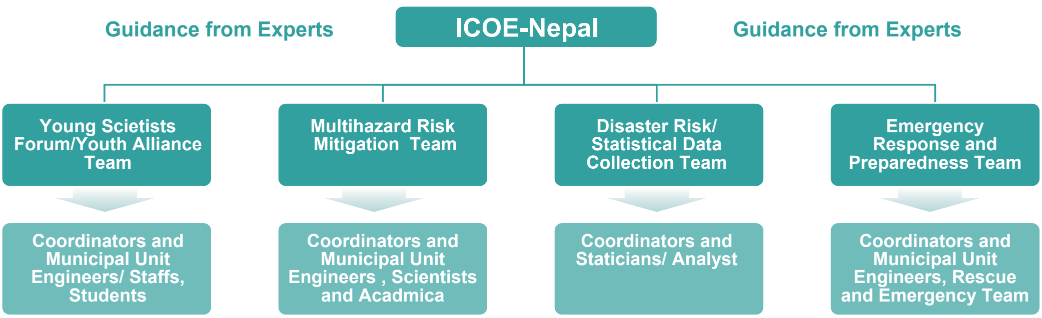
The ANCST Special Topic Group incubated and established U-INSPIRE Malaysia@UKM in 2019, which is now part of the regional U-INSPIRE network championed by UNESCO's Regional Science Bureau for Asia and the Pacific. The launch of U-INSPIRE Malaysia@UKM saw the participation of representatives of U-INSPIRE networks from Indonesia, India, Pakistan, Nepal and The Philippines, who shared experiences and ongoing initiatives from their respective countries (Figure 4-2). Through the work of ANCST Special Topic Group on Young Professionals in DRR and Climate Change, U-INSPIRE networks (via the U-INSPIRE Alliance platform) are now linked to other youth groups such as the IRDR Young Scientists, the United Nations Major Group for Children and Youth (UNMGCY), and the Children in a Changing Climate coalition (CCC), helping bridge DRR and climate change adaptation. ANCST also conducted the workshop "Building Disaster and Climate Resilience in Cities in Kuala Lumpur" on 15-16 October 2019. This workshop involved the participation of experts from the UNDRR Asia-Pacific Science, Technology and Academia Advisory Group (APSTAAG), with the purpose of taking stock of new scientific knowledge on tropical cities. In addition to building capacity, the workshop was intended to marshal future research and lay the foundation for supporting the IPCC Special Report on Climate Change and Cities in the upcoming Seventh Assessment cycle. A total of 141 participants representing multiple disciplines and 14 countries shared the latest findings for cities, including modelling of geophysical and atmospheric hazards, critical infrastructure resilience and pathways for building disaster resilience as climate changes. Young scientists were exclusively targeted as participants and a few were selected to present posters on their ongoing work.

Figure 4-2: **In 2019, ICoE-SEADPRI-UKM, ANCST and partners launched U-INSPIRE Malaysia@UKM, which is now linked to a significant network of active youth groups, to empower young scientists to bridge DRR and climate change adaptation at the local level.**

◆ IRDR ICoE NSET

IRDR ICoE-NSET will continue to focus on embedding science and technology in disaster risk reduction efforts of Nepal by establishing thematic hubs at the municipality levels. The hubs will have members from different institutions and include both state and non-state actors, and will work towards providing definite conclusions that may be then applied, either by adapting global knowledge into local context, or by conducting solution-finding focused research that would be helpful for evidence-based decision making and for encouraging investment in DRR. The ICoE expects to pilot 2-3 hubs in the next year. Though their foci will differ, all will work to support the following objectives:

Figure 4-3: **Future Strategy of ICoE-Nepal showing hubs**



- To promote the use of science and technology in the assessment of disaster and climate hazard and risk in the municipal jurisdiction and help mainstream efforts into the ongoing development works.
- To promote the involvement of youth in municipal development activities, tying up with academic institutions blend knowledge and bring tangible outcome (Dixit, n.d.).

◆ IRDR ICoE RIG-WECEIPHE

Integrated researches are very much needed for a better understanding of the risk interconnectivity. Therefore, it is critical to establish an institutional framework in support of these integrated efforts. One of the key issues for establishing the framework is to strengthen multi-stakeholder partnerships, to bridge academic communities, government authorities, development organizations, private sectors and NGOs to put into practice of the value chain “Science in Service to Society”. As the first ICoE in the Chinese Mainland, ICoE RIG-WECEIPHE is willing to make its contribution in this regard and will work with WMO MAP-AQ Asian Office Shanghai and other IRDR ICoEs to be a liaison hub to facilitate the efforts to enhance the integrated research on the interconnectivity risks associated with climate change (weather/climate extremes in particular), air pollution and public health, the capacity development, technical transfer and wider engagement for better governance in achieving sustainable and resilient development.

Therefore, we call for the development of the network and alliance together with multi-stakeholder in support of implementation of the research agenda to connect the high prioritized actions set by global agendas, such as “race to zero” for achieving goals of carbon neutrality in the mid-21th century, and one health for addressing epidemic disease through co-designing, co-initiating requirement driven R&D and co-organizing joint actions for better science-based governance.

4.3

Assessment and important recommendations from the mid-term review of 2016 and the Action Plan 2018-2020

The co-sponsors of IRDR and the host commissioned a mid-term review for IRDR in 2016. This was a most critical action as the review identified the weaknesses and challenges of IRDR at the mid-stage of its implementation, allowing it to improve in a timely manner. Many improvements have been made since as a result, but the essence of the 2016 assessment and recommendations remain valuable and stimulating even today. It is hence included below for reference.

Mid-term Review

As the Review is intended to inform the unfolding of the next 4-5 years phase of the ten-year IRDR Program ('IRDR'), the seven-member Review panel focused their work purposefully on identifying critical areas for improvement.

The Review panel's overall assessment is that upon its establishment, IRDR was a well-conceptualized, timely and innovative - potentially even pioneering - initiative in the increasingly important domain of disaster risk reduction. Its design was ambitious. It reflected the effort needed to bring to fruition a global research program that had to promote and demonstrate new ways of thinking and working in order to influence policies and practices that benefit societies and vulnerable communities around the world.

However, decisions during the inception phase led to a pared down program that has yet to convince that IRDR's initial objectives can be achieved by the end of its ten-year lifetime. Despite the commitment of the excellent scientists on the Scientific Committee, their active engagement in important global and regional initiatives, four main research projects, and the establishment of a network that provides an IRDR footprint in 30 countries around the world (by June 2016), progress has been slow, and the program foci and results too limited to meet the goals of the Science Plan and the expectations created by the program.

The Review panel found the situation to be the result of a confluence of several key factors: decisions during inception, prompted in part by challenges in how such Interdisciplinary Bodies are set up; fast turnover in Executive Directors at the International Program Office (IPO) in Beijing (the first such IPO established outside Europe); and a series of governance, leadership and management weaknesses, including a failure to raise sufficient program funds to give life to its strategic intent.

The Review panel is convinced that IRDR remains a very worthwhile endeavour. In principle, it maintains a significant niche and comparative advantage that continue to provide a good value proposition for its stakeholders, both within and outside the scientific arena. It remains reasonably well positioned in an important area of work, and has been making fair progress in spite of significant obstacles. Many useful lessons have been learned, and there is goodwill among all parties concerned - the Scientific Committee, the main donor (CAST), the IPO, its host organization, the Institute of Remote Sensing and Digital Earth of the Chinese Academy of Sciences (RADI/CAS), and the co-sponsoring organizations - to collaborate to accelerate IRDR's path towards impact on science, policy and practice.

However, if success is to be visible by 2020, several key challenges need to be resolved with a sense of urgency as well as strong leadership. The Review panel shaped their recommendations around these challenges, and recommends that the following five aspects be addressed through dynamic cooperation among all key stakeholders, including the three co-sponsors, who are asked to take on a stronger role in future:

1. Adjust the program scope and direction. Reshape the program by building on the foundation laid in the first phase - strengthening and redirecting its efforts in order to achieve the objectives set out in the original Science Plan - and position it further in the 'disaster risk reduction for sustainable development' space. This will require an undertaking to expand the time horizon of the program 2025 if progress is satisfactory over the next few years - thus with ongoing support subject to strong accountability measures.

2. Improve the business model. Change IRDR's business (strategic and resourcing) model by moving it away from the unsuccessful project-driven, ad hoc approach to a more strategic, programmatic approach, with concerted efforts to explore and tap unconventional sources of funding.

3. Sharpen governance. Adjust the governance system to remove conflicts of interest, support stronger leadership, ensure proper oversight and appropriate lines of accountability, engage the co-sponsors, and use the strengths of each component of IRDR in an appropriate way to relieve the very significant burden of work on the Scientific Committee.

4. Improve management. Put useful monitoring, evaluation and knowledge management systems in place that can support a more strategic, adaptive, evidence-informed management approach for the whole IRDR 'family'. Enhance branding and communication systems to ensure clear program boundaries and greater, more targeted visibility. Ensure meaningful and respectful relationships between the Scientific Committee, the IPO, the program donor and host organizations, as well as the IRDR network nodes, the International Centres of Excellence (ICoEs), and its Regional and National Committees.

5. Move towards collective impact. Mobilize the different components and nodes of the IRDR network, based on the relationships built up over the years, to align and collaborate as a (global) 'action network' - based on solid, long-term partnerships wherever this makes strategic sense. Make use of the opportunity to do context-sensitive, innovative comparative work, respectful of different conditions and cultures, that can strengthen science for policy and practice.

In response to the mid-term review, efforts were made by IRDR SC and IRDR IPO under the direction of its co-sponsors and host organizations. Internally in IRDR, there were extensive discussions and suggestions for strategic actions. In 2018, these efforts resulted in the establishment of IRDR Action Plan 2018-2020 with specific actions and time frame. Since its adoption, IRDR SC and IPO have been implementing the Action Plan, whose output has already been reported in Chapter 2 and 3 of this Compilation. The Action Plan 2018-2020 has proved to be clear, easy to follow and more accountable.

Since 2016, a significant part of above five key recommendations from the mid-term review has been addressed. For instance, an oversight committee consisting of the ISC, UNDRR, CAST, CAS and AIR, and the Chair of IRDR SC and ED of IRDR was established, meeting once each year for overall programme coordination. This has helped sharpen the governance and steer the programme's implementation. Progress has also been made in terms of mobilizing different components and notes of the IRDR network, and IRDR SC meetings are open to all IRDR NCs and ICoEs, as well as the chairperson of each IRDR Working Group.

At the same time, it is also noted that some of the 2016 recommendations are still not fully implemented. The adjustment of programme scope and direction, for instance, is a process which was only started at the end of 2019 after GP2019, when the co-sponsors decided to develop a new global research agenda on disaster risk and push forward an integrated science on risk (which to IRDR may become one of the implementation options in the future). As to change of business model and relieve the IRDR SC's burden on programme management, that was achieved in part by letting the IPO handle most of the operational issues. However, the institutional arrangement for empowerment of other IRDR components entities in programme governance, including planning and decision making, remain an issue. This should be addressed in IRDR's next phase.

Table 4-1. IRDR Action Plan 2018-2020

		Action	Description	Deliverables	Lead Group	Outcomes & Impact	Timeframe
Improve Governance of IRDR	1	The Coordination Group meeting	An annual meeting of the Coordination Group	Strategic decisions and recommendations to IRDR SC and IPO	ISC Secretariat	Improved programme development policy and coherence & communication among co-sponsors, SC and IPO	2019-2020
	2	Annual donor reporting	Preparation of a comprehensive report of IRDR to the donors and co-sponsors on programme implementation	Annual report	IPO	Transparency and annual review of accountability vs IRDR goals and objectives	2018-2020
Expand the IRDR Network and Scientific Outputs	3	Contributing toward the improvement of coherence between SFDRR, SDGs and the Paris Agreement	Mainstreaming relevant SDGs and climate targets related to DRR in IRDR WGs, NCs, ICoEs and Young Scientists	IRDR key programme components and their products with clear indications to SDGs and climate targets	SC, IPO	IRDR showcases the interconnection of SFDRR priorities and the targets with SDG targets and other UN frameworks on SD	2018-2020
	4	Partnership development with G-STAG and Global ST partnership	Making joint effort with G-STAG and regional STAGs and be active in Global ST partnership in promoting integrated DRR research.	IRDR contribution at G-STAG, reginal STAG and Global ST partnership meetings	SC, IPO in cooperation with STAG	IRDR recognized as one of main driving forces in global STI mobilization for SFDRR	2018-2029
	5	Working Groups research plan Recompose the DATA, FORIN, AIRDR and RIA working groups by incorporating previous SC Members, ICoEs, NCs, IRDR Young Scientists and stakeholders from broader DRR community	- Revising working groups and define activities - Including the previous SC members - Organising a working session/ workshop to take stock and reprioritize/align Integrated Research and WG´s task around SFDRR and SDG. - Capacity Building - Promoting Integrated research approach	Specific Research Plans of WG and enhanced research teams. A number of working papers from WGs and other IRDR components ICoE joint technical workshop/conference	WG Chairs/co-Chairs, IPO	Enhanced WG outcomes Linkage and cooperation among SC, WG, ICOE´s, NC´s, Young Scientist and ISC Regional Offices and UNISDR Offices improved.	2018-2020
	6	WGs on SFDRR, CCA and SDG´s	Creation of a New Working Group to align IRDR research and overall IRDR work to SFDRR, CCA and SDG´s	WG reports	Working group chairs and co-chairs	IRDR position vs global climate change synergized	2018-2020

	Action		Description	Deliverables	Lead Group	Outcomes & Impact	Timeframe
Expand the IRDR Network and Scientific Outputs	7	New case studies on IRDR	Develop case studies with reinforced WG´s on Integrated Research for DR, Policy and Practice.	Case Studies developed by region	WG´s, ICOE´s, NC´s, Young Sc	Capacity building and IRDR network strengthened	2019-2020
	8	Continuation of Young Scientists Programme	Recruitment of young scientists through workshops and training activities	New Young Scientists members	IPO, SC Working Groups	START partner	2018-2020
	9	Expansion of IRDR base of experts by appointing "Associate Members" *(name will be changed with prior agreed TOR by the co-sponsors)*	Exemplary individuals in integrated DRR research and previous SC members	List of proposed new members.	IPO	Reinforce IRDR Working Groups Support for capacity building	2018-2020
	10	Support and partnership with IRDR associated projects	Three specific approved projects (DBAR DRR WG, SiDRR, NZ)	DRR databases, models, training packages and reports	IPO with specific project leaders	Concrete cases and products in support of IRDR mission and objectives.	2017 onward
	11	Support for ST Roadmap	*Specific contributions to Expected Outcomes Understanding Disaster Risk (1,2; 1.4); and Strengthening Disaster*	*Risk Governance to Manage Disaster Risk (2.1); among others through different WG´s*	SC, WGs, ICoEs, NCs	Use of ST, in particular integrated research approaches, in DRR related governance improved.	2018 onwards
	12	Periodic synthesis case study. A selected team of authors to produce a short report as an exemplar of Tokyo statement outcome	Conduct a synthesis of state of knowledge on SFDRR priorities targeting 2019 Global Platform	Reports of the case study	ISC, IPO, Risk-KAN Development Team	A joint IRDR contribution toward 2019 Global Platform.	2018-2019
	13	Support selected national DRR platforms as exemplars[58]	Co-develop with UNISDR guidelines to enhance national DRR platforms in selected countries.	Initial 2020 rolled out to several by 2030	IPO with UNISDR and its regional offices	Pilot examples for the development of national DRR platforms.	2018-2020

58 This needs to be further checked. Not sure if SC members have already some countries in mind for the 'national DRR platforms'

		Action	Description	Deliverables	Lead Group	Outcomes & Impact	Timeframe
Expand the IRDR Network and Scientific Outputs	14	Contributing to ISC's leading role in the S&T Major Group for the 2019 Global Platform	Lead and organize specific events and dialogues within S&T Major Group at 2019 Global Platform	Suggestions and recommendations of the S&T MG events	ISC, IPO, SC and some ICoEs	Advancement of S&T contributions in the implementation of SFDRR	2018-2019
	15	A specific task on operationalization of SFDRR indicators	A co-implemented task on indicators	A consolidated proposal on SFDRR indicators	DATA Group	Contribution to SFDRR	2018 -2019
	16	Contribute actively toward the development of Risk-KAN	Working with WCRP, Future Earth and other partners to develop a Knowledge Action Network	Risk-KAN become operational.	ICSU, ED, IPO, SC members	Improved ST action networks for SFDRR	2018-2020
	17	Regional DRR Events in all regions	IRDR contributing through SC members, NCs and ICoEs to DRR regional meetings and events on DRR & SDGs	Participation and technical advice.	SC, NCs and ICoEs in liaison with ISC and UNISDR regional offices; IPO to report	IRDR Promotion and Visibility of the Program	2018-2020
	18	Co-organize Scientific Form on Landslides	Work with ICL to organize Tokyo WLF5 in Kyoto	Specific papers and publications on landslide related risks.	ICL, SC, IPO	Specific contribution of IRDR toward Sendai Partnership (on landslides)	2020
Improve the visibility of IRDR	19	Communication and outreach	Implementation of IRDR communication strategy approved at 18th session of SC meeting	Operation in major social media, web and wikipedia	IPO	Enhanced IRDR communication and public understanding	2018-2020
	20	Special IRDR Journal Issue	Specific topic, tentative	1 Publication	SC	IRDR Legacy	2018-2019
	21	An IRDR Handbook	A stock taking handbook of science on Integrated Research on DRR	1 Publication	SC and Working Group	IRDR Legacy	2018-2020
	22	Scientific/Policy Output 2020 per IRDR WG	Short publication for decision makers on policy and practice	1 short Publication Guidelines	Working Groups	IRDR legacy	2018-2020

4.4 Programme management

4.4.1 Overall management arrangements

The programme management of IRDR are ensured through the following arrangements:

- A Letter of Agreement between IRDR Co-sponsors and the host country China, and Memorandum of Understanding on the establishment of IRDR IPO in Beijing for IRDR, both signed in 2010 for period of 10 years[59].
- IRDR SC to guide the overall scientific programme implementation. The members of IRDR SC are nominated by ISC Board.
- IRDR IPO to executive IRDR workplan under the guidance of IRDR SC and its Chair. IPO reports its work to IRDR SC and to IRDR co-sponsors and the donor on regular basis.
- A coordination committee consisting of the co-sponsors, host of IPO, IRDR Chair and the Executive Director of IPO ensure the oversight function This committee was established following IRDR mid-term review in 2016 and meets once a year. Thus far, the committee has met in Paris (2018) & Geneva (2019).

4.4.2 Financial management

Regarding the budget, the host of IRDR IPO, namely CAST, CAS, and AIR, provide funding as well as financial management for the regular activities of IRDR-IPO. This includes staff cost of IPO, cost for organizing and facilitation of participation of one SC meeting each year, publication of IRDR reports and papers, maintenance of IRDR web-portal and social media, and organizing meetings and seminar per the requests of the programme. IPO also provide support to expert missions and some ICoE and Young Scientists to attend IRDR meetings. In parallel, ISC finances one session of IRDR SC meeting each year. Both ISC and UNDRR provide support IRDR experts to participate international meetings and forum when it is needed.

It has been noted that all IRDR NCs and IRDR ICoEs are self-funded. Some ICoEs have flagged the need to have seed fund from IRDR for their initiatives and activities. Through its partnerships, IRDR has also supported capacity building and training by grouping resources with its partners. It is clear however, that the current arrangement and financial management support is not efficient enough to meet the requirement of IRDR work. In its next phase, IRDR must establish a regular programme budget supported by the financial systems to enable the IPO to carry out studies and commission research work internationally, and in particular in IRDR nodes in developing countries. Without this the implementation of new phase of IRDR will be hampered, as already the case during 2010-2020.

Table 4-2. Staffs of IRDR IPO (2010-2020)

Executive Director	Science Officer	Communications Officer	Administrative Officer	Administrative Assistant
Jane Rovins	Kerry-Ann Morris	Luke Driskell	LANG Lang	ZHAO Cuili
Rudiger Klein	CHENG Yaoying	Anna Rudashko		WANG Jiqiang
William Paton	Anne Castleton	SHU Yang		
Rajib Shaw	LU Kuanju	Chin Cabrido		
HAN Qunli	LIAN Fang	JIN Xianlin		

59 These two documents are provided in the appendix and they have been both extended to the end of 2021 in 2020 based on mutual agreement reached by the parties concerned.


KAMA

Chapter 5. Challenges in a diverse and dynamic DRR landscape

As an international scientific research programme, IRDR has set a clear vision and mission and has provided coherent research objectives for the international DRR research community. The previous chapters have reviewed in detail the actions, products, services and achievements of IRDR over the last 10 years and discussed its impact. That being said, one needs to realize that, as a new scientific initiative, which is further meant to be both interdisciplinary and cross-cutting, as well as effective in outreaching and productive under diverse geographic, socio-economic and cultural settings, its implementation inevitably will run into continuous challenges. If IRDR is to continue as an international facility for research and knowledge actions, a comprehensive and objective reflection on such challenges must be made. The diverse needs, varied interests across stakeholders, and gaps in different dimensions in the implementation of IRDR, must be documented and reviewed.

To this end, this chapter of the Compilation provides space for IRDR communities, especially IRDR ICoEs and IRDR NCs, but also individual experts, to express their views and criticisms, discuss lessons learnt, and provide suggestions and advice on both IRDR as a whole and on their own institutions for future improvement. We strongly believe that such collective views will help the sponsors of IRDR and the host of IPO, as well as the research communities in disaster risk science, to better understand the nature and characteristics of the DRR landscape.

Furthermore, as the COVID-19 pandemic occurred while this Compilation was being prepared, additional comments and observations as to how to handle such disaster as well as similar risks in the future were solicited and have been included. While it is true that the launch of the UN Roadmap for the COVID-19 Recovery has addressed much of the concerns herein expressed, keeping a record of these issues remain useful as they are part of the memory of how IRDR members, though not directly working on health issues, reacted to this huge unforeseen disaster, whose full impact may not even be fully appreciated yet.

5.1

Insights from NCs and ICoEs on key challenges and lessons learnt

As indicated in the Term of Reference, IRDR's NCs and RC help foster a much-needed interdisciplinary approach to disaster risk reduction within national scientific and policy-making communities, whereas ICoEs contribute to IRDR's areas of study and promote and disseminate IRDR concepts, approaches and methodologies to a wider audience. NCs and ICoEs are the main components for academic research and play important roles in knowledge production and sharing as well as knowledge-to-action initiatives. From a decade-worth of engagement in the field, IRDR NCs and ICoEs have obtained numerous insights as to research gaps and priority settings. In addition to each NC/ICoE's views and suggestions as to these gaps and directions for future work, the comments below also include information on what aspects of DRR each NC/ICoE has been pursuing. It goes without saying that the views are based on each NC/ICoE's respective condition and capacities. These important and vibrant comments and views should be given great consideration in constructing IRDR's next phase.

Note: Some comments are in bold. This was made by the editing team to further highlight views and points of note the team believes are particularly important.

From IRDR ICoE-VaRM

The key research gaps in IRDR relate to the translation of the science and results into actionable information that can be used in meeting national goals and targets under both the Sendai Framework and other UN agendas. This requires not only the development of better measurements and data, but also improved understanding of applications and uses for such information by policy makers and practitioners.

From IRDR ICoE-DCE

1) Infrastructure Strengthening and Knowledge Hubs

The IRDR ICoE-DCE research group intends to further expand the infrastructure of its knowledge hub. Specifically:

- Disaster Research Laboratory

IRDR ICoE-DCE intends to establish a fully functional and well-equipped Disaster Research Laboratory with all relevant digital facilities with internet connectivity and related software programmes like GIS and Remote Sensing imageries etc.

- Virtual Satellite and Weather RADAR Station

IRDR ICoE-DCE recently came to an agreement with the CAS to establish a virtual satellite station and weather RADAR station at the University of Peshawar (host to IRDR ICoE-DCE), entitled "DBAR, International Center of Excellence in Integrated Research and Digital Earth". The IRDR ICoE research group, academics (both affiliated with the projects and others), practitioners, and line agencies will all be able to collect live digital data from 21 Chinese satellites at the Center. This will contribute towards both the Sendai Framework as well as IRDR's Science and Technology roadmap.

2) Research Gaps and Future priorities of ICoE-DCE

Following are the major gaps and future priorities for IRDR ICoE-DCE:

- Enhancing capacity-building of IRDR research group and IRDR young scientists;
- Periodically organizing training workshops on DRR research gaps and key challenges;
- Organizing conference on SFDRR and S&T Roadmap on a yearly basis;
- Mainstreaming Science & Technology in DRR;
- Exploring linkages between Science-Policy and Practice;
- Improving knowledge transfer to key stakeholders;
- Sensitizing of youth (for example through awareness campaigns);
- Contributing to the forecasting and early warning of hydro-meteorological disasters;
- Focusing on climate change adaptation and mitigation;
- Providing feedback at multiple levels (national, regional and local level government etc).

From IRDR ICoE IRDRS

Considerable research activity by Institute members already occurred prior to the establishment of IRDR ICoE IRDRS in 2019, often in collaboration with Australia's key research body in this domain, the Bushfire and Natural Hazards Cooperative Research Centre (BNHCRC). Completed BNHCRC projects have covered bushfire scenarios and economic methods, as well as both policy and legal aspects of natural hazards. BNHCRC scholarships have supported a number of PhD scholars in these and other areas. Institute member Dr. Michael Eburn for example has long maintained a respected advisory blog that is widely read amongst emergency management practitioners (https://emergencylaw.wordpress.com/).

Such diverse research has brought valuable insights. For example, in a novel program appraising the form and value of post-disaster inquiries, for the first time the recommendations of over 140 post-event inquiries held in Australia between 2009-18 were analysed. Key themes were identified and an open access data base of previous inquiries made available (Cole et al. 2018. Can major post-event inquiries and reviews contribute to lessons management? *Australian Journal of Emergency Management*. 33(2): 34-3; database located at https://www.bnhcrc.com.au/utilisation/ddr). As part of another study, an unprecedented analysis of house losses from the 2009 fires in the state of Victoria provided new insights into the landscape factors affecting asset loss (Gibbons, et al. 2012. Land management practices associated with house loss in wildfires. PLoS One, 7(1), e29212). Later fire events are currently being analysed, providing additional land management insights for wild fire protection.

Building on such work, the ICoE was established in 2019 to address specific gaps and shortcomings in current approaches. **One of these is to strengthen connections and collaboration across the Asia-Pacific/SE Asia/Oceania regions**, the potential of which was demonstrated when the Australian National University (ANU, host of the ICoE) hosted the regionally-focused 14th APRU Multi-hazard Symposium in October 2018. A significant product of such collaboration and mutual lesson-drawing has been this book: James, H. (ed). 2019. *Population, Development, and The Environment: Challenges to Achieving the SDGs in the Asia Pacific*, Palgrave Macmillan.

The second gap is to attend more to the equity dimensions of disasters, under a program of work on 'disaster justice', covering multiple forms of justice across the DRR spectrum, including distributional and procedural justice before, during and after disaster events. This has culminated in a publication by Lukasiewicz, A. & Baldwin, C. (eds.) 2020. *Natural Hazards & Disaster Justice: Challenges for Australia and Its Neighbours.* Palgrave MacMillan.

The third gap is a less than optimal level of cross-disciplinary and research-policy connection across disciplines and hazards. Via its International Advisory Board as well as through other means, the Institute has established collaborations with key federal agencies and a range of research disciplines, organising cross-disciplinary research scoping exercises that draw previously unconnected areas of expertise together. The potential of cross-disciplinary awareness has been emphasised during responses to the 2019-2020 Australian wildfires, and highlighted again under COVID-19. The Institute contributed to a national exercise in identifying research capabilities to inform fire response, revealing some widespread but mostly small clusters of capacity that invite further synergies.

From IRDR ICOE-SEADPRI-UKM

The IDRC Science Plan 2010-2020 is comprehensive with respect to the coverage of major programmes on natural hazards and disasters. Notwithstanding, a decade on, the advancement of science means an update on the issues is needed.

The Sendai Framework acknowledges that disasters are exacerbated by climate change and called for more dedicated action in tackling climate change and variability for enhanced coherence across the Paris Agreement and SDGs. The use of climate change scenarios at global, national and local levels is explicitly mentioned in the Sendai Framework. **A priority in this context is the limitation of downscaled global climate change projections as well as global datasets for local level decision-making in some regions such as Southeast Asia**. This has to be addressed in a candid and transparent manner. Guidelines are required for the use of best available science at the local level, especially where climate projections are not reliable. Among other updates, the guidelines could be made to cover common approaches for identification of susceptible areas, exposed assets and vulnerable communities, area and context specific recognition of cascading and slow onset hazards, and matching scales of science information and decision-making.

In some countries, if the primary data is obtained from government agencies, they do not allow the information they generate on hazards and risks to be shared with the public. The importance of **open data has to be resolutely promoted** at all levels, to ensure that scientists at the national and local levels have proper access to information that would enable them to generate local knowledge, which could then be shared with the public. Local information on hazards and risks should be open to the public to effectively build community resilience. The Sendai Framework calls for open exchange of data and non-sensitive risk information in dealing with multi-hazards and risk-informed decision-making as a guiding principle. This is in coherence with the Paris Agreement and the SDGs where transparency of institutions at all levels is also emphasised. IRDR should embrace this challenge to build resilience successfully at the local level.

From IRDR ICoE CR

Research and practice from the ICoE reveal a number of challenges in addressing risk management at a community/local government level with respect to low-likelihood (but destructive) risks, including: 1) A paucity of risk based policy within local government; 2) Cognitive biases influencing risk perception across a range of hazards; 3) Challenges for how easily risk modelling can be used within local government; and 4) Concerns about motivation of decision makers to enable risk management policy development.

As such, we recommend the following solutions to further develop a pathway forward for local governments to better their risk management policy for low-likelihood but destructive risks: 1) **Further provide resources from national risk management initiatives;** 2) **Include debiasing techniques as part of natural hazard risk management workshops** so that practitioners and decision makers are better informed about how innate cognitive biases influence their perceptions of low-likelihood risks; 3) **Further develop risk modelling through a bottom-up, participatory approach** to enhance the usefulness and usability of the models; 4) **Review the flexibility of natural hazard policy instruments to enable policy for low-likelihood hazards** that have intervals over thousands of years, thus providing a way forward for extra long-term planning instruments.

For more information on this topic, see:

Crawford, M.H., Saunders, W.S.A., Doyle, E.E.H., Leonard, G.S., Johnston, D.M. (2019). The low-likelihood challenge: Risk perception and the use of risk modelling for destructive tsunami policy development in New Zealand local government. Australasian Journal of Disaster and Trauma Studies 23: 3-20.

Crawford, M. H., Crowley, K., Potter, S. H., Saunders, W. S. A., & Johnston, D. M. (2018). Risk modelling as a tool to support natural hazard risk management in New Zealand local government. International Journal of Disaster Risk Reduction, 28, 610-619. doi: 10.1016/j.ijdrr.2018.01.011.

Saunders, W., Grace, E., Beban, J., & Johnston, D. (2015). Evaluating land use and emergency management plans for natural hazards as a function of good governance: A case study from New Zealand. International Journal of Disaster Risk Science, 6, 62-74. doi: 10.1007/s13753-015-0039-4

From IRDR ICOE CCOUC

As IRDR's International Centre of Excellence in Health and Community Resilience, **ICoE-CCOUC believes that health should be, but has not yet been, foregrounded in the DRR research agenda**. The foregrounding of health in DRR research and practice is epitomised in the paradigm of Health Emergency and Disaster Risk Management (Health-EDRM) (Chan and Shaw, 2020). DRR research is also dominated by case studies, which requires a better integration through an overarching framework. Health-EDRM provides such an integrated and interdisciplinary approach to overcome the parochial sectoral, uni-disciplinary, and traditional technical approaches to DRR.

The core of Health-EDRM is to put people's health at the centre of emergency and disaster risk management. It is people-centred and encompasses all-hazards in orientation. Internationally, it is advocated by the World Health Organization (WHO) and enshrined in such disaster-related international policy frameworks as the Sendai Framework, SDGs and Paris Agreement. With a focus on strengthening the role of science and for all stakeholders and groups (including women, children, people with disabilities and older people) affected to be considered in disaster risk management. In addition to fitting into this multi-stakeholder, bottom-up approach to disaster risk management, the prevention concept arguably also provides one of the key hinges to unify this emerging field of Health-EDRM, a cross-over between health and disaster risk reduction, encompassing the disciplines of emergency and disaster medicine, DRR, humanitarian response, community health resilience, and health system resilience. The WHO suggests the goal for Health-EDRM as minimising the health impact of emergencies and disasters, with the prevention concept capturing the crux of cost-effectiveness behind various means to this end. For example, this includes: ensuring safe hospitals to mitigate negative public health consequences post-disaster, safe water supplies to reduce exposure to hazards, vaccinations to minimise vulnerabilities, mass casualty response plans to strengthen local capacities for response and recovery, and community healthcare to build local health resilience (WHO, 2015).

Under the Health-EDRM framework, emergency and disaster risk management measures involving health and other sectors can help avoid or reduce the health impacts of disaster, such as deaths, injuries, diseases, disabilities and psychosocial problems. According to the WHO, Health-EDRM refers to the systematic analysis and management of health risks posed by emergencies and disasters, through hazard, exposure and vulnerability reduction, as well as preparedness, response, and recovery. Since the traditional focus of the health sector in emergencies and disasters has been on the clinical on-site response to and recovery from emergencies and disasters, Health-EDRM will re-direct this traditional focus to the upstream aspects of preparedness and hazard, exposure and vulnerability reduction by emphasising prevention, including the development of community and country capacities to provide timely and resource-effective response and recovery, as well as building resilient health systems based on community-level primary healthcare to reduce community vulnerability, to protect health facilities and services, and to scale-up health response to meet the surging health needs post disaster (Chan and Murray 2017; WHO et al. 2017).

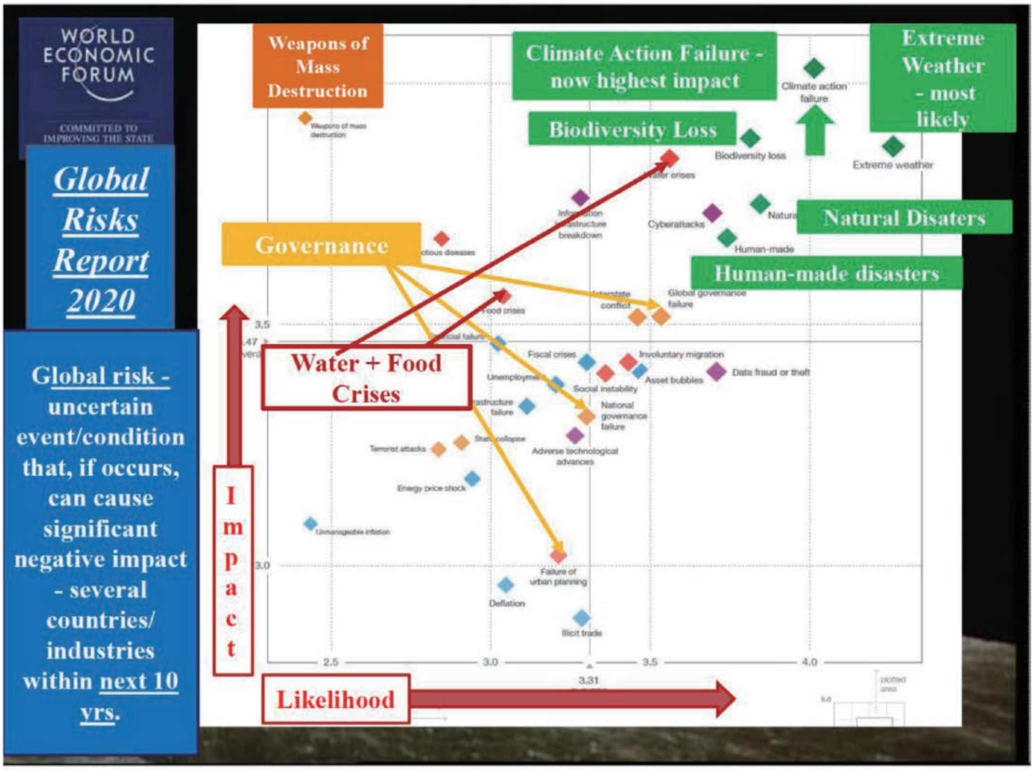
Moreover, the prevention-focused Health-EDRM also echoes the Sendai Framework's expected outcome ("The substantial reduction of disaster risk and losses in lives, livelihoods and health"), goal ("Prevent new and reduce existing disaster risk through the implementation of integrated and inclusive economic, structural, legal, social, health, cultural, educational, environmental, technological, political and institutional measures that prevent and reduce hazard exposure and vulnerability to disaster, increase preparedness for response and recovery, and thus strengthen resilience.") and 3 of its 7 global targets ("Reduce disaster mortality, reduce the number of affected people, and reduce disaster damage to critical infrastructure and disruption of basic services, including health facilities") (United Nations Office for Disaster Risk Reduction 2015).

From IRDR ICoE-DRHBPI

In addressing the main challenges of the Sendai Framework and the IRDR Objectives, the IRDR program should have a strategy and actions to bring together the ICoEs (of which there are now 16) and link them into active and integrated research projects. The ICoEs provide expertise across issues and have ongoing programs and projects. Bringing these together, and linking the IRDR projects will enhance the research agenda and its outputs. **Analysis should be done of the coordinated expertise and issues of the present ICoEs and identify possible gaps which would be filled by inviting other organizations to become active ICoEs**.

Recognizing the linkages across Global Agenda 2030 issues, as we are presently seeing with the COVID-19 pandemic, which needs to be addressed along regular disaster risk reduction actions, it is important that there be enhanced coordination with other programmes – Urban Health, Future Earth, World Climate Research Program, International Network of Government Science Advice (INGSA) and others - to ensure that the IRDR science is effectively utilized by governments and organizations. An example is the Systemic Risk KAN (Knowledge Action Network), co-sponsored by IRDR, FE and WCRP which has been a very productive interactive group. Support needs move beyond discussions into actions. Similar networks could be created.

Figure 5-1: Global Risks Report 2020



In preparing and presenting the research plan, it is **important to reference to the WEF Global Risk Report 2020, in addition to the GAR 2019**, to frame the objectives and research agenda within the Global 2030 Agenda – Sendai Framework, Paris Agreement, SDGs, New Urban Agenda etc. World Economic Forum's 2020 Global Risk Report ranks *Extreme Weather Events* (e.g., storms, floods, wildfires …) as the highest risk for countries or industries over the next 10 years in terms of likelihood and 4th highest in terms in impact (Figure 5-1). *Climate Action Failure* (actions for emissions reductions and climate change adaption which is disaster risk reduction for climate events) ranks as the number one risk by impact and number two by likelihood over the same time period. *Natural Disasters* are also of high likelihood, as indicated in the diagram below. The GRR Report also links the disaster impacts with issues of governance – echoing Sendai Objective 2 and IRDR Objective 2.

From IRDR ICoE UR&S

Research and experience to reach "effectiveness" with respect to disaster risk management and adaptation to climate change. **Research to "assess prevention" … how to measure resilience, the avoided deaths and losses? …how much safety is enough safety?** These issues are unsuspectedly related to the robustness of risk modelling, as well as understanding, interpretation and communication.

From IRDR ICoE REaL

Both the IRDR Science Plan and Sendai Framework place emphasis on the importance of building capacity to address Disaster Risk, but **provide little guidance or insight upon how to invest in capacity building**. The Sendai Framework in particular places a lot of emphasis on education 'for children' as a form of awareness and informing public, but **little emphasis on education as an investment to raise capacity and enhance understanding of risk, as a means of building more a resilient society and systems, and to create the next generation of professionals who will implement DRR principles in across various fields and sectors**. Perhaps there should be greater emphasis on investing in higher education institutions which are centres for general and specialised training, research, knowledge generation and advocacy for DRR initiatives.

From IRDR ICoE NSET

◆ Challenges

- **Having sufficient investment to conduct research projects has always been problematic in less developed countries** like Nepal. Moreover, it is important to blend academia and practice and involve both academics and practitioners in small to large scale research projects to bring tangible outcomes for society.

- Use of modern measures that involve extensive use of science and technology sometimes is difficult due to cost for countries like Nepal, and yet are essential for tackling various extensive and intensive disaster events. This includes early warning systems, use of modern equipment like drones and satellite mapping for landslide mitigation and urban planning.

- **Lack of holistic policies and guidelines, which are further often non-scientific and not updated in a timely manner** make implementation difficult at the time of actual disasters. For instance, in the aftermath of Gorkha Earthquake 2015, only the 2017 Nepal Disaster Risk Management Act was passed – and it further has not been brought into full-fledged action. In addition, as in the case of the current COVID-19 pandemic, many countries including Nepal lacked proper guidelines to control its outbreak. Such aspects need to be addressed and the ICoE can take the lead to bring in science and technology into such efforts.

- Universities in Nepal still have not incorporated a minimum level of disaster risk reduction education (at least at the undergraduate level). Additionally, undergraduate courses in engineering do not teach much about construction of load bearing masonry/stone in mud mortar buildings despite their prevalence and importance to DRR. Courses should be amended to focus on promoting seismic resistant construction technologies along with international practices. Nepal's reconstruction in the wake of the 2015 Earthquake itself should be one of the important chapters of disaster risk reduction. The ICoE can play a facilitator's role in this project.

- **Multi-hazard maps should be developed at local level and should be interpreted/ disseminated at local level**. The ICoE should bring or develop such projects and support the municipal units in Nepal.

◆ Lesson Learnt

- Beyond the formulating of guidelines/regulating documents in DRR for Nepal's development, applications thereof are often difficult in practice. For instance, a large proportion of buildings are constructed without any building permits in most municipalities: to bring them into the building permit system and up to code is a challenge.

- To implement the socio-technical module of assistance or "bottom to top approach" in regulating the building permit system in rural and urban municipalities of Nepal as a result of the Gorkha Earthquake Housing Reconstruction Project Experience.

- To **expand IRDR-ICoE platform to collaborate and lead multi-hazard disaster-resilient projects**. In addition, to tie up the research efforts to SDGs and Climate Change Adaptation with help from young scientists forums and youth alliances like U-Inspire.

- To strengthen the national institutes for research such as the National Academy of Science and Technology to conduct research on topics that may benefit sectors such as agriculture, health and disaster risk reduction in Nepal and its regions.

- **Continuation of the IRDR programme for next decade is essential for continued enhancements of national credibility for worldwide** ICoEs and ICoE-Nepal in particular to continue its effort in reducing risk.

From IRDR ICoE TDDR

ICoE-TDDR seeks to contribute to multiple Sendai Framework targets, as a **greater understanding of risk and development can enhance the effectiveness of decision-making systems in reducing social, environmental and economic disaster risks and impacts (targets a-d)**. In particular, by supporting Priority 2: Strengthening disaster risk governance to manage disaster risk, we see potential for the TDDR framework and guidelines to inform both a greater number of and better quality DRR strategies that consider a broader range of risks, as well as the connections with sustainable development and climate change.

ICoE-TDDR's mission and work has direct relevance to SDG targets 1.5, 13.1, and 16.6. Target 1.5 is to build the resilience of the poor and those in vulnerable situations and reduce their exposure and vulnerability to climate-related extreme events and other economic, social and environmental shocks and disasters by 2030. Target 13.1 is to strengthen resilience and adaptive capacity to climate-related hazards and natural disasters in all countries. Target 16.6 is to develop effective, accountable and transparent institutions at all levels. The ICoE **seek to contribute to pursuing DRR, sustainable development and climate change policy goals in greater harmony** than is currently done at present in most contexts.

ICoE-TDDR supports the S&T expected outcome of a stronger involvement and use of science to inform policy- and decision-making within and across all sectors at all levels. Specifically, we hope our framework and approaches can facilitate greater dialogue between scientists/researchers and decision-/policy-makers in both the DRR and sustainable development spaces, around the need to transform the relationship between development and disaster risk towards more equitable, resilient and sustainable outcomes for all.

The **overarching recommendation to DRR and development decision-makers in policy and practice spaces is to better account for the complex relationship between development and disaster risk**. Further, we encourage actors to consider pathways to transformation, including exposing development-disaster risk trade-offs; prioritizing equity and social justice in approaches to secure resilience; and enabling transformation through adaptive governance. ICoE-TDDR stands ready to support any actors wishing to pursue pathways towards more equitable, resilient and sustainable outcomes for all.

From IRDR ICoE ITC

◆ Multi-hazard assessment

- Move toward a more holistic and integrated way of thinking about hazards, away from the many geomorphological definitions.

- Rethink some of the standard engineering probability methods that are not correct, nor useful when it comes to complex multi-hazard situations.

- The field of non-physical risk assessment (social) has developed a lot with indicators able to show change in vulnerability and resilience, but much remains to be done. Studies of economic vulnerability is still in its infancy because the economic effects of a disaster sometimes reach far beyond the area of the disaster.

- Do more regarding vulnerability and exposure assessments at global level.

- Give more attention to prevention and preparedness - e.g. stimulate mainstreaming of risk in spatial planning processes and address communication gaps between these two fields (and others).

- Test decision support systems that can address integrated planning and decision-making processes related to DRR - especially in prevention. The systems are often theoretical but not really repeatedly tested in case study areas (including evaluation).

◆ Build back better:

- Develop rapid and automated post-disaster damage assessment, for the entire spectrum of hazards [damage signatures are hugely variable], and covering both physical and functional damage. [Charter-type damage mapping continues to be a manual affair].

- Characterize post-disaster recovery better, with focus on functional recovery, and develop better understanding of the recovery process, in particular what influences it. [we are reasonably good in assessing physical recovery {= mainly reconstruction}, but typically don't understand well why some areas recover well, others not, and also what socio-economic changes are actually accompanying the recovery]. How best to influence the recovery process to build back better and arrive at a lower risk situation remains in our view very poorly understood.

- Improve efficiency in use of spatial data, including remote sensing imagery, in a multi-scale context remains a challenge. A reviving of the old GEOSS (global earth observation system of systems) would be useful here. Often, the detailed local data (UAV etc.) obtained needs to be meaningfully and rapidly integrated with satellite data.

From IRDR ICoE RIG-WECEIPHE

◆ Risk interconnectivity

Human beings are facing a series of risks, especially those associated with climate change, and these risks are hyper-interconnected with serious effects on the planetary health, sustained society and economy of human being. To address the challenges are calling for united, innovated and science-based actions at national, regional and global levels in response to climate emergency and one health for achieving SDGs and building resilient societies. Identification of the irreversible "tipping point" of the multi-risk, triggered by climate change, is the key for actions to address multi-risk interconnection for better governance in the era of post-pandemic and carbon neutrality. At present, lots of researches have highlighted the risks of public health from meteorological factors (such as heatwave, cold surge, etc.), air pollution (such as PM2.5, NOx, O3) and others, yet the interconnectivity of those hazards and its impacts to human society is rarely explored. The cross-cutting issues among risks of climate change and planetary health and vulnerability of human society need to be addressed.

◆ Emergence of new risks

Existing approaches to thinking about and managing risk are being overwhelmed by the climate change and pandemic's systemic nature. In the era of post-COVID-19 and carbon neutrality, emergences of new risks should be put into attention. In addition to the traditional risks, efforts should also be distributed to explore the possibility of the emergence of new risks and the associated DRM. For example, the increased frequency of extreme weather events may set a high requirement of emergent energy supplies, which might induce a new risk in a special period due to the shift from traditional energy supply driven by fossil fuels to green energy supply. Moreover, as a consequence of keeping social distance in the post-COVID-19 era, people's communication is expected to highly rely on IT technology. These may lead to the failure of current DRM mode.

Therefore, more efforts are needed to decipher systemic risk, particularly the interconnectivity of climate change associated hazards and their impacts on the public health, and to investigate the emergence of new risks and associated DRM, for better governance and building resilient communities, which is the main focus of the ICoE RIG-WECEIPHE.

From IRDR NC of New Zealand

New Zealand has a strong involvement in the initiation of IRDR, promoting and developing transdisciplinary research within IRDR and then translating this into the structure of its own national research programs. Building on this and the outcomes of the Sendai Framework, New Zealand's developed a National Disaster Resilience Strategy - Rautaki ā-Motu Manawaroa Aituā. The role of the Strategy is to set out goals and objectives for disaster risk and emergency management over the next ten years. The previous Strategy was over ten years old, predating the 2010 and 2011 Canterbury and 2016 Kaikōura earthquakes. The current Strategy aims to incorporate lessons learned from these and other events in New Zealand and overseas, and takes a fresh look at priorities. The Strategy has a strong focus on wellbeing, reflects increased understanding of national risks, and responds to increased community expectations of our emergency management system. It also builds on the New Zealand Government's work to reform the emergency management system to improve how New Zealand responds to natural disasters and other emergencies.

From IRDR NC of Germany

In relation to the priorities defined by the Sendai Framework and the related EU Action Plan 2015-2030, as well as the key outcomes and actions identified by the UNISDR Science and Technology Roadmap, IRDR Germany published the ESPREssO Vision Paper, aiming to support the preparation of the Horizon Europe Framework

Program 2021-2027. The Vision Paper (Zuccaro et al., 2018) represents the contribution of the ESPREssO project towards a new strategic vision on disaster risk reduction and climate change adaptation in Europe, and promotes new ideas for the future roadmap and agenda of natural hazard research and policymaking over the next ten years. The findings from ESPREssO Stakeholder Forums have been confronted with the four priorities of the Sendai Framework. Based on the four Sendai priorities, the opportunities emerging from an integrated vision of the Disaster Risk Management (DRM) cycle and its linkages with key overarching issues emerging from the networking activities of ESPREssO project (such as the integration of DRR and CCA) are explained. Connected to the Research and Innovation topics in the field of natural hazards, the ESPREssO vision presents the identified gaps and needs and addresses them in the form of five broad "missions" which outline the scope and expected impact of the proposed actions (Zuccaro et al., 2018). The five missions are as follows:

- Reach new frontiers in the field of probabilistic simulation models, vulnerability and risk assessment.
- Increase the quality, reliability and availability of data for performing quantitative assessments.
- Explore possibilities for improving risk governance approaches.
- Overcome the "implementation gap" through the promotion of innovative approaches to exploit the results of research advancements into resilience-driven investments.
- Effectively integrate social and behavioral sciences in DRR, CCA and DRM domains.

From IRDR NC of France

Based on the research-actions undertaken, we identify the following challenges:

- How to take into account the diversity of territories as well as the diversity of risks (known and emerging) in the elaboration, deployment and evaluation of public policies?
- How to characterize, report and evaluate territorial transitions, transitions in the phases of prevention and disaster risk management?
- How can public-private partnerships be nudged towards providing more data and knowledge sharing and improved public policies?
- How can responsible approaches of big data analysis and the use of artificial intelligence be put in place for better disaster risk prevention and management?
- How can we identify the tipping points in disaster risk prevention and management?
- What forms of cooperation between human and social sciences, life sciences, engineering sciences and health sciences may be used for better governance of risks and crises?
- How can a culture and memory of disaster risk be developed at the national and international levels?
- What are the contributions and limitations of resilience approaches? What are the new methodological and conceptual needs?
- What are the initiatives and lessons learned from build back better? How many are articulated with insurance mechanisms in place?
- How can ethical issues related to expertise, risk management, and regulations be taken into account?

From IRDR NC of China

1. Considering UN SDGs, Paris Agreement, Sendai Framework, we can extend the IRDR scope to all the catastrophic factors restricting sustainable development.

2. The natural sciences have a key role in the forecasting of natural hazards and characterizing their attendant risks and mitigating the adverse effects. We should strengthen natural risks related studies to better understanding the mechanism of hazards.

3. With the COVID19, the coupling interaction between human environment, social environment and nature has become more and more close. Natural science disciplines can achieve a common number; however, social scientists on the contrary give us a lot of vision. We should consider how we understand the interaction between social sciences and how to reflect the social risk. More attention could be paid on the observation and the research of human behaviours, including knowledge dissemination and predictions.

4. We should add more components on contributions of data and digital technology for DRR. Lack of access and availability of data is restricting comprehensive understanding of DRR challenges. Collecting information from alternative and emerging data sources and the capacity to meaningfully integrate these with traditional data sources are key areas for capacity development in many countries, especially for developing countries. In present times software and data analysis is becoming widely accessible due to open sources initiatives, and cloud computing technologies and programs such as CASEarth provide valuable resources for multi-source data integration contributing to information driven policy and decision support systems for disaster risk reduction.

From IRDR NC of Colombia

NC Colombia identified the research gaps from the perspective of Sendai Framework Priority 1 Understanding disaster risk. Efforts should be made from different levels are presented in the Table 5-1.

Table 5-1. Research Gaps and Priority Setting from IRDR NC of Colombia

	Research gaps and priority setting
Main streams	1. Interdisciplinary proposals for risk assessment 2. Planning, governance, territorial and economic development from risk management 3. Resettlement of post-disaster communities. 4. Methods for including natural phenomena in land-use planning. 5. Integration of public institutions to generate and use of open data 6. New models of governance and social participation. Planning and development instruments, which conclude risk management and climate change 7. Responsibility and co-responsibility in disaster risk management.
National and local levels	1. Modeling and simulation (e.g., probabilistic modeling, high-performance numerical modeling) for several hazard phenomena. 2. Effects of hazardous events on biodiversity. Models for evaluating expected environmental losses due to hazards and post-disaster phenomena. 3. Open data infrastructure (cyber-infrastructure) and high-resolution geographic information systems for the main geophysical and socioeconomic variables. 4. Development of remote sensing and communication technologies for risk monitoring, hazard, exposure, vulnerability, and risk assessment. 5. Time series building (historical evidence) and development of indicators on events of interest from national to local scale. 6. Low-cost risk information systems for land-use planning for municipalities of category 5 and 6. For example, the development of geospatial methodologies for data generation. 7. Technical procedures and standardization of data from the open data infrastructure.

	Research gaps and priority setting
National and local levels	8. Health post-disaster impact (mental and physical health). 9. Financial risk mitigation measures evaluation. Insurance management analysis and financial protection, a social context approach. 10. Economic losses assessment. 11. Ecosystem-based solutions. 12. Resilient cities. Infrastructure planning to face extreme climate variability 13. Mitigation and evacuation alternatives 14. Protection and stability coastline solutions 15. Flood control measures -eutrophication prevention and wetlands conservation 16. Preparedness mechanisms for the emergency response. 17. Evacuation plans and disaster contingency plans 18. Infrastructure and portable - inexpensive technologies to generate energy, drinking water and provide and continuity to telecommunications in disaster response processes 19. Prioritization of attention to municipalities at risk 20. Education at all educational levels in DRR to create a culture of sustainable development
Global and regional levels	1. Hazard, exposure, vulnerability and risk assessment for several hazard phenomena. 2. Risk assessment technologies 3. Technologies for standardized real-time hazard monitoring, early warning systems, and preparedness for response at a local scale. 4. Risk threshold definition methodology 5. Participatory monitoring or citizen science for the different threatening phenomena. 6. Early warning systems with cities evacuation protocol 7. Development and strengthening of monitoring and forecasting methodologies.
All levels	1. Machine learning and big data methods applied to early warning systems 2. Creative and cultural industries to promote a culture of safety, awareness, and communication of risk-oriented to the diverse population in Colombia 3. Social appropriation of risk knowledge based on aspects of risk perception, risk communication, and social construction of risk

5.2

Comments on key challenges and lessons learnt, and directions for future cooperation from SC members and EDs

Jane Rovins

- There has been and continues to be a gap in the link between research and practice. DRR practitioners need to be engaged in all aspects of the research, not just at the end or as subjects of the research.
- When the UNDRR S&T group was reconstituted it was never clear what the relationship between them and the IRDR Science Committee was, especially as they had similar roles and functions, not to mention overlapping membership.

Rajib Shaw

The ST roadmap should be the primary driver of IRDR research. Currently, IRDR research priorities seem to be disjointed and out-of-sync with the UN ST process. This needs to be filled-up, and the ST roadmap can be a good bridge for this. A few emerging research areas are suggested below:

- Governance-related research on systemic and cascading risk (including biological hazards as well as NATECH)
- Social innovation and disaster risk reduction
- Disaster risk reduction as a business strategy
- New and emerging technologies and Disaster Risk Reduction
- Ecosystem-based disaster risk reduction
- Critical infrastructure resilience and disaster risks
- Climate fragility and disaster risk reduction

Salvano Briceno

Key challenges remain:(a) focusing on the social vulnerability component of risk, while maintaining a clear understanding of natural hazards and of preparations and actions required to respond to, and recover from, disasters. This challenge requires a close collaboration with research on hazards and disaster management but with a separate focus as these usually tend to distract from the key goal. It is rather urgent to focus on understanding vulnerability to hazards with respect to its human, social, economic, ecological, institutional, physical, ethical and other elements. Reducing vulnerability and augmenting resilience must be the clear goals of policies in the field of DRR, with specific objectives in land use planning, environmental and urban management as well as most other policy sectors (agriculture, energy, education, health, tourism, etc.), and with governance focused on specifically on it, separate from governance focused on disaster management, response and recovery.

(b) facilitating the team effort between UNISDR and ISC to provide more effective advice and support to governments, academia and international organizations in the field of DRR. Working in close collaboration with relevant institutions such as relevant UN agencies, development banks, scientific unions and key NGOs in the field and encouraging governments with more expertise to cooperate with governments which are less familiar therewith (it is understood of course that expertise in DRR does not necessarily match the country's level of economic development).

(c) influencing academic work and research on risks related to natural hazards, addressing such risks with integrated approaches which are policy and awareness-raising oriented. The FORIN methodology and approach, as well as other IRDR tools, should be widely promoted around the world to ensure that future policy advice in the is increasingly based on integrated research.

A long-term strategy and action plan based on these three goals could provide a clearer and more effective path for future cooperation in reducing risks related to natural hazards.

5.3

Preparation of the new DRR research agenda

As was highlighted at the May 2019 Global Platform for Disaster Risk Reduction, the world is increasingly threatened by the occurrence of both familiar and unfamiliar transboundary, systemic and cascading hazards and disaster risks in a hyperconnected and rapidly changing world. In the brief period since then, we have witnessed extensive wildfires, extreme weather events, outbreaks of desert locusts crossing continents and, worst of all, the COVID-19 pandemic. The pandemic in particular has clearly highlighted the underlying vulnerabilities ingrained in our social, economic and financial systems, unfortunately providing stark support for the Sendai Framework's call for a new, more comprehensive, multi-hazard and systemic approach to disaster risk reduction and resilience. The need for science, and applying it towards evidence informed policies, legal and regulatory frameworks, and action across all sectors and communities, has never been greater.

At the 2019 oversight committee meeting, ISC and UNDRR suggested developing a global research agenda to guide the work of scientists, researchers, academics, technical institutions in both the public and private sectors; and building the evidence base needed for risk-informed decision-making across all geographic locations, sectors and scales. The Agenda it began to formulate proposes new strategic areas of cooperation in DRR science and policy, namely in: Data and knowledge; New and existing technologies – development, application and access; Scientific understanding on increasing risks and uncertainties; Science, policy and society engagement, dialogue and action; Institutional capacity development; Collaborative global and regional governance of transboundary risks; and Private sector impetus towards DRR. The development of the Agenda has been led by a small "Leadership Group" from the IRDR SC and IPO, and its sponsors ISC and UNDRR. Two groups have been established to support this work: Core Group (CG) and Expert Review Group (ERG). The Leadership Group consists of representatives of ISC, UNDRR, and IRDR with two co-chairs and external members appointed to join the projects. Besides all members from Leadership Group, the CG contains several IRDR SC members and experts from IRDR partners. The Expert Review Group consists of the IRDR SC, IRDR ICoEs and NCs, representatives of the STAGs, as well as a wide range of people from diverse backgrounds (science, advocacy, funder, private sector) outside the IRDR community. The Core Group is responsible for developing and writing the Agenda under the guidance of the Leadership Group. The Expert Review Group provides comments and suggestions.

The new Agenda will summarize the rationale for its development, indicate the recent evolution and emerging issues in the field of DRR, and suggest mechanisms for its implementation. The vision of the Agenda is to have science supporting a safe and sustainable humanity through the implementation of the Sendai Framework, Paris Agreement and the SDGs. The final version will be adopted at the IRDR Conference 2021 and then presented in the ISC General Assembly 2021.

Chapter 6. Closing remarks

As can be concluded from the information summarized in the previous chapters of this IRDR Compilation, as well as from the views expressed by the members of IRDR community throughout, the calls from ISC and UNDRR through IRDR have truly stimulated the DRR research community over the past 10 years, producing important and tangible research results. Indeed, IRDR's broad range of actions toward the overall IRDR objectives are well aligned with the priorities and targets of the Sendai Framework.

Despite not being in itself a research-intensive programme, some work of IRDR through its own leadership or in cooperation with its partners has had global significance. These include for example the development of the 2014 Peril Classifications and Definitions, one of the bases for new work of the Sendai Hazard categories and terminologies, and FORIN, a broadly adopted methodology to look at the integrated underlying courses of disasters. It also includes the re-contextualized ST DRR Roadmap developed together with STAG in 2018-2019 to help DRR research institutions to further align their efforts with the Sendai Framework and facilitate their respective reporting thereunder. Finally, a series of policy papers and recommendations by IRDR have addressed important subjects related to climate change, urban resilience, social impacts, science policy and support toward risk science, and made technical contributions in the inception and development of regional multi-hazard early warning systems.

The Compilation further demonstrated that IRDR has been a programme with research and knowledge actions components, with concrete activities at regional, national and community levels and cross a range of thematic risk domains. This aspect of action was not often reported on in the past, but are made obvious by the Compilation, with IRDR NCs and ICoEs clearly playing strong roles in connecting global agenda to national and regional needs and contexts. Among their many roles, NCs are best placed in assisting prioritizing national DRR actions and in reporting toward the implementation of Sendai Framework, and ICoEs are robust leaders both in producing knowledge in different research domains and in capacity building in their respective regions. A strong sign of youth engagement in DRR and in building safe and resilient societies has been demonstrated through the IRDR Young Scientists scheme and the U-Inspire network, an initiative of DRR young practitioners that IRDR has co-sponsored with UNESCO and others institutions. As IRDR looks back on its 10-year implementation, it has clearly demonstrated the goals of putting science knowledge in action and building DRR institutional capacity.

As a relatively 'new' science endeavour on integrated DRR research, there were also important lessons learnt over the duration of the programme, in particular in terms of programme governance and operation coordination, resource mobilization and associated mechanisms, science communication with societies, and the development of partnerships. The international scientific communities, including IRDR members, must take these lessons into account in their planning for better future cooperation.

We note that, in parallel to the process of preparing this Compilation through 2020, IRDR was further charged by its co-sponsors, using the IRDR mission as its base, to lead the development of a new DRR research agenda toward 2030 and beyond. The new mission was intended to look at from much broader contexts in global development and to address the growing demands for understanding systemic, cascading and transboundary hazards and disaster risks.

Then came COVID-19.

In 2020 the world witnessed the sweeping impact of the pandemic, from the massive infections of populations and a record-high loss of human life, to the dramatic erosion in employment, from the collapse of international transportation services to the interruption of school education at all levels to name but a few, costing economies trillions of dollars (or really any other main currency) worth of damage. Perhaps worst of all, the deep and profound social stress and damages the pandemic has caused will take a very long time to heal and to repair. All of a sudden, and unfortunately for all because of its immense impact, the pandemic clearly confirmed the underlying vulnerabilities ingrained in our social, economic and financial systems, providing stark evidence to support the Sendai Framework's call for a new, more comprehensive, multi-hazard and systemic approach to disaster risk reduction and resilience.

The work and efforts reported in the Compilation will thus serve as building blocks toward a future stage of international cooperation in DRR and risk science, as well as in the science effort post Covid-19 recovery. To the editing team of this Compilation, the mission started in 2010 in IRDR is not yet accomplished in 2020, and indeed it could not be so by its very nature. IRDR 2010-2020 is not the conclusion but rather only the initial part of a long journey for sciences in a world that is becoming increasingly uncertain. There is no doubt that integrated research on disasters and risks needs to be continued with new designs, energized with new resources, and mainstreamed with better synergy with other global frameworks in order to respond to the aspirations of people to build future societies that are more inclusive, safer and more sustainable.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Special Thanks to the Editing Team

Over last 20 months, the editing team has worked very hard to collect, compile and verify the information from the members of IRDR community for this publication. This task took much longer than was originally anticipated. The Covid-19 pandemic has indeed disrupted, and, unfortunately, continues to disrupt the rhythms of work and life of many. Despite all the difficulties, here we have it: IRDR Compilation 2010-2020 is now available for distribution. In addition to the acknowledgement to all contributors above, I want to express special thanks to LIAN Fang, Science Officer from IPO, and to SONG Wanjuan, ZHANG Haiying and WANG Lei, three young researchers from IRDR China. Your dedication and persistence in work are remarkable. I also thank Simeng HAN for language checking and editing, and to ZHOU Zhou for the nice layout design.

You have demonstrated what good teamwork can achieve.

HAN Qunli, Executive Director, IRDR-IPO

Annex1 Establishment document of IRDR

LETTER OF COOPERATION

**BETWEEN
THE INTERNATIONAL COUNCIL FOR SCIENCE,
THE INTERNATIONAL SOCIAL SCIENCE COUNCIL,
THE UNITED NATIONS INTERNATIONAL STRATEGY FOR DISASTER REDUCTION,
THE CHINA ASSOCIATION FOR SCIENCE AND TECHNOLOGY,
THE CHINESE ACADEMY OF SCIENCES AND THE CENTER
FOR EARTH OBSERVATION AND DIGITAL EARTH**

THE INTERNATIONAL COUNCIL FOR SCIENCE (hereinafter referred to as "ICSU"), THE INTERNATIONAL SOCIAL SCIENCE COUNCIL (hereinafter referred to as "ISSC"), THE SECRETARIAT OF THE UNITED NATIONS INTERNATIONAL STRATEGY FOR DISASTER REDUCTION (hereinafter referred to as "UNISDR"), THE CHINA ASSOCIATION FOR SCIENCE AND TECHNOLOGY (hereinafter referred to as "CAST"); THE CHINESE ACADEMY OF SCIENCES (hereinafter referred to as "CAS"), AND THE CENTER FOR EARTH OBSERVATION AND DIGITAL EARTH OF CAS (hereinafter referred to as "CEODE") (hereinafter collectively referred to as the "Parties"),

NOTING that in October 2008 the 29th ICSU General Assembly endorsed the recommendation of a Planning Group that a new international programme named "Integrated Research on Disaster Risk - addressing the challenge of natural and human-induced environmental hazards" (hereinafter referred to as "IRDR") be established for a duration of ten years,

NOTING that the ISSC subsequently decided, at its 27th General Assembly, to co-sponsor the IRDR programme,

NOTING the UNISDR's intention expressed in January 2009 to co-sponsor the IRDR programme,

RECOGNIZING that disaster prevention and mitigation are critical dimensions of the global poverty reduction agenda, and should be an integral part of all international and national development efforts,

TAKING NOTE of the fact that in August 2008, ICSU issued a call for offers from its National Scientific Members to host and provide finances for an International Programme Office that would serve the needs of the IRDR programme and specifically its Scientific Committee,

CONSIDERING the generous offer from the China Association for Science and Technology (CAST), made in collaboration with the Chinese Academy of Sciences (CAS), subsequently accepted by ICSU with a notification to CAST and CAS on 6 November 2009,

RECOGNIZE that:

1

1. The IRDR is an internationally integrated, multidisciplinary, all-hazards research programme, whose objectives are: the scientific characterization of natural and human-induced hazards, vulnerability and risk; the understanding of decision-making in complex and changing risk contexts; the reduction of risk and curbing losses through knowledge-based actions; and contributing towards the attainment of the aims and objectives of the *Hyogo Framework for Action 2005-2015: Building the Resilience of Nations and Communities to Disasters.*

2. A Scientific Committee, whose membership is jointly established by ICSU, ISSC and UNISDR, will formulate strategic guidance on the IRDR programme implementation.

3. CAST, a non-governmental organization under Chinese law, accepts to host the International Programme Office of the IRDR Programme on the premises of CEODE of CAS in Beijing, People's Republic of China.

4. CAST and CAS will work with the Chinese Academy of Social Sciences (CASS) and other institutions in China to provide sustained intellectual and material support for the Office.

5. CAST undertakes to provide financial support to the Office of the equivalent of at least €300,000 (three hundred thousand euros) per year for a period of ten years. These funds shall be transferred to CEODE, for use in accordance with the conditions established by the IRDR Scientific Committee. The financial support provided by CAST shall be used primarily for the salaries of staff members of the Office and to meet the cost of staff operations, including international telecommunications and travel.

6. The International Programme Office shall be directed by an Executive Director selected in close consultation by the Parties and the Chair of the Scientific Committee following a process of open, international recruitment. The Executive Director shall be responsible for overall IRDR programme implementation and related outreach activities. The International Programme Office will be staffed with other personnel who are locally recruited, and may include from time to time visiting scientists and staff seconded by other organizations.

7. CEODE, for its part, undertakes to provide appropriate and fully equipped office space for the International Programme Office for a period of ten years, beginning February 2010.

8. CAST shall facilitate unimpeded access to the International Programme Office for visiting researchers and experts, irrespective of provenance or nationality. The Office personnel shall enjoy unhindered access to scientific information/literature and to the international scientific research community through the provision of regular Internet channels.

9. Specific agreements among relevant Parties will regulate the establishment, functioning, financing and other administrative matters related to the IRDR programme and the International Programme Office.

10. The Parties will undertake a joint review of the progress in respect to the matters covered by this Letter of Cooperation by the end of 2012.

Beijing, 22 February 2010.

For and on behalf of ICSU

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Annex 2 IRDR Science Plan (executive summary)

The impacts of natural hazards continue to increase around the world; the frequency of recorded disasters affecting communities significantly rose from about 100 per decade in the period 1900-1940, to 650 per decade in the 1960s and 2000 per decade in the 1980s, and reached almost 2800 per decade in the 1990s. Hundreds of thousands of people are killed and millions injured, affected or displaced each year because of disasters, and the amount of property damage has been doubling about every seven years over the past 40 years. Although earthquakes and tsunamis can have horrific impacts, most disaster losses stem from climate-related hazards such as hurricanes, cyclones, other major storms, floods, landslides, wildfires, heat waves and droughts. Current evidence demonstrates that changes in the global climate will continue to increase the frequency and severity of climate-related hazards.

Globalization, population growth, widespread poverty, particularly in hazardous areas, and a changing climate will cause the risk associated with natural hazards to be even greater in the future, with more people and communities at risk. In urban regions, the complex infrastructure systems that make life and economic activity possible, the concentration and centralization of economic and political functions, social segregation and complex spatial and functional interrelationships, all contribute to the vulnerability of populations to disruptions caused by hazards.

The ICSU Priority Area Assessment on Environment and its Relation to Sustainable Development (2003) and the ICSU Foresight Analysis (2004) both proposed 'Natural and human-induced hazards' as an important emerging issue. The executive summary of the ICSU Priority Area Assessment on Capacity Building in Science (2005a) stated that a great challenge is 'a development problem…the widening gap between advancing science and technology and society's ability to capture and use them.'

It is the assessment of the ICSU Planning Group that, despite all the existing or already planned activities on natural hazards, an integrated research programme on disaster risk reduction, sustained for a decade or more and integrated across the hazards, disciplines and geographical regions, is an imperative. The value-added nature of such a programme would rest with the close coupling of the natural, socio-economic, health and engineering sciences.

The Planning Group recommends that the Research Programme be named **IRDR – addressing the challenge of natural and human-induced environmental hazards** (acronym: IRDR).

The Science Plan of the proposed IRDR Programme would focus on hazards related to geophysical, oceanographic and hydrometeorological trigger events; earthquakes; volcanoes; flooding; storms (hurricanes, typhoons, etc.); heat waves; droughts and fires; tsunamis; coastal erosion; landslides; aspects of climate change; space weather and impact by near-Earth objects. The effects of human activities on creating or enhancing hazards, including land-use practices, would be included. The IRDR Programme would deal with epidemics and other health-related situations only where they were consequences of one or more of the aforementioned events. Technical and industrial hazards and warfare and associated activities would not be included *per se*. The focus on risk reduction and the understanding of risk patterns and risk-management decisions and their promotion would require consideration of scales from the local through to the international level.

The increases in costs of disasters are taking place in both developed and developing countries, which suggest that reducing the risks from hazards is not simply a matter of economic growth and development. There is a great shortfall in current research on how science is used to shape social and political decision-making in the context of hazards and disasters. These issues also highlight the need for more systematic and reliable information on such events. An aim of the Programme would be to both generate new information and data and to leave a legacy of coordinated and integrated global data and information sets across hazards and disciplines, with unprecedented degrees of access.

IRDR would leave the legacy of an enhanced capacity around the world to address hazards and make informed decisions on actions to reduce their impacts, such that in ten years, when comparable events occur, there would be a reduction in loss of life, fewer people adversely impacted, and wiser investments and choices made by governments, the private sector and civil society.

The IRDR Programme would have three research objectives, the first of which deals with the characterization of hazards, vulnerability and risk. The identification and assessment of risks from natural hazards on global, regional and local scales, and the development of the capability to forecast hazardous events and their consequences would be, of necessity, interdisciplinary. Understanding of the natural processes and human activities that contribute to vulnerability and community resilience will be integrated to reduce risk. This objective would address the gaps in knowledge, methodologies and types of information that are preventing the effective application of science to averting disasters and reducing risk.

The second research objective involves understanding decision-making in complex and changing risk contexts. Understanding effective decision-making in the context of risk management – what is it and how it can be improved – calls for an emphasis on how human decisions and the pragmatic factors that constrain or facilitate such decisions can contribute to hazards becoming disasters and/or may mitigate their effects.

The third research objective, on reducing risk and curbing losses through knowledge-based actions, would require integration of outputs from the first two and could only be achieved through implementing and monitoring informed risk reduction decisions and through reductions in vulnerability or exposure. Processes of human adjustment or adaptation can be used to reduce vulnerability and increase resilience.

Three cross-cutting themes would support these objectives: capacity building, including mapping capacity for disaster reduction and building self-sustaining capacity at various levels for different hazards; the development of case studies and demonstration projects; and assessment, data management and monitoring of hazards, risks and disasters.

The Planning Group has identified the major programmes and projects that already exist in the field of natural hazards and disasters and, through an extensive consultation process, the Programme would further explore these and other activities and enter into agreements as to how they might become components of the whole as partners in research.

During the first three years, the Programme would establish a team of co-sponsors and make arrangements with existing programmes so as to undertake research with shared outcomes and responsibilities. A Scientific Committee, mandated by the co-sponsors and with support from an International Project Office, would have the responsibility for building the formal linkages with partners in research. The collaborating organizations, working through a Consultative Forum, would become significant actors in the Programme.

In addition, new projects would be initiated to put in place, in a priority sense, the elements needed to fully meet the objectives over a ten-year timescale. It is recommended that the Scientific Committee, when established, create two working groups to help scope out the programme and lay the firm basis for further programme development. These would be working groups for forensic investigations of recent disaster events, and for a long-term hazards research network.

Annex 3 Mid-term Review of 2016 (executive summary)

This report is the result of an independent mid-term, formative, forward-looking Review of the program of work of the *ICSU IRDR* Interdisciplinary Body, established in 2010 with co-sponsorship by the ISSC and the UN Office for Disaster Risk Reduction (UNISDR), and with financial support primarily from the CAST, a national ICSU member.

As the Review is intended to inform the unfolding of the next 4-5 year phase of the ten-year IRDR Program ('IRDR'), the seven-member Review panel focused their work purposefully on identifying critical areas for improvement.

The Review panel's overall assessment is that upon its establishment, IRDR was a well-conceptualized, timely and innovative - potentially even pioneering - initiative in the increasingly important domain of disaster risk reduction. Its design was ambitious. It reflected the effort needed to bring to fruition a global research program that had to promote and demonstrate new ways of thinking and working in order to influence policies and practices that benefit societies and vulnerable communities around the world.

However, decisions during the inception phase led to a pared down program that has yet to convince that IRDR's initial objectives can be achieved by the end of its ten-year lifetime. Despite the commitment of the excellent scientists on the Scientific Committee, their active engagement in important global and regional initiatives, four main research projects, and the establishment of a network that provides an IRDR footprint in 30 countries around the world (by June 2016), progress has been slow, and the program foci and results too limited to meet the goals of the Science Plan and the expectations created by the program.

The Review panel found the situation to be the result of a confluence of several key factors: decisions during inception, prompted in part by challenges in how such Interdisciplinary Bodies are set up; fast turnover in Executive Directors at the International Program Office (IPO) in Beijing (the first such IPO established outside Europe); and a series of governance, leadership and management weaknesses, including a failure to raise sufficient program funds to give life to its strategic intent.

The Review panel is convinced that IRDR remains a very worthwhile endeavour. In principle, it maintains a significant niche and comparative advantage that continue to provide a good value proposition for its stakeholders, both within and outside the scientific arena. It remains reasonably well positioned in an important area of work, and has been making fair progress in spite of significant obstacles. Many useful lessons have been learned, and there is goodwill among all parties concerned - the Scientific Committee, the main donor (CAST), the IPO, its host organization, the Institute of Remote Sensing and Digital Earth of the Chinese Academy of Sciences (RADI/CAS), and the co-sponsoring organizations - to collaborate to accelerate IRDR's path towards impact on science, policy and practice.

However, if success is to be visible by 2020, several key challenges need to be resolved with a sense of urgency as well as strong leadership. The Review panel shaped their recommendations around these challenges, and recommends that the following five aspects be addressed through dynamic cooperation among all key stakeholders, including the three co-sponsors, who are asked to take on a stronger role in future:

1. **Adjust the program scope and direction**. Reshape the program by building on the foundation laid in the first phase - strengthening and redirecting its efforts in order to achieve the objectives set out in the original Science Plan - and position it further in the 'disaster risk reduction for sustainable development' space. This will require an undertaking to

expand the time horizon of the program 2025 if progress is satisfactory over the next few years - thus with ongoing support subject to strong accountability measures.

2. **Improve the business model**. Change IRDR's business (strategic and resourcing) model by moving it away from the unsuccessful project-driven, ad hoc approach to a more strategic, programmatic approach, with concerted efforts to explore and tap unconventional sources of funding.

3. **Sharpen governance**. Adjust the governance system to remove conflicts of interest, support stronger leadership, ensure proper oversight and appropriate lines of accountability, engage the co-sponsors, and use the strengths of each component of IRDR in an appropriate way to relieve the very significant burden of work on the Scientific Committee.

4. **Improve management**. Put useful monitoring, evaluation and knowledge management systems in place that can support a more strategic, adaptive, evidence-informed management approach for the whole IRDR 'family'. Enhance branding and communication systems to ensure clear program boundaries and greater, more targeted visibility. Ensure meaningful and respectful relationships between the Scientific Committee, the IPO, the program donor and host organizations, as well as the IRDR network nodes, the International Centres of Excellence (ICoEs), and its Regional and National Committees.

5. **Move towards collective impact**. Mobilize the different components and nodes of the IRDR network, based on the relationships built up over the years, to align and collaborate as a (global) 'action network' - based on solid, long-term partnerships wherever this makes strategic sense. Make use of the opportunity to do context-sensitive, innovative comparative work, respectful of different conditions and cultures, that can strengthen science for policy and practice.

Annex 4 IRDR Strategic Plan 2013-2017 (Strategic goals and Actions)

Strategic goals and activities

The vision of the IRDR programme is being pursued through the principal goals and strategic activi- ties proposed in the IRDR Science Plan (ICSU 2008) and in the IRDR Strategic Plan (2013-2017), as detailed in the table below. The successful implementation of these actions will depend on the support of the implementation of this plan and active collaboration, cooperation and partnership with organizations that have similar existing research activities, and policy- and decision-making processes.

Attainment of these goals will lead to a better understanding of hazards, vulnerability and risk; the enhanced capacity to model and project risk into the future; greater understanding of the decision- making choices that lead to risk and how they may be influenced; and how this knowledge can effectively lead to disaster risk reduction.

The overall global benefits of the IRDR programme are dependent on the recognition of the value of risk reduction activities, which are likely to come through evidence-based case studies and successful demonstration projects; assessments, data management and monitoring of hazards, risks and disas- ters; and capacity building, including mapping capacity for disaster risk reduction and building self- sustaining capacity at various levels for different hazards.

Goals
1. Promote integrated research, advocacy and awareness-raising. *This goal is concerned with developing and promoting integration and collaboration within the disaster risk reduction community to avoid unnecessary duplication and to maximise research outcomes.*
1.1. Promote original knowledge generation and transfer through integrated approaches in research, education and policy-making in the academic sector and in collaboration with public and private sectors and civil society organisations. 1.2. Implement the AIRDR project to provide a baseline of the current state of the science in IRDR to measure effectiveness of multiple programmes, use it to identify and support a long-term science agenda for the research community and funding entities, and to provide scientific evidentiary basis in support of policy and practice. 1.3. Advance capacity building for young scientists and future endeavours to develop inter- national science leadership in the field of disaster risk reduction. 1.4. Ensure disaster risk reduction research programmes and policies are integrated across disciplines, and contribute to enhancing policy-making and capacity building for the effective reduction of disaster risk.
2. Characterisation of hazards, vulnerability, and risk. *This goal looks at identifying hazards and vulnerability leading to risks from natural hazards on global, regional and local scales; the development of the capability to forecast hazard events and assess risks; and dynamic modeling of risk. It also addresses the gaps in knowledge, methodologies and types of information that are preventing the effective application of science to averting disasters and reducing risk.*
2.1 Develop and implement the Disaster Loss Data (DATA) project to identify what data and quality are needed to improve integrated disaster risk management by bringing together loss data stakeholders. 2.2 Integrate knowledge about the natural processes, incremental decisions, historically derived national and international structural and institutional forces, and social and cultural practices, beliefs and perceptions that shape the resilience and vulnerability of communities, in order to bring about a paradigm and cultural shift in the ways disasters and their underlying root causes are understood and risks managed. 2.3 Develop an understanding of how emerging communication and other technologies and the globalisation of the world economy influence resilience, vulnerability, risks and hazards.

Goals
3. Understanding decision-making in complex and changing risk contexts. *This goal focuses on understanding effective decision-making in the context of risk man- agement – what it is and how it can be improved. It looks at identifying relevant decision- making systems and their interactions; understanding decision-making in the context of environmental hazards; and improving the quality of decision-making practices.*
3.1 Develop the Risk Interpretation and Action (RIA) project to promote the study of how and why people's interpretations of the risks of various natural hazards relate to their actual choices and behaviour. 3.2 Understand decision-making processes and how these shape resilience and vulnerability and contribute to hazards becoming disasters and/or mitigate their effects. 3.3 Clarify the key concepts and theoretical assumptions concerning the processes underlying interpretation of risk and decision-making under uncertainty. 3.4 Promote better integration of social and behavioural sciences in disaster risk research, especially in regard to decision-making, and make such knowledge more accessible to a range of disciplines and to practitioners in the field of natural hazards.
4. Reducing risk and curbing losses through knowledge-based actions. *This goal brings together the outcomes of Goals 2 and 3. It will be accomplished through the implementation of vulnerability assessments and effective approaches to risk reduction.*
4.1 Develop and implement the Forensic Disaster Investigations (FORIN) project to promote methodologies and case studies (10) globally to identify and address the root causes of disasters. 4.2 Identify and work with international organisations to develop and implement global standard indicators and other measures of disaster risk and the effectiveness of disaster risk reduction at national and regional levels.
5. Networking and network building. *This goal focuses on the development, strengthening of and collaboration within the IRDR network at global, regional and national levels.*
1.1 Ensure that the implementation of the IRDR programme is well integrated with co-sponsors' main programmes (ICSU, ISSC, UNISDR), to both benefit from their contri- bution and leverage their support to advance IRDR objectives, including, but not limited to, UNISDR's Global Assessment Report on Disaster Risk Reduction, ICSU's Future Earth and the ISSC's World Social Sciences Forum. 1.2 Strengthen and establish at least three IRDR Regional Committees (RCs) and National Committees (NCs) per year. 1.3 Strengthen and establish IRDR International Centres of Excellence (ICoE). 1.4 Support SC members and their bi-annual meetings, including the recruitment of new SC members. 1.5 Host and organise an IRDR conference every two years.
6. Research Support *This goal focuses on enhancing the support for research and the utilisation of findings.*
6.1 Develop IRDR researchers and research institutions database to facilitate the promo- tion of interdisciplinary and policy-oriented science. 6.2 Facilitate the coordination of interdisciplinary science through the development and maintenance of an events calendar for IRDR-related and similar events. 6.3 To leverage political commitment from existing international mechanisms to ensure that integrated disaster risk reduction research programmes have access to priority funding from development as well as humanitarian, public and private funding sources. 6.4 Develop and strengthen the IRDR IPO and staff capacity and process, including enhancing IRDR communications and networking to facilitate information sharing and closer collaboration among IRDR partners.

Annex 5 IRDR Action Plan 2018-2020

		Action	Description	Deliverables	Lead Group	Outcomes & Impact	Timeframe
Improve Governance of IRDR	1	The Coordination Group meeting	An annual meeting of the Coordination Group	Strategic decisions and recommendations to IRDR SC and IPO	ISC Secretariat	Improved programme development policy and coherence & communication among co-sponsors, SC and IPO	2019-2020
	2	Annual donor reporting	Preparation of a comprehensive report of IRDR to the donors and co-sponsors on programme implementation	Annual report	IPO	Transparency and annual review of accountability vs IRDR goals and objectives	2018-2020
Expand the IRDR Network and Scientific Outputs	3	Contributing toward the improvement of coherence between SFDRR, SDGs and the Paris Agreement	Mainstreaming relevant SDGs and climate targets related to DRR in IRDR WGs, NCs, ICoEs and Young Scientists	IRDR key programme components and their products with clear indications to SDGs and climate targets	SC, IPO	IRDR showcases the interconnection of SFDRR priorities and the targets with SDG targets and other UN frameworks on SD	2018-2020
	4	Partnership development with G-STAG and Global ST partnership	Making joint effort with G-STAG and regional STAGs and be active in Global ST partnership in promoting integrated DRR research.	IRDR contribution at G-STAG, reginal STAG and Global ST partnership meetings	SC, IPO in cooperation with STAG	IRDR recognized as one of main driving forces in global STI mobilization for SFDRR	2018-2029
	5	Working Groups research plan Recompose the DATA, FORIN, AIRDR and RIA working groups by incorporating previous SC Members, ICoEs, NCs, IRDR Young Scientists and stakeholders from broader DRR community	- Revising working groups and define activities - Including the previous SC members - Organising a working session/ workshop to take stock and reprioritize/align Integrated Research and WG´s task around SFDRR and SDG. - Capacity Building - Promoting Integrated research approach	Specific Research Plans of WG and enhanced research teams. A number of working papers from WGs and other IRDR components ICoE joint technical workshop/conference	WG Chairs/co-Chairs, IPO	Enhanced WG outcomes Linkage and cooperation among SC, WG, ICOE´s, NC´s, Young Scientist and ISC Regional Offices and UNISDR Offices improved.	2018-2020
	6	WGs on SFDRR, CCA and SDG´s	Creation of a New Working Group to align IRDR research and overall IRDR work to SFDRR, CCA and SDG´s	WG reports	Working group chairs and co-chairs	IRDR position vs global climate change synergized	2018-2020

		Action	Description	Deliverables	Lead Group	Outcomes & Impact	Timeframe
Expand the IRDR Network and Scientific Outputs	7	New case studies on IRDR	Develop case studies with reinforced WG´s on Integrated Research for DR, Policy and Practice.	Case Studies developed by region	WG´s, ICOE´s, NC´s, Young Sc	Capacity building and IRDR network strengthened	2019-2020
	8	Continuation of Young Scientists Programme	Recruitment of young scientists through workshops and training activities	New Young Scientists members	IPO, SC Working Groups	START partner	2018-2020
	9	Expansion of IRDR base of experts by appointing "Associate Members" *(name will be changed with prior agreed TOR by the co-sponsors)*	Exemplary individuals in integrated DRR research and previous SC members	List of proposed new members.	IPO	Reinforce IRDR Working Groups Support for capacity building	2018-2020
	10	Support and partnership with IRDR associated projects	Three specific approved projects (DBAR DRR WG, SiDRR, NZ)	DRR databases, models, training packages and reports	IPO with specific project leaders	Concrete cases and products in support of IRDR mission and objectives.	2017 onward
	11	Support for ST Roadmap	*Specific contributions to Expected Outcomes Understanding Disaster Risk (1,2; 1.4); and Strengthening Disaster*	*Risk Governance to Manage Disaster Risk (2.1); among others through different WG´s*	SC, WGs, ICoEs, NCs	Use of ST, in particular integrated research approaches, in DRR related governance improved.	2018 onwards
	12	Periodic synthesis case study. A selected team of authors to produce a short report as an exemplar of Tokyo statement outcome	Conduct a synthesis of state of knowledge on SFDRR priorities targeting 2019 Global Platform	Reports of the case study	ISC, IPO, Risk-KAN Development Team	A joint IRDR contribution toward 2019 Global Platform.	2018-2019
	13	Support selected national DRR platforms as exemplars[58]	Co-develop with UNISDR guidelines to enhance national DRR platforms in selected countries.	Initial 2020 rolled out to several by 2030	IPO with UNISDR and its regional offices	Pilot examples for the development of national DRR platforms.	2018-2020

		Action	Description	Deliverables	Lead Group	Outcomes & Impact	Timeframe
Expand the IRDR Network and Scientific Outputs	14	Contributing to ISC's leading role in the S&T Major Group for the 2019 Global Platform	Lead and organize specific events and dialogues within S&T Major Group at 2019 Global Platform	Suggestions and recommendations of the S&T MG events	ISC, IPO, SC and some ICoEs	Advancement of S&T contributions in the implementation of SFDRR	2018-2019
	15	A specific task on operationalization of SFDRR indicators	A co-implemented task on indicators	A consolidated proposal on SFDRR indicators	DATA Group	Contribution to SFDRR	2018 -2019
	16	Contribute actively toward the development of Risk-KAN	Working with WCRP, Future Earth and other partners to develop a Knowledge Action Network	Risk-KAN become operational.	ICSU, ED, IPO, SC members	Improved ST action networks for SFDRR	2018-2020
	17	Regional DRR Events in all regions	IRDR contributing through SC members, NCs and ICoEs to DRR regional meetings and events on DRR & SDGs	Participation and technical advice.	SC, NCs and ICoEs in liaison with ISC and UNISDR regional offices; IPO to report	IRDR Promotion and Visibility of the Program	2018-2020
	18	Co-organize Scientific Form on Landslides	Work with ICL to organize Tokyo WLF5 in Kyoto	Specific papers and publications on landslide related risks.	ICL, SC, IPO	Specific contribution of IRDR toward Sendai Partnership (on landslides)	2020
Improve the visibility of IRDR	19	Communication and outreach	Implementation of IRDR communication strategy approved at 18th session of SC meeting	Operation in major social media, web and wikipedia	IPO	Enhanced IRDR communication and public understanding	2018-2020
	20	Special IRDR Journal Issue	Specific topic, tentative	1 Publication	SC	IRDR Legacy	2018-2019
	21	An IRDR Handbook	A stock taking handbook of science on Integrated Research on DRR	1 Publication	SC and Working Group	IRDR Legacy	2018-2020
	22	Scientific/Policy Output 2020 per IRDR WG	Short publication for decision makers on policy and practice	1 short Publication Guidelines	Working Groups	IRDR legacy	2018-2020

Annex 6 Co-sponsors and Ex-officios

International Science Council (ISC, formerly the ICSU and the ISSC)

Howard MOORE

Heide HACKMANN

Vivi STAVROU

Anne-Sophie STEVANCE

Aerospace Information Research Institute (AIR, formerly the CEODE, and then the Institute of Remote Sensing & Digital Earth (RADI)), Chinese Academy of Science (CAS)

GUO Huadong

United Nations on Disaster Risk Reduction (UNDRR, formerly United Nations International Strategy for Disaster Reduction Secretariat (UNISDR))

Andrew MASKREY

KAN Feng Min

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Jenty KIRSCH-WOOD

Annex 7 IPO and the staff members

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HAN Qunli

Administrative Officer

LANG Lang

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Kerry-Ann MORRIS

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Anne CASTLETON

LU Lucy Kuanju

LIAN Fang

Communications Officer

Chin CABRIDO

JIN Xianlin

Administrative Assistant

ZHAO Cuili

WANG Jiqiang

Annex 8 ToR of Scientific Committee and the members

Terms of Reference (ToR)

of the Scientific Committee of the Research Programme 'IRDR - addressing the challenge of natural and human-induced environmental hazards'

On the basis of the report "A Science Plan for IRDR: addressing the challenge of natural and human-induced environmental hazards" developed by the ICSU Planning Group on Natural and Human-induced Environmental Hazards and Disasters, it has been decided to establish a ten-year, internationally integrated, multidisciplinary, all-hazards research programme, whose objectives are the scientific characterization of natural and human-induced hazards, vulnerability and risk; understanding decision-making in complex and changing risk contexts; and reducing risk and curbing losses through knowledge-based actions. The programme is founded on the recognition that disaster prevention and mitigation are critical dimensions of the global poverty reduction agenda, and an integral part of development efforts.

The Scientific Committee of the IRDR Programme (SC- IRDR) is appointed jointly by the ICSU and the ISSC. Members are normally appointed for a period of three years, renewable once.

The SC-IRDR shall consist of a Chair, a Vice-Chair and no more than ten/twelve additional members, serving in their personal capacity and appointed on the basis of their standing in the international scientific community and their commitment to the strategic objectives of the Programme. The membership of the Committee shall also aim to include, as far as possible, a balanced representation of relevant disciplines in the natural, social and engineering sciences, with due regard given to regional and gender balance. The Chair, Vice-Chair and ordinary members of the SC-IRDR will be selected by mutual agreement between ICSU and ISSC and appointed jointly by the two organizations. In addition, each sponsor will appoint an ex officio member. The Chair may invite additional persons to attend sessions for specific agenda items as necessary.

The SC-IRDR may establish and convene working groups, whose membership shall be decided upon by the Committee.

In performing its functions, the SC-IRDR shall be supported by an IPO.

The Committee shall work closely with all relevant national and international organizations actively engaged in disaster risk assessment and mitigation. In particular, the Programme shall interact with members of the ICSU and ISSC families, as appropriate.

The SC-IRDR shall meet at least twice a year. The specific tasks of the SC-IRDR are:

(a) To further define the inter-disciplinary scientific strategy and determine its specific objectives and priorities; this will involve, through an extensive consultation process, the continued identification and exploration of the major programmes and projects that exist in the field of natural and human-induced hazards and disasters and, where appropriate, the conclusion of agreements as to how they might become components of IRDR.

(b) To develop, and keep under continuous review, an implementation plan for the Programme in close consultation with potential research partners, and to ensure that the plan develops in such a way as to make optimal use of available resources;

(c) To establish and implement a mechanism for the design, guidance, development and oversight of the Programme;

(d) To facilitate the exchange of information among the scientists participating in the Programme and the natural and human-induced hazards and disaster community in general, as well as relevant scientific institutions and agencies at the national and international levels;

(e) To promote the goal and objectives of the Programme, its deliberations and achievements through development of capacity building and outreach programmes in order to attract and form a new generation of individuals at all levels that can address natural and human-induced hazard and disaster issues, and to capture the interest of the general public and decision-makers in the importance of risk reduction for human well-being and sustainable development;

(f) To work with appropriate organizations, including the Global Terrestrial and Ocean Observing Systems (GTOS and GOOS) and the Group on Earth Observations (GEO) of the Global Earth Observation System of Systems (GEOSS) to ensure the development of sustained monitoring and enable continuous observations relating to natural and human-induced hazards;

(g) To convene sessions of an Open Consultative Forum to which all stakeholders will be invited. The Forum will serve as a consultative process for expressions of views on the Programme development, as a platform for dialogue among the various stakeholders and as a venue for exchange of information on Programme implementation. The Forum shall be convened at least once per year, preferably in conjunction with a major international disaster and risk event;

(h) To raise additional funds for the planning and coordination activities, including activities of any working groups that the SC-IRDR may wish to set up, and to assist in convincing national and international funding bodies to fully support the research activities of the Programme; and

(i) To provide oversight and guidance to the activities of the IPO of IRDR.

The SC-IRDR shall report annually to the Executive Board of ICSU and the Executive Committee of ISSC on programme organization and implementation, and to the executive heads of both organizations following each of the Committee's meetings.

Approved by the ICSU Executive Board at its 99th Meeting, 25 October 2008, Maputo, Mozambique and the ISSC 27th General Assembly, 26 November 2008, Cape Town, South Africa

List of SC member (in the time order of the appointment)

Raymond CHAN

Richard EISER

Ferruccio FERRIGNI

William HOOKE

Michel LANG

Allan LAVELL

Gordon MCBEAN (Chair)

Maria PATEK

Ortwin RENN

Chamhuri SIWAR

Steven SPARKS

Astri SUHRKE

Coleen VOGEL

Angelika WIRTZ

Irasema ALCÁNTARA-AYALA

David JOHNSTON (Chair)

Shuaib LWASA (Chair)

Kuniyoshi TAKEUCHI

Djillali BENOUAR

Jörn BIRKMANN

Ann BOSTROM

Sálvano BRICEÑO (Chair)

Omar Darío CARDONA

Susan CUTTER

S.H.M. FAKHRUDDIN

Virginia JIMÉNEZ DÍAZ

Anthony OLIVER-SMITH

Mark PELLING

Sisi ZLATANOVA

John HANDMER (Chair)

Haruo HAYASHI

Virginia MURRAY

Peng CUI

Claudine UWERA

Jana SILLMANN

Wei-Sen LI

Rajib SHAW

Riyanti DJALANTE (Chair)

Tiana Mahefasoa RANDRIANALIJAONA

Nesreen Daifallah AL-HMOUD

Alonso Brenes TORRES

Annex 9 ToR of IRDR National Committee and the members

Terms of Reference

Co-sponsored by the ICSU, ISSC, and United Nations International Strategy for Disaster Reduction (UNISDR), a ten-year Integrated Research on Disaster Risk Programme (IRDR) was launched to address the major challenges of natural and human-induced environmental hazards. It aims to adopt an international, transdisciplinary and cross-hazard approach to conduct disaster risk reduction (DRR) research, and to reduce the impacts as well as losses induced by natural hazards.

The IRDR Programme is directed by the Science Committee of the IRDR (IRDR SC). The IPO was established to support IRDR SC and to help promote and disseminate its scientific results to target audiences at various levels. IRDR National Committees (NC) and Regional Committees (RC) are designated to promote the visions and legacies of IRDR and expand its work at the national and regional levels.

1. Objectives of IRDR NC/RC

First, IRDR NC/RCs are encouraged as mechanisms to mainstream integrated research into disaster risk reduction efforts at national and regional on an institutionalized basis, to enhance the coordination and cooperation among multi-stakeholders for the sustainability of the integrated research, and to improve the capacity of countries and regions in the field of disaster risk reduction. **Second**, IRDR NC/RC is to serve as focal point to promote IRDR-related research initiatives of host countries, and to enhance the links between national and international disaster risk research programmes and activities. **Third**, IRDR NC/RCs is to couple with IRDR SC, IPO and IRDR partners in pursuit of IRDR objectives, the identification of research priority, the development of research plan, implementation of programme and other activities to achieve IRDR goals.

2. Selection Criteria and Process

IRDR NC/RC should build on existing systems/ entities relevant to disaster risk research and practice. The organization (preferably an academic institution) leading the IRDR NC/RC should be a permanent structure that is in a sufficiently high position to have a strong leadership and capacity to coordinate other sectors within the country or region, to leverage political commitment and to mobilize resources for the IRDR purposes.

Each IRDR NC/RC will be designated on the basis of the following criteria:

- A good track record in, or commitment to, trans-disciplinary research related to disaster risk, combining social science, natural science, engineering as well as policy, etc.;
- Provision of unhindered access to researchers from participating countries and international visitors in region;
- Proven multi-national experience in research excellence related to disaster risk reduction;
- Internal capabilities to manage multi-national research teams;
- Commitments to provide appropriate support (funding or in kind) for the national, regional and international components consistent with IRDR objectives.

Admission of IRDR NC/RCs will follow these steps:

Submission of Application

Interested entities should submit an Expression of Interest (EOI) to the IRDR IPO via email: connect@irdrinternational.org.

The EOIs should include:

- A description of the organization, including its basic organizational structure, key personnel, funding sources, scientific research capacity, linkage with national and international disaster risk research and reduction networks.

- An overview of the professional activities for the past years, including past and ongoing programme with regard to disaster risk research.
- A vision and proposal to develop the IRDR NC/RC in its country (NC) or region (RC), including the incorporation of IRDR objectives into its own mission and its implementation as well as a description of existing organizations, programmes and other relevant DRR activities in the country and/or region.

Review and Evaluation of Application

IRDR will review and assess EOI in accordance with criterion, and the IRDR Science Committee will make the final designation.

3. Designation and Composition

Each IRDR NCs are expected to include, in their make-up, researchers from the natural, social, health and engineering sciences, along with policy makers and practitioners related to disaster risk reduction and management, and to maintain a close relationship with other interested organizations, such as UNISDR National Platform for Disaster Risk Reduction where such a body exists and ICSU and ISSC representatives or relevant contacts.

IRDR RCs are designed for the purposes of IRDR as a grouping of spatially contiguous countries which search to promote common and complementary advance in disaster risk reduction and research in a common region or common language. IRDR RCs could be proposed by leading authority, institution, academy of a country in certain region, or reputed, capable or by international organization which is committed to IRDR.

4. Governance

Each IRDR NC should be self-organized and be governed in accordance with their respective national institutions (relevant policies, legislation and organizational arrangements). IRDR NC/RC will function individually, but maintain close interaction with IRDR SC and IRDR IPO.

5. Tasks and Activities

In support of IRDR Science Committee, IRDR NC/RC will undertake the following activities:

- Foster and support participation in IRDR on the part of institutions and individual scientists.
- Serve as the national or regional focal point for IRDR.
- Foster networking and collaboration among domestic, regional and international disaster risk reduction science and technology activities.
- Improve scientific knowledge and enhance the integration of science in disaster risk reduction planning, policies and programmes domestically, regionally and internationally.
- Support efforts to update and report on national and regional disaster risk reduction activities aligned with the Hyogo Framework of Action's strategic priorities, with emphasis on the science and technology activities and engage in the discussions for the post-2015 regime on disaster risk reduction and contribute to the national or regional discussions for other relevant global negotiations (climate change adaptation, earth systems, etc.).
- Provide scientific advice to policy-makers, taking into consideration on national and regional disaster risk reduction initiatives.
- Assist in fundraising for IRDR activities and projects.

6. Reporting

The IRDR NC/RC will provide semi-annual reports to the IRDR SC via IRDR IPO prior to each IRDR SC Meeting. At a minimum, IRDR NC/RC will submit a yearly work plan and an annual summary report.

List of IRDR NCs

NCs	Host Institutes
IRDR Australia	Bushfire & Natural Hazards Cooperative Research Centre (BNH CRC)
IRDR Canada	Science and Technology Working Group, Canada’s Platform for Disaster Risk Reduction
IRDR China	CAST
IRDR Colombia	National Committee of Disaster Risk Knowledge, National Unit for Disaster Risk Management of the Presidency of the Republic of Colombia
IRDR France	Scientific Council, Association Française Pour la Prevention des Catastrophes Naturelles (AFPCN)
IRDR Germany	German Committee for Disaster Reduction
IRDR New Zealand	Natural Hazards Research Platform (NHRP)
IRDR USA	Natural Hazards Center (NHC), Institute of Behavioral Science, University of Colorado at Boulder
IRDR Iran	A group of eight Iranian research institutes and scientific associations
IRDR Indonesia	Indonesia Institute of Sciences (LIPI)
IRDR Japan	Science Council of Japan (SCJ)
IRDR Republic of Korea	National Disaster Management Research Institute (NDMI) in Ministry of the Interior and Safety
IRDR Nepal	National Reconstruction Authority of Nepal

Annex 10 ToR of IRDR International Centres of Excellence and the members

Terms of Reference

Co-sponsored by the ICSU, ISSC, and United Nations International Strategy for Disaster Reduction (UNISDR), a ten-year **Integrated Research on Disaster Risk Programme (IRDR)** was launched to address the major challenges of natural and human-induced environmental hazards. It aims to adopt an international, transdisciplinary and cross-hazard approach to conduct disaster risk reduction (DRR) research, and to reduce the impacts as well as losses induced by natural disasters.

The IRDR Programme is directed by the **Science Committee of the IRDR (IRDR SC). The IPO** was also established to support the work of the Science Committee and to help promote and disseminate its scientific results to target audiences at various levels.

A limited number of **International Centres of Excellence (ICoE)** will be established to make contributions during the term of IRDR and to make IRDR's further development possible and sustainable. The ICoEs can be based on existing institutions focusing on disaster risk education, research and technical cooperation. They should operate as network mechanisms engaging other similar institutions in their region, country or city.

Objectives of IRDR ICoE

Generally, each ICoE will be developed to contribute to IRDR's main principles, objectives and studying domains and to promote and disseminate widely the IRDR concepts, approaches and methodologies. The ICoEs would not only be committed to supporting SC and IPO in facilitating IRDR but also to be developing as a global network for IRDR knowledge, expertise and researchers. Specifically, ICoEs will envision 3 objectives for their activity in IRDR. **Firstly**, each ICoE research programme will embody an integrated approach to disaster risk reduction that directly contributes to the IRDR Science Plan and its objectives: the scientific characterization of natural and human-induced environmental hazards, vulnerability and risk; the understanding of decision-making in complex and changing risk contexts; and the reduction of risk and curbing losses through knowledge-based actions. The ICoE will also contribute to the cross-cutting themes of: capacity building; case studies and demonstration projects; and assessment, data management and monitoring. The ICoE and the IRDR projects will collaborate to provide global contributions towards achieving the IRDR legacy. The ICoE will, in particular, enable regional scientific activities through geographically-focused contributions based on more localized inputs and by being visible centres of research motivate participation in the IRDR. **Secondly**, ICoEs will be supportive in developing and strengthening powerful partnership with UN Agencies and organizations at international, regional and national levels working on disaster risk, which will provide a reserved supply of intelligent and informational resources for IRDR. **Thirdly**, the ICoEs will further extend their core function as facilitators of IRDR and will be an international center for providing support for decision-making, promulgating achievements of DRR research, as well as fostering DRR senior researchers and practitioners. All the above with a view to ensure the shift of focus towards disaster risk reduction in research and policy-making.

Main Roles of IRDR ICoEs

In order to comply with the objectives of IRDR Science Plan and its own objectives, roles of ICoE would be broadly categorized as below:

- Conduct IRDR at local, regional, and global scale, meeting with objectives of 4 IRDR Working Groups;

- Provide specifically-designed technical cooperation on disaster risk and reduction management for policy and decision-making;
- Provide technical support for formulating regional, national or local disaster risk reduction programs based on integrated research;
- Promote IRDR research by conducting regular trainings, workshops or other activities for disaster managers, decision- makers, and junior researchers.
- Facilitate and participate in IRDR events;
- Contribute to disaster risk researchers' network or platform

Criteria for designation of IRDR ICoE

The ICoE will be sited in various locations around the world chosen by IRDR SC to provide broad geographic distribution and a mix of disciplinary and hazard foci. The Centres will be designated on the basis of the following criteria:

- A good track record in, or commitment to, transdisciplinary research on disaster risk, combining social science, natural science, engineering as well as policy, etc.;
- Provision of unhindered access to researchers from participating countries and international visitors;
- Proven multi-national experience in research excellence related to disaster risk reduction;
- Internal capabilities to manage multi-national research teams;
- Commitments to provide appropriate support, including funding and in-kind for the national and international components consistent with IRDR objectives;
- Provision of fully equipped office space and supporting services;

Selection Process of IRDR ICoE

The IRDR ICoE selection round could be conducted through the following competitive process.

Submission of Application

Interested organizations, foundations, institutions, academies, universities, and other capable entities can submit an Expression of Interest (EOI) to the IRDR IPO directly via

email: connect@irdrinternational.org;

These EOIs will be reviewed by IRDR. They should incorporate the following parts:

- A description of the organization requesting IRDR ICoE, including its basic organizational structure, key personnel, funding sources, scientific research capacity, linkage with international disaster risk research network
- An overview of the professional activities for the past years, including past and ongoing programme with regard to disaster risk research..
- A plan of incorporating IRDR objectives into its own missions and its implementation.
- A vision to develop the IRDR ICoE
- Identification of funding and other support

Review and Evaluation of Application

IRDR will review and assess applications in accordance with criteria. Recommendations will be made to the IRDR Science Committee. The IRDR Science Committee will have final decision.

Organization of IRDR ICoE Network

The ICoEs will vary in their structure and include the possible establishment of a Centre to act as a host institution and coordinating mechanism shared between several institutions in different countries, within one country or one city. The Host Institution will be agreed between the participating organizations and the IRDR Science Committee (SC).

Each ICoE will have both local and international components. The local component will consist of a strong cadre of disaster risk reduction academics and researchers from universities, academies of science, institutes and centres within the host country (or countries). The international component will consist of short- and longer-term (6-12 month) visiting scientists from developed and developing countries and support to host workshops, colloquia and 2 scientific meetings that bring together scientists on, for example, case studies or forensic investigations. These could then be extended to other countries in longer-term cooperative studies.

As a contribution to international science and the IRDR Programme, the ICoE is expected to provide for openness of data, information and outputs for all to use. The ICoE is expected to be sustained for at least 5 years.

The IRDR ICoE network and each ICoE will be overseen by an international advisory board (IAB) of 5 to 9 members appointed by the IRDR SC in consultation with the Host Institution. Each ICoE shall be headed by a Director, who shall be responsible for the administration and operation of the Centre and appointed by the Host Institution in consultation with the IAB and IRDR SC.

As a part of IRDR initiative in the structure diagram, the IRDR ICoE will function independently and work closely with IRDR Regional and National Committees and the IPO, under the overall guidance and supervision of the IRDR SC. IRDR ICoE should provide bi-annual reports to the IPO prior to the IRDR SC meetings. At a minimum, the ICoE shall submit their work plan and annual report to the IPO for the SC on a yearly basis.

Funding for IRDR ICoE

The funding for each ICoE will be provided by the Host Agencies/Organizations for the duration of the Centre's life. The Host Institution will be expected to provide and mobilize funding for all day-to-day operations as well as for projects and visiting scientists. Fundraising would be undertaken jointly with the IRDR IPO and supported by SC members as needed.

List of IRDR ICoEs (in the time order of establishment)

Location	ICoE sand the Host Institutes
China	**IRDR ICoE-Taipei** **Home Institution:** *Academy of Sciences located in Taipei, China*
United States	**IRDR ICoE in Vulnerability and Resilience Metrics (IRDR ICoE-VaRM)** **Home Institution:** *Hazards and Vulnerability Research Institute (HVRI), Department of Geography, College of Arts and Sciences, University of South Carolina, Columbia, South Carolina, USA*
New Zealand	**IRDR ICoE in Community Resilience (IRDR ICoE-CR)** **Home Institution:** *Joint Centre for Disaster Research (JCDR), Massey University, Wellington, New Zealand*
Colombia	**IRDR ICoE in Understanding Risk & Safety (IRDR ICoE-UR&S)** **Home Institution:** *Disaster Risk Management Task Force, Institute of Environmental Studies (Instituto de Estudios Ambientales – IDEA), National University of Colombia (Universidad Nacional de Colombia), Manizales City, Colombia*
South Africa	**IRDR ICoE for Risk Education and Learning (IRDR ICoE-REaL)** **Home Institution:** *Periperi U (Partners Enhancing Resilience for People Exposed to Risks) Consortium, Research Alliance for Disaster and Risk Reduction (RADAR), Department of Geography and Environmental Studies, Stellenbosch University, South Africa*
United Kingdom	**IRDR ICoE in Risk Interpretation and Action (IRDR ICoE-RIA)** **Home institution:** *Centre for Integrated Research on Risk and Resilience (CIRRR), Department of Geography, King's College London (KCL), London, UK*

Location	ICoE sand the Host Institutes
Canada	**IRDR ICoE for Disaster Resilient Homes, Buildings and Public Infrastructure (IRDR ICoE-DRHBPI)** **Home Institution:** *Institute for Catastrophic Loss Reduction (ICLR), Western University, Toronto, Canada*
Germany	**IRDR ICoE on Critical Infrastructures and Strategic Planning (IRDR ICoE-CI&SP)** **Home Institution:** *Institute for Spatial and Regional Planning (IREUS), Department of Civil Engineering and Environmental Management, University of Stuttgart, Germany*
China	**IRDR ICoE for Collaborating Centre for Oxford University and CUHK (CCOUC) for Disaster and Medical Humanitarian Response (IRDR ICoE-CCOUC)** **Home Institution:** *Collaborating Centre for Oxford University and CUHK (CCOUC) for Disaster and Medical Humanitarian Response*
Malaysia	**IRDR ICoE for Disaster Risk and Climate Extremes (IRDR ICoE-SEADPRI-UKM)** **Home Institution:** *Southeast Asia Disaster Prevention Research Initiative (SEADPRI-UKM), the National University of Malaysia*
Nepal	**IRDR ICoE for National Society for Earthquake Technology- Nepal (IRDR ICoE-NSET)** **Home Institution:** *National Society for Earthquake Technology-Nepal*
Netherlands	**IRDR ICoE in Spatial Decision Support for Integrated Disaster Risk Reduction (IRDR ICoE-SDS IDRR)** **Home Institution:** *Faculty of Geo-Information Science and Earth Observation (ITC),The University of Twente*
Sweden	**IRDR ICoE on Transforming Development and Disaster Risk (IRDR ICoE-TDDR)** **Home Institution:** *SEI Initiative on Transforming Development and Disaster Risk*
Australia	**IRDR ICoE on IRDR Science (IRDR ICoE-IRDRS)** **Home Institution:** *Disaster Risk Science Institute, The Australian National University*
India	**IRDR ICoE on Resilient Communities & Settlements (IRDR ICoE-RCS)** **Home Institution:** *Visvesvaraya National Institute of Technology (VNIT), India*
Pakistan	**IRDR ICoE on in Disaster and Climatic Extremes (IRDR ICoE-DCE)** **Home Institution:** *Department of Geography, University of Peshawar, P*akistan
China	**IRDR ICoE on Risk Interconnectivity and Governance on Weather/Climate Extremes Impact and Public Health (IRDR ICoE-RIG-WECEIPHE)** **Home Institution:** *Fudan University, China*

Annex 11 IRDR Young Scientists Programmes and the list of young scientists

Terms of Reference

Introduction

The Sendai Framework for Disaster Risk Reduction (SFDRR) calls for enhanced role of science and technology for evidence based decision-making. It also urges the need for innovation and partnership, which is linked to practise and diverse stakeholders. IRDR, with its mandate for integrated and trans-disciplinary research, would like to promote capacity building of young professionals, and encourage them to undertake innovative and needs based research which makes science-policy and science-practice linkages stronger.

Objectives

- Increase awareness among young scientists about Sendai Framework implementation and provide opportunities for further engagement through the Young Scientists Program on DRR.
- Collate existing research knowledge on DRR and identify research gaps and priorities in relation to the Sendai Framework Priorities for Action
- Identify opportunities to fund continued multi-disciplinary research by young scientists and early career researchers
- Provide technical support to promising young researchers in DRR fields
- Build and foster strong and dynamic networks among worldwide experts and institutions in DRR fields
- Develop, over time, a community of high-quality young professionals that can provide support for policy making decisions related to DRR

Eligibility

To be an IRDR Young Scientist, following are the necessary criteria:

- Increase awareness among young scientists about Sendai Framework implementation and provide opportunities for further engagement through the Young Scientists Program on DRR.
- Collate existing research knowledge on DRR and identify research gaps and priorities in relation to the Sendai Framework Priorities for Action
- Identify opportunities to fund continued multi-disciplinary research by young scientists and early career researchers
- Provide technical support to promising young researchers in DRR fields
- Build and foster strong and dynamic networks among worldwide experts and institutions in DRR fields
- Develop, over time, a community of high-quality young professionals that can provide support for policy making decisions related to DRR

Programme benefits

Once selected, as fellow can be an “IRDR Young Scientist” for a period of maximum three years. The fellow will receive the following benefits:

- Link to IRDR network of professionals and practitioners
- Access to IRDR Scientific Committee (SC) for academic support / advice
- Participation in IRDR related training programs (there would be a different selection process for each of the training program)

- A certificate for IRDR Young Scientist upon successful completion

Responsibility of IRDR Young Scientists

- Contribute to innovative research in the field of disaster risk reduction
- Be the ambassador of IRDR in different conferences and/or social media
- Develop and contribute to networking of young professionals
- Submit a 6-month report of activities in the prescribed format of IRDR
- Acknowledge the contribution of IRDR in the academic paper, thesis etc.

Selection

The members of Selection Panel will make evaluation considering the following aspects of the applicants: if they are toward integrated research, having strong relation to Sendai Framework four priorities and the level of innovation in the research. Gender and regional balance should also be considered in the evaluation and selection.

The members of Selection Panel are: Virginia Murray, Shuaib Lwasa, Rajib Shaw, Qunli Han

List of Young Scientists

List of 1st Batch

Name	Country	Nationality	Field of study	RP Topic
Angelo Paolo L. TRIAS	Australia	Philippines	Humanitarian, Emergency and Disaster Management Studies	Connecting the actors, discovering the ties: Exploring the organisational networks of disaster risk reduction (DRR) interventions and projects in Asia and the Pacific
Anissa SARAH	Indonesia	Indonesia	Account	Regular Socialization of Public Awareness on the Importance of Emergency Response to the Disaster
Armand KABLAN	Côte d'Ivoire	Côte d'Ivoire	Hydrogeology (Environment and Sanitation Engineering)	Open and green spaces in African urban areas: An assessment of the opportunity and challenges in risk reduction context
Ayesha SIDDIQI	UK	Pakistani	War Studies/Geography	How do conflict affected communities in LMICs experience and construct disasters, especially politically?
Barrett RISTROPH	USA	USA/Russia	Planning	how Alaska Native Villages (ANVs) are adapting to flooding, erosion, and species shifts, how laws can help or hinder adaptation processes, and the correlation between community characteristics, vulnerability, and disaster declarations.
Basanta Raj Adhikari	Nepal	Nepalese	Geology	Land degradation and community based disaster risk reduction plan in the Himalayas: A case study of Rupa lake Watershed, Kaski, Nepal
Behrooz Balaei	New Zealand	Iranian	Disaster Management (Civil Engineering)	Measuring water supply system resilience to earthquakes
Chekwemboi Christine	Uganda	Ugandan	Environment and natural resources	Adaptation to climate change risks in the Lake Kyoga Basin
CHIAN Siau Chen	Singapore	Singaporean	Engineering	catastrophe modelling, landslide and underground lifelines.
Dao Nguyen-Khoi	Vietnam	Vietnam	Integrated River Basin Management	Impacts of climate change and land-use change on hydro-meteorological and agricultural droughts in the Central Highlands of Vietnam
Doris Jimena Roncancio Benitez	Brazil	Colombia	Public Health	Health risk assessment relating to the variability of extreme air temperatures in Colombia for the planning of mitigation and adaptation strategies to face climate change.
Edris ALAM	Bangladesh	Bangladeshi	Disaster Management	Climate change perceptions, impacts and adaptation of Bangladeshi coastal communities
Elisha Anne Pei Yi TEO	Singapore	Malaysian	Physical Geography	Digging for lost rivers in Thailand: Reconstructing historical channel shifts in the Chiang Mai Intermontane Basin

Name	Country	Nationality	Field of study	RP Topic
Fátima Antonethe Castaneda Mena	Guatemala	Guatemalan	Renewable Energy	Management and Restoration of Forest Ecosystem for purposes of Food Security and Energy in Central America
Flavio Lopes Ribeiro	USA	Brazilian	Disaster Science and Management	Individual and Community Responsibility for Water Management as a Strategy to Mitigate the Impact of Drought in the Semiarid Region of Brazil
Geoffrey Mwangi Wambugu	Kenya	Kenyan	Environmental Science (Geo-spatial Modelling)	Agro-Pastoralists and Drought: Exploring Climate-smart Mitigation Strategies among Women in the ASALs
Givemore Munashe Makonya	South Africa	Zimbabwean	Plant Eco-physiology	Thermotolerance genotypes for sustainable Chickpea production in South Africa
Glenn Fernandez	Japan	Philippines	Global Environmental Studies	Empirical Research on Earthquake Risk Perception and Housing Reconstruction in Kathmandu, Nepal and on Earthquake, Cyclone, and Fire Risk Perception and Housing Safety in Yangon, Myanmar
Harold Aquino	New Zealand	Philippines	Civil Engineering	Developing storm resilience through building code upgrades and its impact on affordability of houses in the Philippines
Indrajit Pal	Thailand	Indian	Geography	Investigating Critical Factors for Social Resilience and Risk Governance for Flood Adaptation in Ayeyearwady Delta, Myanmar
JIA Yang	China	Chinese	Physical Geography	Influence of Climate Change on the Formation of Various Mountain Hazards in the Central and Eastern Himalayas
Gabriel Kojo Frimpong	Nigeria	Ghanaian	BOTANY/ POSTHARVEST TECHNOLOGY	use gamma radiation to decontaminate and preserve freshly harvested and dried pepper fruits
LEI Yu	China	Singapore	Geotechnics Engineering	A QUANTITATIVE RISK ASSESSMENT METHOD OF HUMAN SETTLEMENTS SUBJECT TO DEBRIS FLOW IMPACT
LIU Tingxi	China	Chinese	Tourism Management	Post-disaster community resilience and tourism development: The case ofWenchuan earthquake areas in China
Marie Delalay	Singapore	Swiss	Geography	Flood risk assessment under different scenarios of climate change, urban expansion, and economic exposure: A probabilistic analysis of the Upper Seti River Watershed in Nepal
Masahiko Haraguchi	USA	Japanese	Earth and Environmental Engineering	Innovations towards Climate induced Disaster Risk Assessment and Response
Md. Shamsuzzoha	Bangladesh	Bangladeshi	Geography and Environmental Studies	Strengthening economic security through social capital: Households' adaptation to cyclone risk in Bangladesh

Name	Country	Nationality	Field of study	RP Topic
Oluwatosin Adejoke Oyedele	Nigeria	Nigerian	Agricultural Economics	DYNAMICS OF FOOD INSECURITY IN NIGERIA
Poorna Sandakantha YAHAMPATH	Sri Lanka	Sri Lankan	Past Climate Changes	Approaching multi-proxy analysis for review Quaternary palaeo-climate reconstruction in Ratnapura and Sri Lanka
Ranit CHATTERJEE	Japan	Indian	Disaster Management	Recovery Process of Micro Small and Medium Scale Businesses in Backdrop of 2015 Nepal Earthquake
Saadia Majeed	Australia	Australia and Bangladesh	Disaster Risk Management	Comprehensive Framework for Disaster Risk Management (CFDRM) Application Programme
Sameer Deshkar	India	Indian	Disaster Risk Resilience	Prioritizing Disaster Risk Resilience Strategies and Locations for their Implementation through Local Community Participation in Urban-Rural Transect Areas
Sandra Delali Kemeh	Germany	Ghanaian	Disaster Risk Reduction, Climate Change Mitigation and Adaptation	Exploration of Potential Benefits of the landscape approach in Drought Risk Reduction: A case study of Masongaleni, Kibuwezi in Maukueni County, Kenya.
Sarah Hasan	Pakistan	Pakistani	RS and GIS	Investigation of Geomorphology of Northern Pakistan and surrounding regions: Insides from Remote Sensing and GIS
Sarah Lindbergh	USA	Brazilian	Environmental Planning	The role of infrastructure vulnerability assessment in natural disaster response planning
Shan Nawaz Khan	Pakistan	Pakistani	Disaster Management	APPLICATION OF GIS/RS IN ASSESSMENT OF FLOOD HAZARD, VULNERABILITY AND RISK
Spyros Schismenos	China	Greek	Disaster Management	PREPAREDNESS, RESILIENCE & EDUCATION AGAINST TORRENTS (PREDATOR)
TAN Chunping	China	Chinese	Physical Geography	Drought Disaster Risk and Its Projection Under RCP Scenarios in the Silk Road Economic Belt of China
WANG Guanghui	China	Chinese	Sustainable development	Comprehensive Risk Assessment of Coastal Cities through Sea Level Rise in China and America: A social development perspective
WANG Jiao	China	Chinese	Geotechnical Engineering	Study on failure mechanism and criterion of moraine deposits under climate change
CUI Yan	China	Chinese	Law	Overview of Disaster Risk Governance and Regulatory System in China

List of 2nd Batch

Name	Country	Nationality	Field of study	RP Topic
Abhinav Walia	Indian	Architecture	Humanitarian, Emergency and Disaster Management Studies	Managing Urban Flooding in the era of Changing Climate: Way forward for smart Governance
Akvan Gajanayake	Sri Lankan	Engineering	Account	Measuring social, environmental and economic impacts of road failure due to natural disasters
Avirut Puttiwongrak	Thai	Environment and Resource System Engineering	Hydrogeology (Environment and Sanitation Engineering)	Preliminary Assessment of Seawater Intrusion Problem in Phuket Island, Thailand
Brennan Vogel	Canadian	Climate Change Laboratory	War Studies/Geography	Analysis of the social, political and cultural dimensions that impact climate change policy and practice, with an applied focus on the governance context of Canada's coastal First Nations and municipalities.
Chow Ming Fai	Malaysia	Civil Engineering	Planning	The potential of parameter estimation through regionalization for flood simulations in ungauged mesoscale catchments
Débora A. Swistun	Argentina	Enviroenmental Anthropology	Tourism Management	The determinants of housing, health and environmental policies in the Matanza-Riachuelo river's basin (Buenos Aires, Argentina) and the ways in which they impact on the neighbourhoods settled in environmental risk areas
Emmanuel Raju	Indian	Disaster Risk Management	Geography	Increasing Stakeholder Diversity in Disasters - Lessons for Disaster Risk Management
Florian Roth	German	Political Science	Earth and Environmental Engineering	A Context-Specific Framework for Integrating Social Vulnerablity in Mapping
Idowu Ajibade	Nigerian	Geography		Building resilient cities: a proposal for 'transformative and just adaptation' in the Global south.
Ignatius Gutsa	Zimbabwean	ANTHROPOLOGY		Examining the importance of everyday local level sources of reading the weather and seasons in rural Zimbabwe for disaster risk reduction in the face of climate change
Imon Chowdhooree	Bangladeshi	Urban and Regional Planning		IMPACTS OF STRUCTURAL MITIGATION MEASURES ON PERCEPTIONS OF COMMUNITY FLOOD RESILIENCE: EXPERIENCES FROM HAOR COMMUNITIES OF BANGLADESH
Jose Areekadan	Canadian	Management		Sichuan Business Continuity Assessment during Earthquakes and Natural Disaster
Karen McNamara	Australian	Geography		Are we 'building back better'? Exploring disaster response efforts in the Asia-Pacific region

Name	Country	Nationality	Field of study	RP Topic
Khalid Md. Bahauddin	Bangladeshi	Leadership for sustainable Development		Coastal Floods in Bangladesh: How people's Interpretation of Personal, Social and Institutional Resources Influence Flooding Preparedness
Md. Abdus Sattar	Bangladeshi	Environmental Sciences		Forecasting of cyclone risk for coastal community and exploring risk reduction strategies in Bangladesh
Mizan Bustanul Fuady Bisri	Indonesia	Political science		The Networked-Politics of Science and Policy Interface on Disaster Risk Reduction in Southeast Asia: A Comparative Perspective
Mohammad Aminur Rahman	Australian	Development and Disaster		IMPACT OF STRUCTURAL DEVELOPMENT PROJECTS ON VULNERABILITY OF COASTAL COMMUNITIES TO DISASTER
Mohan Kumar Bera	Indian	Social Science		Collective Efforts of People to Reduce Natural Disasters: A Study of Sundarban Islands
Mortuza ahmmed	Bangladeshi	Statistics, Bio-statistics & Informatics		Factors Associated with Safe Delivery Practice in Bangladesh
Richard Adu	Ghanaian	Enviornmental Science		FLOOD CONTROL MANAGEMENT IN MONROVIA: A SUSTAINABLE WAY TO A RESILIENT AND LIVABLE CITY
Saja Aslam A.M.	Sri Lankan	Social resilience/ DRR		An approach to develop risk-sensitive development plans to build resilient communities
Sandra M. Carrasco M.	Peru	Environmental Management		Self-help transformations of post-disaster housing and community empowerment in Asia-Pacific
Saswata Sanyal	Indian	Disaster Preparedness, Mitigation and Management		assess how social capital helps in preparedness and response towards natural disasters among communities in this high risk area
Shyamli Singh	Indian	Bio-Pesticides		Community-centric Disaster Risk Reduction: An Instrument for Climate Risk Management
Suraj Gautam	Nepalese	Disaster Risk Management		Preparation of Landslide Susceptibility Mapping focusing on Landslide Risk Assessment and Risk Perception in the Sindhupalchowk district
Tanwa Arpornthip	Thai	Physics		Disaster ratio analysis for Flood Risk Assessment of Thailand's Andaman Region
Tinsaye Tamerat	Ethiopia	Social Work		Africanizing Sendai framework with special emphasis on “Green Famine” resilience in the Horn of Africa

Name	Country	Nationality	Field of study	RP Topic
Vivien How	Malaysia	Enviornmental Health- Health Risk Assessment		Integrating Science-based Knowledge into Innovation Action for Community-based Disaster Risk Reduction (DRR) Program
Xianlin Jin	Chinese	Communication Studies		Impact of Health Consciousness on Response to Haze Warning Messages: A Test of the Extended Paraller Process Model in an Enviornmental Health Risk Context
Yan Yan	Chinese	Geotechnical Engineering		Monitoring and early warning system for debris flow and debris flow monitoring
Zubaria Andlib	Pakistani	Economics		An Assessment of Women’s Vulnerabilities and Adaptation Strategies to Climate Change Hazards in Coastal Area of Balochistan, Pakistan

List of 3rd Batch

Name	Country	Nationality	Field of study	RP Topic
Abayineh Amare Wolde-amanuel	Ethiopia	Ethiopian	Environment and Development	Index-Based Livestock Insurance: New op-tions to manage climate risks in Ethiopia
Amrit Prasad Sharma	Nepal	Nepali	Environmental Science	Watershed based climate and disaster risk assessment in Riu-Khola Sub Watershed, Maadi, Chitwan, Nepal.
Anna Barra	Spain	Italian	Geotechnical Engineering	SENTINEL-1 FOR GEOHAZARD MONITOR-ING AND RISK MANAGEMENT
Anne Simiyu	Kenya	Kenyan	Climate Change and adaptation	E Green water Management for Food Secu-rity and Sustainable livelihoods in dry-lands-A case of Ukambani Region in Kenya
Bikram Manandhar	Nepal	Nepali	Watershed Management	Hydrological characterization of an un-gauged or limited precipitation monitoring data basin for flood risk assessment and water resource management- learning and sharing knowledge across the region
Chandra Laxmi Hada	Nepal	Nepali	Comprehensive Crisis Management	Rethinking Participatory Approach in the preparation of Risk Sensitive Land Use Planning (RSLUP) for emerging Nepali Towns
Fajar Shidiq Suwarno	Indonesia	Indonesian	Disaster Management	Urban Community Empowerment Strategy for Preventing House Fires in Dense Set-tlements in Jakarta, Case Study: Cipinang Besar Utara Urban Village
Frederick Dapilah	Germany	Ghanaian	Human Geography	Coproducing knowledge for flood risk re-silience and urban sustainability in Sub-Sahara Africa: The case of Accra, Ghana
Gosaye Degu Belay	Ethiopia	Ethiopian	Disaster & Emergency Health	ESTIMATING THE HOUSEHOLD RESILIENCE FOR DROUGHT DRIVEN FOOD INSECURITY USING SYSTEM DYNAMICS MODEL: THE CASE OF AFAR NATIONAL REGIONAL STATE OF ETHIOPIA
Hastoro Dwinantoaji	Japan	Indonesian	Disaster Nursing	Effectiveness of Snakes and Ladders Game on Flood Disaster Risk Education and Health Education on Basic First Aid Man-agement for Children in Indonesia
Hendy Irawan	Indonesia	Indonesian	Electrical Engineering and Informatics	Data Fusion for Detection and Parameteri-zation of Earthquake Sources
Hugues Yénoukoumè HANGNON	Belgium	Beninese	Environment Sciences	The future of Ouagadougou by 2030 against the risk of flooding
Ifedotun Victor Aina		Nigerian	Agricultural Economics	ANALYSIS OF CLIMATE CHANGE RESILIEN-CY THROUGH INDEX INSURANCE AMONG SMALLHODLER FARMERS IN SOUTHERN GUINEA SAVANNAH OF NIGERIAN

Name	Country	Nationality	Field of study	RP Topic
Irfan Ahmad Rana	Pakistan	Pakistani	Regional and Rural Development Planning	Community Resilience and Multi-Hazard Risks in Urban Areas of Pakistan
Jahir Anicama Diaz	Peru	Peru	Geography	The impact of hydro meteorological infor-mation systems in agriculture sector in Peru and Chile against to floods and droughts
Jaime Angelo Victor	Philippines	Filipino	Geotechnical Engineering	DEVELOPMENT OF A RAPID ASSESSMENT METHOD FOR SHALLOW LANDSLIDE SUS-CEPTIBILITY, HAZARD AND RISK – CALI-BRATED FOR LOCALIZED APPLICATION
Johnrev Guilaran	New Zea-land	Filipino	Psychology	Work and Interpersonal Relationships among Emergency First
Kamran Azam	Pakistan	Pakistani	Management	Mainstreaming the Coping Capacities for Risk Reduction and Resilience through Community Centered Trans-Durand Diplo-macy: A Case of Kabul River Basin
Kripa Shrestha	Nepal	Nepali	Enviornmental Science	LANDSLIDE RISK ASSESSMENT OF CHEPE RIVER CORRIDOR, WEST NEPAL
Kristoffer Berse	Philippines	Filipino	Urban Engineering	SCIENCE ADVICE FOR DISASTER RISK RE-DUCTION: A SCOPING STUDY ON THE POLICY-SCIENCE INTERFACE OF DISASTER GOVERNANCE IN THE PHILIPPINES
Kumbirai Ivyne Mateva	Malaysia	Zimbabwean	Biological sciences	What functional strategies drive drought survival and recovery in bambara ground-nut (Vigna subterranea (L.) Verdc.)?
Ma. Brida Lea D. Diola	Philippines	Filipino	Enviornmental Risk and Assessment	Disaster Waste Management in The Philip-pines: Assessment and Recommendations
Marina Drazba	New Zea-land	USA	Civil and Environmental Engineering	Managing the risk, not the disaster. Build-ing community resilience in the face of Landslide Risk. Case Studies: Mexico; Fiji; Bangladesh
Mayeda Rashid	Australia	Bangladeshi	Disaster Risk Reduction	TEACHER-DELIVERED, CHILD PARTICIPA-TORY DISASTER RESILIENCE EDUCATION PROGRAM FOR CHILDREN
Michael Boyland	Thailand	UK	Disasters, Adaptation and Development	Transforming Development and Disaster Risk in the Mekong Region: An Integrated and Trans-disciplinary Research Plan to the IRDR Young Scientists Programme
Monica Cardarilli	Italy	Italian	Environmental and Safety Engineering, Natural Hazards and Disaster Risk Reduction	SPATIO-TEMPORAL VARIABILITY ANALYSIS OF TERRITORIAL RESISTANCE AND RESILI-ENCE TO RISK ASSESSMENT
Mouloud Hamidatou	Algeria	Algerian	Seismic engineering of soils and structures	Capturing the uncertainty of seismic activi-ty rates in probabilistic seismic hazard as-sessments

Name	Country	Nationality	Field of study	RP Topic
Mujiburrahman	Australia	Indonesian	Humanitarian, Emergency and Disaster Management	GOVERNANCE AND DECENTRALIZATION OF MULTI HAZARD EARLY WARNING SYS-TEM IN INDONESIA
Ngwa Kester Azibo	Cameroon	Cameroonian	Rural Development and Administration	A gender analyses of the determinants for the adoption of disaster management mechanisms in Sub-Saharan Africa: A Mul-tiple Case Study Analyses
Paul Andrés Muñoz Pauta	Belgium	Ecuadorian	Water Resources Engineering	Flash flood forecasting in a mountain catchment based on the Random Forest algorithm: An strategy for disaster reduc-tion in mountain areas
Raju Chauhan	Nepal	Nepali	Environmental Science (Climate Change and Disaster Risk Management)	Reliability and Effectiveness of Flood Early Warning System in Nepal
Rita Thakuri	Nepal	Nepali	Crisis Management	Empowerment of Women Mason in Gorkha Earthquake Reconstruction: Facts and Challenges
Robert Šakić Trogrlić	UK	Croatian	DRR	THE ROLE OF LOCAL KNOWLEDGE IN COMMUNITY-BASED FLOOD RISK MANAGEMENT IN MALAWI
Rodrigo Rudge Ramos Ribeiro	Portugal	Brazilian	Geosciences, Environment and Spatial Planning	Climate risks in rural areas and adaptation processes: a national vision of Portugal
Sandeeka Mannakkara	New Zealand	New Zealand	Civil and Environmental Engineering specialising in Disaster Management	Development of the “Build Back Better Tool” to Implement Sendai Framework Priority 4
Shabir Ahmad Kabirzad	Afganistan	Afghan	Environmental and Urban Planning	Assessing Sendai Framework Execution in Afghanistan Context
Shakeel Ahmed Khan	Pakistan	Pakistani	Disaster Management	Assessing Geohazard Mitigation and Linking Disaster Risk Perception to Preparedness for Resilient Communities: A case study of Attabad landslide dam.
Sharad Wagle	Thailand	Nepali	Structural Engineering	2015 Gorkha Earthquak reconstruction initiative in rural area of Nepal and its challenges
Simon Wagner	Germany	German	Geography of Enviornmental Risks and human security	Assessing institutional capacities of municipal urban planning departments to integrate future-oriented vulnerability information in the context of rapid urbanization into public infrastructure planning by city size
Somana Riaz	Pakistan	Pakistani	Disaster Management	Sustainable Socio-Economic Aspects of CPEC
Supriya Krishnan	India	Indian	Social Sciences	The Future Ground Urban planning under long-term climate uncertainty

Name	Country	Nationality	Field of study	RP Topic
Suresh Chaudhary	China	Nepali	Physical Geography	Continuity and Transformation of Community Resilience against earthquake in Nepalese cities
Sushila Khatri	Nepal	Nepali	Environmental Science	INCREMENT OF SOIL COHESION BY THYSANOLAENA MAXIMA TO MITIGATE SHALLOW LANDSLIDE IN SIMBARI WATERSHED, SINDHULI
Syed Zulfiqar Ali Shah	Germany	Pakistani	Land-use conflicts	Diverting Disasters: A Multi-Method Analysis of Flood Management and its Conflict Implications in Pakistan

List of 4th Batch

Name	Country	Nationality	Field of study	RP Topic
Md. Abul Kalam Azad	Canada	Bangladeshi	Natural Resources Management	Role of Disaster Governance in Health Risk Management during Humanitarian Crisis: A Case Study on Coastal Communities of Bangladesh
Siswani Sari	Germany	Indonesian	Geography	The Roles of Aceh Government to Sustain Disaster Risk Reduction in Aceh Province, Indonesia
Charlotte Kendra de Zuñiga GOTANGCO	Philippines	Filipino	Earth and Atmospheric Science	A SYSTEMS APPROACH to URBAN RESILIENCE
Khamarrul Azahari Razak	Malaysia	Malaysian	Landslides, multihazard risk, remote sensing, GIS	Disaster Risk Repository and Mainstreaming DRR into Development Planning: A transdisciplinary approach
Mira Khadka	Nepal	Nepalese	Glaciology	Projection of Future Flood Scenarios Integrating Glacio-hydrological and Hydraulic Modelling in Koshi River Basin, Nepal
Qurban Rahim	Pakistan	Pakistani	Engineering	Avalanche and Debris Flow Mitigations
Shruthi Dakey	India	Indian	Disaster Risk Reduction and Socio-Ecological Systems	Applying Socio-Ecological Systems perspective for gaining resilience in coastal rural communities of India
Tesfahun Kasie	Ethiopia	Ethiopian	International Cooperation for Local Development	Modeling Drought Extreme Events – Testing Resilience Properties of Food Emergency Response Systems in Africa.
Farman Ullah	Thailand	Pakistani	Disaster Preparedness, Mitigation and Management	Assessing Flood Risk in Rural Areas of Khyber Pakhtunkhwa, Pakistan
Ghani Rahman	Pakistan	Pakistani	Climate Change/ Geography	Analysis of Climatic Variability and Its Impact on Drought Reoccurrences, Intensity and Trend Prediction Using Multi-Indices in Khyber Pakhtunkhwa, Pakistan
Godfrey Chiabuotu Onuwa	Nigeria	Nigeria	Agricultural economics	CLIMATE CHANGE PERCEPTIONS AND ADAPTATION PRACTICES AMONG FOOD CROP FARMERS IN NORTH CENTRAL NIGERIA
Kaushal Raj Gnyawali	China	Nepalese	Geotechnical Engineering	Application of free and open-source software in detection, initiation and runout dynamics of large landslides in China and Nepal
Sangeeta Prajapati	India	Indian	Disaster Mitigation and Management	Earthquake Induced Landslide Assessment focusing on Hazard and Risk Perception in the Chamoli District Uttarakhand, India

Name	Country	Nationality	Field of study	RP Topic
Suman Chapagain	Nepal	Nepalese	Disaster Risk Management	THE STUDY OF TRENDS OF HAZARDS AND PEOPLE'S PERCEPTION TOWARDS RISK DUE TO URBANIZATION: A COMPARATIVE STUDY OF KATHMANDU METROPOLITAN CITY AND BIRATNAGAR METROPOLITAN CITY OF NEPAL
Chioma Nwakanma	Nigeria	Nigeria	Animal and Environmental Biology	Assessment of Ecosystem Diversity, Economic and Health Implications of Climate Variability on Rural Dwellers in the Riverrine Areas of Abia State
Jeevan Madapala	India	Indian	Disaster Mitigation and Management	Urban Flood Resilience: A Case Study of Gurugram
Kanchan Kumar	India	Indian	DROUGHT, FINANCIAL INSTITUTIONS AND AGRARIAN CRISIS	Drought and Farm Loans: A study of Financial Institution's Compensatory Government Expenditure
Mbiafeu Nfonbeu Marlene Francine	Cameroon	Cameroonian	Environmental Ecnomics	Climate Change and Food Security in Cameroon: A comparative Economic Analysis of Resilience and Adaptation in Different Agro-ecologies
Muhammad Yaseen	Pakistan	Pakistani	Geology	Valuation of the Landslides along the Dargai–Malakand Road, Khyber Pakhtunkhwa part of CPEC Pakistan: Implication from geological aspect of slope failure and mitigation approach for future disaster risk reduction
Nargis Shabnam	India	Indian	Remote Sensing and GIS Applications	Estimating Future Changes in Landslide Risk for Himalayan Terrain
Reza Bakhshoode	Iran	Iran	Environmental Engineering	Nature-based solutions for urban blue and grey water under changing climate
Samuel Weniga Anuga	Ghana	Ghana	Environmental Science	Climate change and mental health risks of smallholder farmers in Northern Ghana
Sasmita Poudel Adhikari	China	Nepalese	Public Health	A study on nutritional status of children under five years of age in earthquake affected areas of Nepal
Sheeba Farooq	Pakistan	Pakistani	Development Policy	BUILDING COMMUNITIE'S RESILIENCE TO MANAGE NATURAL DISASTERS
Sitotaw Haile Erena	Ethiopia	Ethiopian	Environmental Planning	Understanding the type, nature, causes, frequency and driving forces of flooding in Dire Dawa city, Ethiopia
Su Li	China	Chinese	Applied Economics	Does Resilience Policies in Post-Disaster Period Worsen Air Quality of the Disaster Affected Areas and Their Neighboring Areas? A Research on the 2008 Wenchuan Earthquake
Tantely Sarah Randriamparany	Madagascar	MALAGASY	Economy, Resource Natural Policy	GENDER AND RESILIENCE TO DISASTER RISKS IN THE URBAN ENVIRONMENT : ANTANANARIVO

Name	Country	Nationality	Field of study	RP Topic
Ivan Taslim	Indonesia	Indonesian	Engineering of Geology	Manufacture of Conblock Materials by Utilizing Clay Sediments for Flood Risk Reduction in Coastal Lake Limboto
Sabrina Zaman	Bangladesh	Bangladeshi	Disaster Management	Gendered Culture and Water Security: an exploratory study in coastal region of Bangladesh
Shengnan Wu	China	Chinese	Mountain Hazards	Study on the Risk Communication in the Emergency Response from the Perspective of Discourse Analysis
Sushila Paudel	Japan	Nepalese	Disaster Nursing	Participatory Action Research in Community-Based Health Education Program for Disaster Preparedness
Typson Dahan	Togo	Togolese	Biology Vegetable	FIRES, VEGETABLE DYNAMICS AND CLIMATE CHANGE IN CONTACT AREA FOREST-SAVANNA: CASE OF THE DEPARTMENT OF TOUMODI IN IVORY COAST CENTER
Adnan Arshad	China	Pakistani	Laboratory of Climate Change & Adaptation	Impact Assessment of Regional Climate Warming and Extreme Weather Events to Natural Resource Managment
Akinola Olalekan	Nigeria	Nigeria	Biogeography	RISK ASSESSMENTS SURVEY OF URBAN TREES IN THE NIGERIAN SELECTED CITIES (PORT HARCOURT AND IBADAN)
Ali Said	Tanzania	Tanzanian	Climate Change and Sustainable Development	THE ROLE OF MANGROVE FORESTS IN REDUCING THE IMPACTS OF CLIMATE CHANGE-RELATED DISASTERS IN WEST B DISTRICT, ZANZIBAR
Nformi Tarshi Lesly	Cameroon	Cameroonian	ENVIRONMENTAL DYNAMICS AND RISK	Investigating the impact of climate on crops production
Nirdesh Nepal	China	Nepalese	Geotechnical Engineering	Landslide risk management along highways connecting China and Nepal
Rina Suryani Oktari	Indonesia	Indonesian	Disaster Management	SECI-based Knowledge Creation in Enhancing Community Resilience towards Disaster Risk and Climate Change
Shakeel Mahmood	Pakistan	Pakistani	Geography	Flood Risk Modelling and Management in Panjkora Basin, Eastern Hindu Kush, Pakistan
Subeg M Bijukchhen	Nepal	Nepalese	Strong-motion seismology	Use of ambient seismic noise to estimate velocity structure of Bhaktapur, Nepal
Yifei Cui	China	Chinese	Geotechnical Engineering	Investigation of Internal Erosion of Wide Grading Loose Soil

Name	Country	Nationality	Field of study	RP Topic
Isaac A. OYEKOLA	Nigeria	Nigeria	Sociology and Anthropology	Social Health Insurance and Attainment of Sustainable Health Financing among Older
Olufemi Adetunji	Australia	Nigeria	Architecture	Social Participation Framework for Climate Change Adaptation in Public Built Heritage in Nigeria
Oluwafemi A. Sarumi	Nigeria	Nigeria	Computer Science	DEVELOPMENT OF A PREDICTIVE MODEL TO MITIGATE THE EFFECTS OF FLOOD OCCURENCES IN SUB-SAHARAN AFRICA
Repaul Kanji	India	Indian	Building disaster resilience through corporate social responsibility	Development of an easy-to-use tool to empower residents to assess their vulnerabilities to disaster risk: Building a comprehensive methodology in the Indian context
Sebleweng Ayichew Megerrssa	Ethiopia	Ethiopian	Public Health	RISK ASSESSMENT OF EMERGING ARBOVIRUSES OF PUBLIC HEALTH SIGNIFICANCE FOR REDUCING RISK OF DISASTERS WITH INTEGRATED INTERDISCIPLINARY APPROACH IN ETHIOPIA
Zaw Ko Latt	Myanmar	Myanmar	Biotechnology	Restoration of Soil Fertility in Cyclone Nargis Affected Areas in Myanmar
Zerihun Yohannes	Ethiopia	Ethiopian	Environmental Management	MYTHS AND REALITIES OF GENDER AND CLIMATE SHOCK VULNERABILITY

Annex 12 List of IRDR Publication

2020

- IRDR Working Paper Series – Volume 2

  Sustainable Infrastructure Development, Risk Perception and Vulnerability Assessment in Indian Himalayan Region

  The Biosafety-Biosecurity Culture Interface in Life Sciences Research

  Understanding the Geological Environmental Risks of Permafrost Degradation -Environmental and engineering geology in permafrost area in Northeast China

  Mapping Disaster Risk Reduction Institutions Using Web-based Accessible Information

- Hazard Definition & Classification Review: Technical Review

2019

- Next Generation Disaster Data Infrastructure
- Disaster Loss Data in Monitoring the Implementation of the Sendai Framework
- Achieving Risk Reduction Across Sendai, Paris And the SDGs
- IRDR output of Huangshan Dialogue
- IRDR Working Paper Series – Volume 1

  A Framework for Transforming the Relationship Between Development and Disaster Risk

  Emergency and Disaster Management Programs in disaster prone, resource deficit context

  Making Cities Disaster Resilient in a Changing Climate

  Socio-ecological Resilience as a Sustainable Development Strategy for Remote Rural Settlements in Difference Geo-climatic Zones of India

  Silk Road Disaster Risk Reduction

  - Extraction and Analysis of Earthquake Events Information based on Web Text
  - Disaster Metadata Management System Based on pycsw and Its Application
- IRDR Contributed to the GAR2019
- July 2019 Edition of the DRR & Open Data Newsletter

2018

- Science & technology into action: Disaster risk reduction perspectives from Asia
- Transforming Development and Disaster Risk
- IRDR FORIN Report (Chinese version)
- IRDR Young Scientists Publication: Socio-Ecological Resilience as a Sustainable Development Strategy for Remote Rural Settlements in India-Integrating Community Perspective
- IRDR New Poster and leaflets
- IRDR Statement to 2018 Asian Ministerial Conference on Disaster Risk Reduction
- IRDR ICoE REaL released Summary of Annual Report
- IRDR DATA newsletter: Disaster Risk Reduction and Open Data (2018 August)
- September Edition of DRR and Open DATA newsletter
- Total Warning System for Tropical Cyclone
- Disaster risk Reduction & Open Data Newsletter (Nov 2018)

2017

- A New Publication focused on DBAR DRR–Strengthening Science Capacities for

Sustainable Development and Disaster Risk Reduction: Regional Research Strategy

- ICSU ROAP and IRDR published Science Technology Plan for Disaster Risk Reduction: Asian and Pacific Perspectives
- Co-designing Disaster Risk Reduction Solutions: Towards participatory action and communication in science, technology and academia
- IRDR Policy Briefs for 2017 Global Platform for DRR

Coherence between the Sendai Framework, the SDGs, the Climate Agreement, New Urban Agenda and World Humanitarian Summit, and the role of science in their implementation

Assessing country-level science and technology capacities for implementing the Sendai Framework

Disaster loss data in monitoring the implementation of the Sendai Framework

Forensic Investigations of Disaster (FORIN): towards the understanding of root causes of disasters

Cities and Disaster Risk Reduction

- Gap Analysis on Open Data Interconnectivity for Disaster Risk Research
- IRDR ICoE-REaL delivered quarterly report and indicated the consortium's reach and influence from 'local to global'
- Disaster Loss Data: Raising the standard
- ICoE-REaL release new brochure
- A Global Outlook on Disaster Science

2016

- IRDR new Brochure
- The FORIN Project: A conceptual framework and guide to research
- IRDR Annual Report 2015
- ASIA Science Technology Status for Disaster Risk Reduction White Paper
- Conference outcome: 1st Asian Science and Technology Conference on DRR held on 23-24 August 2016 in Bangkok
- IRDR publishes The FORIN Project: A conceptual framework and guide to research 2016 (Spanish version)
- IRDR new Brochure
- IRDR new network map

2015

- Positioning resilience for 2015: the role of resistance, incremental adjustment and transformation in disaster risk management policy
- IRDR Annual Report 2014
- AIRDR publishes Guide to Assessing IRDR
- IRDR: Is it really integrated?
- AIRDR: Incentives for Disaster Risk Management
- AIRDR: Governance in Disaster Risk Management
- The forensic investigation of root causes and the post-2015 framework for disaster risk reduction
- AIRDR: Transformative Development and Disaster Risk Management
- IRDR Newsletter Vol. 6 No. 1
- Disaster Risk: A Future Agenda for Integrative Science
- Who needs loss data? Background Paper prepared for the 2015 Global Assessment

Report on Disaster Risk Reduction

- Pathways for Transformation: Disaster risk management to enhance development goals
- Strategic mobilization of higher education institutions in disaster risk reduction capacity-building: Experience of Periperi U
- Research Forum 2014: proceedings of the Research Forum at the Bushfire and Natural Hazards CRC & AFAC conference
- The FORIN Project: Understanding the Causes of Disasters
- Guidelines on Measuring Losses from Disasters: Human and Economic Impact Indicators
- New Periperi U Booklet
- New paper on disaster risk research and assessment
- AIRDR Reports
- IRDR Conference Special Issue on Australasian Journal of Disaster and Trauma Studies
- The importance of theory, analysis and practice to integrated disaster research: Introduction to the IRDR Conference Special Issue
- Community-led disaster risk management: A Māori response to Ōtautahi (Christchurch) earthquakes
- Defining disaster: The need for harmonisation of terminology
- A needs-based approach for exploring vulnerability and response to disaster risk in rural communities in low income countries
- Emergency preparedness and perceptions of vulnerability among disabled people following the Christchurch earthquakes: Applying lessons learnt to the HFA
- Environment as trickster: Epistemology and materiality in disaster mitigation
- IRDR Newsletter Vol. 6 No. 2 (February-April 2015)

2014

- IRDR Newsletter Vol. 5 No. 1
- IRDR Peril Classification and Hazard Glossary
- IRDR Newsletter Vol. 5 No. 2
- IRDR Newsletter Vol. 5 No. 3
- 2nd IRDR Conference – Integrated Disaster Risk Science: A tool for sustainability. In: Planet@Risk, 2(5), Special Issue for the Post-2015 Framework for DRR: p. 332-336, Global Risk Forum GRF Davos, Davos
- Uncertainty and decision making:Volcanic crisis scenarios
- Annual Report 2013
- WSS Fellows on RIA* (2014) Reporting on the Seminar – Risk Interpretation and Action (RIA): Decision Making Under Conditions of Uncertainty. Australasian Journal of Disaster and Trauma Studies. 18 (1), pp. 27-37
- IRDR Newsletter Vol. 5 No. 4
- Forensic Investigation of Typhoon Morakot Disaster: Nansalu and Daniao Village Case Study
- Regional Disaster Risk and Vulnerability Reduction Capacity Development (Periperi U Annual Report Oct 2013-Sept 2014)

2013

- Forensic Investigations of Disasters (FORIN) Report No. 1
- Risk Interpretation and Action (RIA) Report No. 1
- Annual Report 2011
- RIA Review Article in the International Journal of Disaster Risk Reduction
- IRDR Strategic Plan 2013-2017
- Annual Report 2012
- JRC Scientific and Policy Report: Recording Disaster Losses

- Issue Brief: Disaster Risk Reduction and Sustainable Development

2012

- ICSU (2008) A Science Plan for IRDR
- Annual Report 2010

2011

- The 2011 Beijing Declaration on IRDR

mobilizing science for disaster risk reduction and development safety

IRDR

Compilation: A ten-year science quest for disaster risk reduction

2010-2020

Executive Summary

IRDR
Integrated Research on Disaster Risk

Executive Summary

About the IRDR Compilation 2010-2020

The idea of having one single publication that features all significant achievements, the remaining gaps and the lessons learnt by the IRDR community during this ten-year cooperation first came out of discussions at the 21st IRDR Scientific Committee (IRDR SC) meeting in May 2019 in Geneva. In October 2019, at its 22nd meeting in Xiamen, IRDR SC officially decided to go forward with this proposal and set up an editing group. At the same meeting, the publication of IRDR Compilation was set as one of three priority tasks of IRDR in 2020 together with the preparation of new Global Disaster Risk Reduction (DRR) research agenda and the IRDR Conference 2020. In February 2020, at the request of IRDR IPO for support, Aerospace Information Research Institute (AIR), which hosts IRDR's International Program Office (IRDR IPO), provided three young scientists to IRDR IPO to assist with the collection of information from the members of IRDR community and to support the initial compilation and editing. In June 2020, at the 23rd IRDR SC online meeting, in the interest of wider distribution, it was further decided to make the Executive Summary of the IRDR Compilation more content substantive. The possibility of providing the Compilation in multiple languages versions was also discussed.

The IRDR Compilation is intended to be a comprehensive and sound record of IRDR and its work over the past 10 years. Further, to ensure transparency and accountability to IRDR sponsors, donors and members of the IRDR community and their partners, the IRDR Compilation provides a complete set of annexes for reference. In a broader sense, the Compilation also aims to help those who are keen to learn and further explore the international scientific cooperation in the fields of disaster risk research, to understand how an international scientific plan has been put in practice and played a catalytic role in mobilizing scientific forces for knowledge actions, and how to move further with the experience accumulated and lessons learnt.

All information and materials included in the IRDR Compilation come from the contributions of the IRDR community, both institutions and individual researchers, including IRDR SC and IRDR IPO, IRDR Working Groups (WGs), IRDR National Committees (NCs), IRDR International Centres of Excellence (ICoEs), Flagship Projects, IRDR Young Scientists Programme, and main partners of IRDR. The IRDR Compilation also use materials extracted from the records of IRDR related meetings, reports and publications. A comprehensive list of references is provided. The structures and narratives of the Compilation, including the uses of the contribution materials are of the collective work of the editing team.

2 The original mission of IRDR and its evolution

2.1 Understanding risk by integrated research[61]

The ICSU Priority Area Assessment on Environment and its Relation to Sustainable Development (2003) and the ICSU Foresight Analysis (2004) both proposed 'Natural and human-induced hazards' as an important emerging issue. In its assessment, the ICSU Planning Group emphasized that, despite all the

61 This session is mainly summarized from *ICSU (2008) A Science Plan for Integrated Research on Disaster Risk* http://www.irdrinternational.org/2012/12/29/irdr-science-plan/

existing or already planned activities on natural hazards, an integrated research programme on disaster risk reduction, that is sustained for a decade or more and integrated across the hazards, disciplines and geographical regions, would be imperative. The value-added nature of such a programme would rest with the close coupling of the natural, socio-economic, health and engineering sciences. The Planning Group recommended that the Research Programme be named IRDR – addressing the challenge of natural and human-induced environmental hazards (acronym: IRDR).

The rationale of proposing IRDR included the following aspects: 1) Natural disasters are a global issue, and can result in great loss of human lives, livelihoods and economic assets in both developed and developing countries. 2) Human interventions in the environment can also increase the numbers and types of hazards and vulnerability to natural hazards. 3) Climate Changes in global context will continue to alter the risk associated with natural hazards. 4) The international context and the HFA indicated that research to identify and analyse successful risk reduction programmes is very important. For the field of disaster risk reduction, there is neither an established and ongoing scientific assessment process, like the IPCC, nor an internationally planned and coordinated scientific research programme. IRDR would fill that latter gap.

The central mission of IRDR is to develop trans-disciplinary, multi-sectorial alliances for: in-depth, practical disaster risk reduction research studies, and the implementation of effective evidence-based disaster risk policies and practices. The research objectives of IRDR are three-fold: 1) understanding of hazards, vulnerability and risk and enhanced capacity to model and project risk into the future; 2) understanding of the decision-making choices that lead to risk and how they may be influenced; and 3) how this knowledge can better lead to disaster risk reduction. The overall global benefits of the IRDR Programme would be dependent on global capacity building and recognition of the value of risk reduction activities, which are likely to come through successful case studies and demonstration projects (Table 1).

Table 1. IRDR missions

Research Objectives	Cross-cutting themes
Characterisation of hazard, vulnerability and risk	Capacity building
Effective decision-making in complex and changing risk context	Case studies and demonstration projects
Reducing risk and curbing losses through knowledge-based actions	Assessment, data management and moni-toring

2.2 From Hyogo to Sendai: IRDR contribution

The Hyogo Framework for Action 2005-2015 (HFA): Building the Resilience of Nations and Communities to Disasters provided critical guidance in efforts to reduce disaster risk and has contributed to the progress towards the achievement of the Millennium Development Goals. However, the implementation of HFA highlighted a number of gaps in addressing the underlying disaster risk factors, in the formulation of goals and priorities for action, in the need to foster disaster resilience at all levels, and in ensuring adequate means of implementation. Ten years after the adoption of the HFA, disasters continue to undermine efforts to achieve sustainable development. Against this background, and in order to reduce disaster risk, the Sendai Framework for Disaster Risk Reduction 2015–2030 was adopted at the 3rd United Nations WCDRR.

IRDR actively contributed to and was integrally involved in the efforts to develop the Sendai Framework. IRDR, in partnership with CAST hosted the 2nd IRDR Conference from 7 – 9 June 2014 in Beijing, China focusing on the theme "Integrated Disaster Risk Science: A Tool for Sustainability". The conference placed emphasis on the importance of science as a tool to address hazard risks, integration and partnership. A key cross-sessional discussion considered the influence of science in HFA and preparations for a new DRR framework which developed into the Sendai Framework. The outcomes of the Conference covered issues on DRR research, education, implementation and practice, and policy implementation for Sendai Framework[62].

IRDR and ICSU acted as the Organizing Partner for the Scientific and Technological Community Major Group (STMG) for the 3rd WCDRR, starting from the First Preparatory Committee Meeting (PrepCom1) in July 2014. IRDR provided an independent collective response to the pre-zero draft, which identified three specific needs, namely to: 1) Develop, on the basis of state-of-the-art prospective knowledge, a forward-looking agenda, notably in terms of linking disaster risk reduction science with the SDGs targets; 2) Emphasise the need for stronger support for science as the foundation for action-oriented cutting-edge knowledge, including necessary monitoring activities; 3) Emphasise the need to better connect national and local levels for the collection and analysis of the necessary vulnerability and loss data as prerequisite for both responsive and preventive planning and investment[63].

Meanwhile, IRDR proposed a '4+2' formula through the statement of STMG to support the implantation of Sendai Framework at the 3rd WCDRR[64]:

- Assessment. Provide analytical tools to advance a comprehensive knowledge of hazards, risks, and underlying risk drivers → regular, independent, policy-relevant international assessment of available science on DRR, resilience and transformations.
- Synthesis. Facilitate the uptake of scientific evidence in policy-making →synthesize relevant knowledge in a timely, accessible and policy-relevant manner.
- Scientific advice. Translate knowledge into solutions → provide advisory capabilities integrating all S&T fields in collaboration with practitioners and policy-makers.
- Monitoring and review. Support the development of science-based indicators, common methodologies and processes → harness / make use of data & information at different scales.
- Communication and engagement. Develop closer partnerships between policy, science and society as well as between researchers → improve the communication of scientific knowledge to facilitate evidence-based decision-making (all levels of government; across society).
- Capacity building. Promote risk literacy through curricular reform, professional training and life-long learning across all sectors of society.

Box 1 Priorities and Targets of Sendai Framework

Sendai Framework[65] proposed four priority areas for sectors to take actions:

62 More details on the outcomes of 2014 IRDR Conference: http://www.irdrinternational.org/2014/08/21/planetrisk-irdrconference2014/

63 The detailed contribution from IRDR towards the Sendai Framework could be referred to the IRDR Annual Report (2014): https://www.wcdrr.org/wcdrr-data/uploads/579/IRDR%20Annual%20Report%202014.pdf

64 The detailed contribution from IRDR to the 3rd WCDRR could be referred to the IRDR Newsletter Vol. 6: http://www.irdrinternational.org/wp-content/uploads/2015/05/IRDR-Newsletter_Vol6-No2-April-2015.pdf

Priority 1: Understanding disaster risk.

Priority 2: Strengthening disaster risk governance to manage disaster risk.

Priority 3: Investing in disaster risk reduction for resilience.

Priority 4: Enhancing disaster preparedness for effective response and to "Build Back Better" in recovery, rehabilitation and reconstruction.

Seven targets were agreed upon to be measured at the global level and will be complemented by work to develop appropriate indicators:

(a) Substantially reduce global disaster mortality by 2030, aiming to lower the average per 100,000 global mortality rate in the decade 2020-2030 compared to the period 2005-2015;

(b) Substantially reduce the number of people affected globally by 2030, aiming to lower the average global figure per 100,000 in the decade 2020- 2030 compared to the period 2005-2015;

(c) Reduce direct disaster economic loss in relation to global gross domestic product (GDP) by 2030;

(d) Substantially reduce disaster damage to critical infrastructure and disruption of basic services, among them health and educational facilities, including through developing their resilience by 2030;

(e) Substantially increase the number of countries with national and local disaster risk reduction strategies by 2020;

(f) Substantially enhance international cooperation to developing countries through adequate and sustainable support to complement their national actions for implementation of the present Framework by 2030;

(g) Substantially increase the availability of and access to multi-hazard early warning systems and disaster risk information and assessments to people by 2030.

2.3 Programme reposition and adjustment over time

The IRDR Science Plan originally published in 2008 was the fundamental document of the programme operations. After the establishment of IRDR programme, the strategic goals and activities to guide the operation of IRDR were further articulated through IRDR Strategic Plan 2013 – 2017[66]. The original three research objectives and three cross-cutting themes were framed into actions in six goals: Goal 1- Promoting integrated research, advocacy and awareness-raising. Goal 2- Characterizing hazards, vulnerability, and risk. Goal 3- Understanding decision-making in complex and changing risk contexts. Goal 4- Reducing risk and curbing losses through knowledge-based actions. Goal 5- Networking and network building. Goal 6- Research Support.

In early 2016, the three co-sponsors of IRDR commissioned an independent, forward-looking mid-term Review covering the first six years of the ten-year program period. The Review Report suggested "rethinking, reforming or reshaping IRDR's strategy" and "operating IRDR as an 'action network' towards collective impact". In response to these suggestions, the IRDR Scientific Committee presented a draft IRDR Strategic Plan of Action for 2017-2020 at the 16th IRDR Scientific Committee meeting. This was further shaped into the IRDR Action Plan 2018-2020[67], which was adopted in 18th IRDR Scientific Committee Meeting. The new Plan puts forth more forward-looking strategic actions employing evidence-based and science-

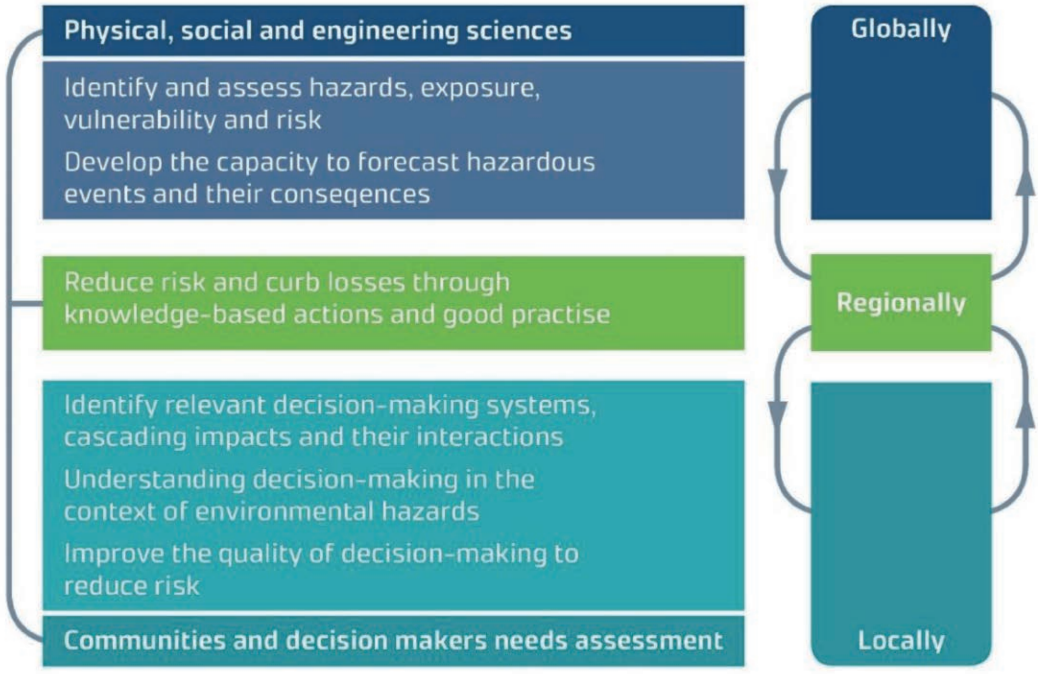
65 https://www.undrr.org/publication/sendai-framework-disaster-risk-reduction-2015-2030

66 http://www.irdrinternational.org/2013/04/15/irdr-strategic-plan-2013-2017/

67 http://www.irdrinternational.org/what-we-do/action-plan-2018-2020/

based decision-making at a crucial time for implementing the Sendai Framework. A total of 23 actions on activities and deliverables were proposed on areas including 1) Science Advocacy at global, regional and national scales; 2) Sendai Framework indicators and strengthening national reporting system; 3) Thematic contribution by Working Groups; 4) Facilitating Associated Projects; 5) Strategic partnership with International Centres of Excellence (ICoEs); 6) Science capacity development: Young Scientists Program; 7) Science outreach by communication strategy and products.

Figure 1: Science behind IRDR: the foundational multi-hazard framework of IRDR to understand and characterize risk, risk production processes and governance, and damage and losses (Fakhruddin & Bostrom, 2019)



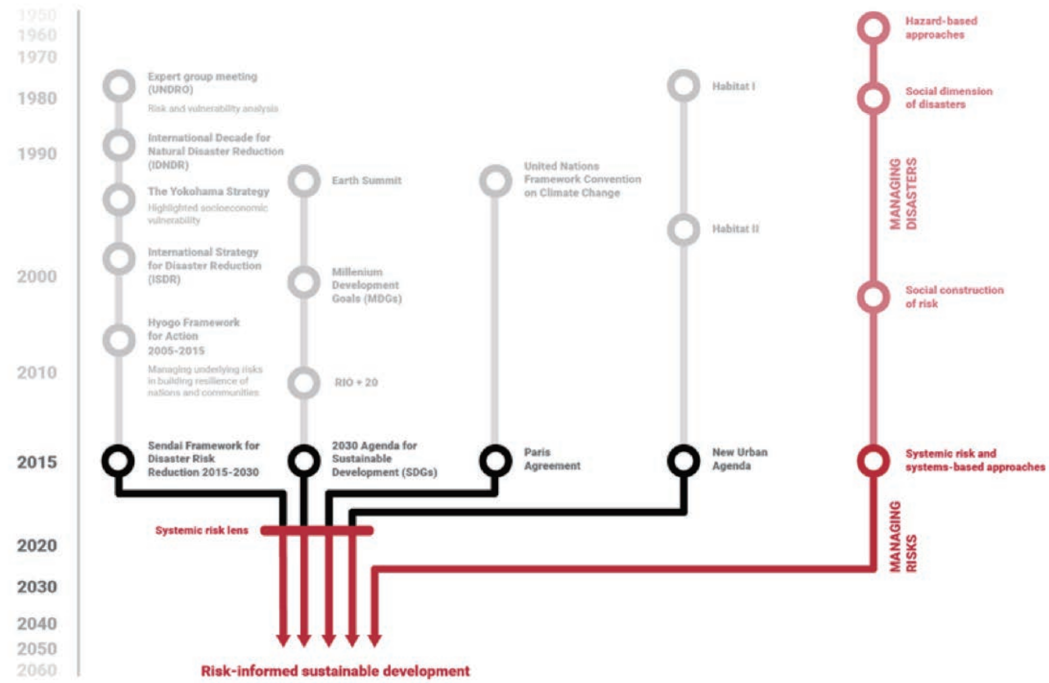
2.4 Further integration with UN 2030 agreements: coherence/ integration/ synergy

In 2015, a number of landmark international agreements were reached at the United Nations. Apart from the Sendai Framework, the world community agreed on Transforming our World: the 2030 Agenda for Sustainable Development (2030 Agenda), the Paris Agreement, the Addis Ababa Action Agenda (AAAA) and the NUA[68]. Each of these agreements has interconnections with the Sendai Framework. It is therefore natural that there have been calls for coherence and synergy to realize the goals and targets of the post-2015 agreements (Figure 2) and make major renovations to current approaches to risk assessment.

68The UN GAR: https://gar.undrr.org/

IRDR has started moving toward this direction. In 2018, IRDR established a new Working Group on DRR-CCA[69]-SDG under its Scientific Committee, to look into the Sendai Framework connections with the Paris Agreement and SDG 11 on cities and SDG 13 on climate change. IRDR also initiated its working paper series to further build the connections between the IRDR research objectives, Sendai Targets, Paris Agreement and SDGs. Increasing discussions and exchanges at IRDR related meetings are focusing on new risks of daunting multi-dimensional, systemic, cascading and transboundary risks and disasters, most recently and overwhelmingly demonstrated by the Covid-19 pandemic. It is clear that the inherent vulnerabilities of our environment and human societies will have to be addressed in transformative ways. In all of these IRDR will have roles to play and work to contribute.

Figure 2: Risk Reduction – a journey through time and space

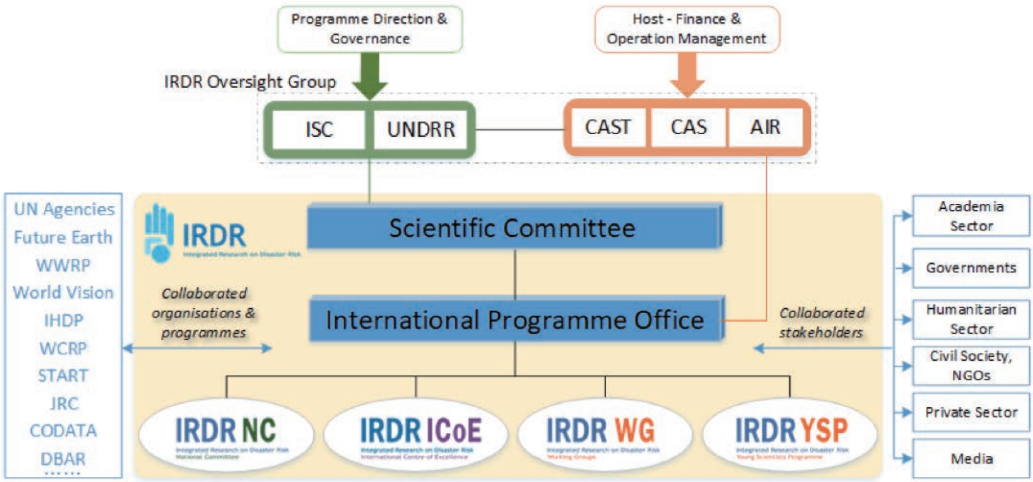


3 IRDR community in action

In line with the IRDR Scientific Plan and under the overall direction of Sendai Framework, IRDR actions are undertaken from its different programme platforms or delivery arms (Figure 3). These include IRDR's six Working Groups (WG) operating under the Scientific Committee, 13 National Committees (NC) and 1 Regional Committee (RC), 16 International Centres of Excellence (ICoE), partnerships with international programmes and organizations, a young scientist (YS) programme and a few cooperative projects. Actions taken by WG/NC/ICoE/YS are under the support of resources from their host institutions. Ownership of the deliverables are shared among host institutions and IRDR.

69 CCA: Climate Change Adaption

Figure 3: **IRDR network and community of practice**



3.1 Root causes of disasters from natural and social perspectives

There is a broad consensus among academics, managers and policy makers within the DRR community that there is insufficient understanding about the underlying or root causes of disasters, including their increased frequency and magnitude. The Forensic Investigations of Disasters (FORIN) Project was initiated by IRDR early in its project cycle as an international response (including both nongovernmental and intergovernmental organizations) to address this knowledge deficiency. The FORIN perspective formalizes the analytical space and agenda for root causality research, enabling a form of analysis that conceptualizes disasters as intrinsic to development and societal processes. Four research approaches are suggested by FORIN including retrospective longitudinal analysis (RLA), FORIN disaster scenario building (FDSB), comparative case analysis, and Meta-analysis(Oliver-Smith et al., 2016). The FORIN perspective and approach postulates that disasters are linked both by systemic causes and by their widespread and expanding consequences, and can be seen as an epidemiological approach to disaster study. IRDR has worked to increase and strengthen the knowledge that underlies evidence-based policy making for disaster risk management at all levels of governance and geographical scales.

3.2 IRDR Peril Classification and Hazard Glossary

In 2014, the IRDR Disaster Loss Data (DATA) WG produced a Peril Classification and Hazard Glossary. This glossary provides guidelines on event classification and a unified terminology for operating loss databases only(IRDR, 2014). Though not intended as a comprehensive list of perils or as a conclusive definitional standard of hazards, this technical paper details the classification scheme and hazard definitions used in loss database, and provides information that has been implemented over time by global databases such UN DesInventar, EM-DAT, NatCatService, and Sigma as well as in national databases such as SHELDUS (US).

Figure 4: Peril classification at the Family and Main Events levels

3.3 IRDR contribution to Sendai Hazard Definition and Classification Review

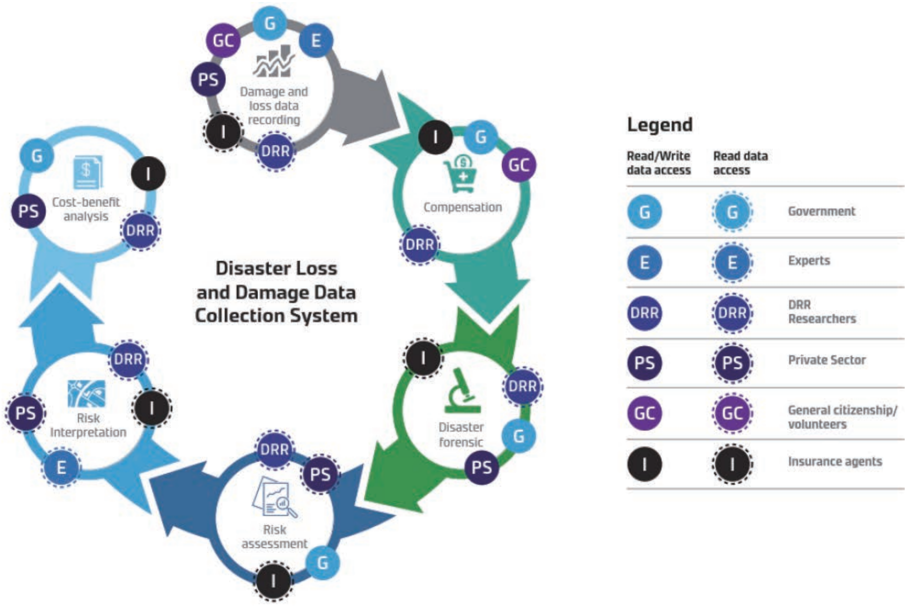
During the *International Conference on Integrated Science & Technology Contributions for Informed National Policy-Making and Action for the Implementation of the Sendai Framework,* a key component of the 20th IRDR SC meeting in 2018, IRDR and UNDRR STAG discussed on the category of Sendai New Hazards, in particular regarding Na-Tech. At the Science and Policy Forum at the 2019 Global Platform for Disaster Risk Reduction (2019GP), UNDRR and ISC announced a Joint Technical Working Group to identify the full scope of hazards relevant to the Sendai Framework and the scientific definitions of these hazards. IRDR actively participated in this working group. Within this context, the current iteration of the hazards list was reviewed during the 22nd IRDR SC meeting, and key themes were identified using a stakeholder survey. Approximately 20 DRR experts participated in this workshop. Five key points, including purpose of the hazards list, clear inclusion criteria, systematic thinking, dissimilarities across nations, and review of the template, were identified during this meeting. The Sendai Hazard Definition and Classification Review Technical Report was then issued on 29 July 2020.

3.4 Standardizing Disaster Loss Data

Disaster reconnaissance and loss data collection are fundamental for a comprehensive assessment of socially, temporal and spatially disaggregated loss data. Standardized loss data is quite useful for risk interpretation during loss forecasting and historical loss modelling, which in turn provide valuable opportunities to acquire better information about the economic, ecological and social costs of disasters. The **IRDR Disaster Loss Data (DATA) WG** is an initiative contributing to the solution of standardising disaster loss data. This project brings together stakeholders from across disciplines and sectors to study issues related to the collection, storage and dissemination of disaster loss data. The aim of this project is to establish an overall framework and protocols for disaster loss data and the collecting of such (Figure 5) for all providers, to establish nodes and networks for databases, and to conduct sensitivity testing among databases to ensure some level of comparability. This project proposed a standard data collection system, which has been adopted by many countries. The project has also led to the production of unified standards on disaster loss assessment and an integrated methodology for disaster loss assessment.

Two successful examples of IRDR's implementation of disaster loss databases include the New Zealand National Loss Database and the Pacific Damage and Loss (PDaLo) Information System. Additional countries that have implemented disaster loss databases include: Cambodia, Nepal, Iran, Timor-Leste, Vietnam, Myanmar, Philippines and Pakistan. The outcomes of this WG has been regularly published in the DRR and Open Data Newsletters

Figure 5: The Disaster Loss and Damage Data Collection System



released monthly by IRDR, CODATA, Public Health England and Tonkin+Taylor.

3.5 Science and technology roadmap to support the Sendai Framework

The science and technology community, as well as other stakeholders, came together at the UN Office for Disaster Risk Reduction (UNISDR) Science and Technology Conference held from 27- 29 January 2016 in Geneva. The outcome of the conference was a 'Science and Technology Roadmap to Support the Implementation of the Sendai Framework for Disaster Risk Reduction 2015-2030' and accompanying partnerships. At the 20th IRDR Scientific Committee meeting 2018, a discussion was organized to review and contextualize the Roadmap with four key questions on 1) implementation of the roadmap, 2) monitoring mechanism, 3) link to national platforms, 4) advocacy messages. The discussion reviewed the original roadmap, developed an outcome matrix, synthesized and organized roadmap actions, integrated 2017 Tokyo Statement recommendations, integrated additional action points based on gap analysis, and restructured S&T roadmap actions and implementation strategies.

During the 2019 Global Platform for Disaster Risk Reduction, IRDR, together with UNDRR and ISC, organized a pre-conference "Science and Policy Forum for the Implementation of Sendai Framework for Disaster Risk Reduction". In this Forum, the contextualized Global Science and Technology Roadmap was launched as a living document to be implemented by the S&T community with a strong partnership with other stakeholders. The core purposes for future development of the roadmap include: 1) Evidence-based policy and decision making; 2) Consolidation of science effort for collective impact; 3) Interlinkages and interconnection among stakeholders, including S&T community. Progress was suggested to be tracked and monitored via the Sendai Framework's Voluntary Commitments online platform.

3.6 Policy recommendations for regional and national levels

IRDR is keen to enhance the role of science in policy development. To this end, IRDR has provided science-based evidence and advice to decision makers and policy makers. After Sendai 2015, IRDR has published policy briefs on critical issues relating to the implementation and monitoring of the Sendai Framework. At the 2017GP, IRDR published five policy briefs and added another two during the 2019GP (Figure 6). During the same year, IRDR launched the IRDR Working Paper Series[70] that called for authors to clearly indicate the contribution to targets of the Sendai Framework and SDGs and provide detailed recommendations to DRR policy (Figure 7).

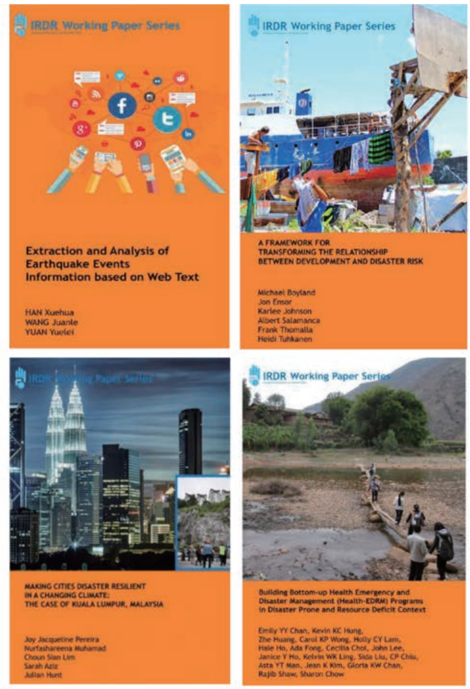
Box 2 IRDR Policy Briefs for Global Platform on Disaster Risk Reduction[71]

2017

- Coherence between the Sendai Framework, the SDGs, the Climate Agreement, New Urban Agenda and World Humanitarian Summit, and the role of science in their implementation (by Virginia Murray, Rishma Maini, Lorcan Clarke, Nuha Eltinay)
- Assessing country-level science and technology capacities for implementing the Sendai Framework (by Rajib Shaw)
- Disaster loss data in monitoring the implementation of the Sendai Framework (by Bapon Fakhruddin, Virginia Murray, and Rishma Maini)

Figure 6: **ISC-IRDR joint policy brief**

Figure 7: **IRDR Working Paper Series**



70 http://www.irdrinternational.org/2019/05/11/irdr-working-paper-series-volumn-1/

71 http://www.irdrinternational.org/2017/05/12/irdr-published-5-policy-briefs-for-2017-global-platform-for-drr/
https://council.science/current/news/isc-launches-policy-briefs-ahead-of-the-un-global-platform-on-disaster-risk-reduction/

- Forensic Investigations of Disaster (FORIN): towards the understanding of root causes of disasters (by Anthony Oliver-Smith, Irasema Alcántara-Ayala, Ian Burton and Allan Lavell)
- Cities and Disaster Risk Reduction (by Mark Pelling, Donald Brown and Fang Chen)

2019

- Disaster Loss Data In Monitoring The Implementation Of The Sendai Framework (by Bapon Fakhruddin, Virginia Murray and Fernando Gouvea-Reis)
- Achieving Risk Reduction Across Sendai, Paris And the SDGs (by John Handmer; Anne-Sophie Stevance, Lauren Rickards, and Johanna Nalau)

IRDR has also collaborated with UN APSTAG to examine the science and technology development status for DRR and recommended 14 priority actions for improvement (*Asia Science Technology Status for Disaster Risk Reduction* and *Science & technology into action: Disaster risk reduction perspectives from Asia*) in 2016 and 2018; and ISC ROAP and other sectors to illustrate the science and technology plan for DRR (*Science Technology Plan for Disaster Risk Reduction: Asian and Pacific Perspectives*) in 2017; Digital Belt and Road (DBAR) DRR Working Group on *Strengthening Science Capacities for Sustainable Development and Disaster Risk Reduction: Regional Research Strategy* in 2017.

In addition, **IRDR NC-Colombia** published a series of risk management guides for both public and decision-makers. The development of the Policy Guidelines for public, private and community sectors in disaster risk management guides the instruments for the actors involved in risk management, at all territorial levels and areas of action. Besides, a series of publications[72;73;74] that guide decision-making for the operation of the National Disaster Risk Management System at the territorial level, and used to achieve the public policy for disaster risk management in the nation. Among them, a short guide entitled "What You Should Know About Forest Fires[75]" aimed to inform, increase awareness and promote community participation on risk management of forest fires.

3.7 Characterization of hazards, vulnerability and risk in countries and regions

IRDR has also actively worked to identify and assess risks from natural hazards at global, regional and local scales, and develop capability to forecast hazardous events and their consequences. For example, **IRDR ICoE for Disaster Resilient Homes, Buildings and Public Infrastructure (IRDR ICoE DRHBPI, Canada)** has expertise in hazard mapping and risk mapping. It has worked on flood mapping and corresponding science-based report for public use, providing information on what flood maps are and their importance; how to address inundation and other hazards and risks and raise community awareness; and the availability of such maps in Canada (The Institute for Catastrophic Loss Reduction, 2019).

Another achievement is the development of the Social Vulnerability Index (SoVI®) and the Baseline Resilience Indicators for Communities (BRIC) due to the efforts of IRDR **ICoE Vulnerability and Resilience Metrics (IRDR ICoE-VaRM, USA)** in cooperation with the Hazards & Vulnerability

72 https://repositorio.gestiondelriesgo.gov.co/handle/20.500.11762/20604
73 https://repositorio.gestiondelriesgo.gov.co/handle/20.500.11762/27251
74 https://repositorio.gestiondelriesgo.gov.co/handle/20.500.11762/27698
75 https://repositorio.gestiondelriesgo.gov.co/handle/20.500.11762/28309

Research Institute (HRVI). Both indices provide empirically-based measurements for comparing the differential impact of disasters, as well as differences in the abilities of communities and the individuals who reside there to adequately prepare for, respond to, recovery from, and enhance resilience to present and future disaster risks[76;77].

Similarly, **IRDR Center of Excellence in Understanding Risk & Safety (IRDR ICoE UR&S, Colombia)** was involved in the development of the Global Risk Model for Global Assessment Report on Disaster Risk Reduction 2013 (GAR2013)[78]. The Centre further developed Brief Risk Profiles for over 200 countries and economies based on the update of the Global Multi-hazard Risk Assessment for the UNISDR GAR15[79], developed a Global Drought Probabilistic Hazard and Risk Model within the framework of the Comprehensive Approach to Probabilistic Risk Assessment (CAPRA)[80], and contributed to the improvement and integration of the UNISDR Risk Knowledge Section to the New Generation CAPRA Robot platform. Besides, the Risk Atlas of Colombia[81] has been prepared by the National Unit for Disaster Risk Management, which is the host of **IRDR NC-Colombia**, and by INGENIAR Risk Intelligence, a leading company in the country in risk management. This product arises given the need to advance in the knowledge of risk at the national and regional level, taking into account that the entity's mission is to improve people's quality of life and contribute to sustainable development. The Atlas provides a better understanding of disaster risk in its dimensions of hazard, vulnerability, degree of exposure, and characteristics of the environment in the country.

IRDR NC-China conducted a continuous tracking study on geological disasters in earthquake areas for more than ten years. Collaborated with the Cardiff University (UK) research team, NC-China studied the dynamic response of slope surface to mega earthquakes, the gestation and formation mechanism of large landslides, and the temporal and spatial evolution law of geological disasters after earthquakes and their long-term effects. It is the first time to combine geological disaster research with sociological research to deeply analyse the impact of geological disasters on the social, economic, and post-disaster resilience of people in the disaster-stricken area in emergency response, post-disaster reconstruction, and recovery stages (Fan et al., 2019).

76 http://www.sovius.org

77 http://artsandsciences.sc.edu/geog/hvri/bric

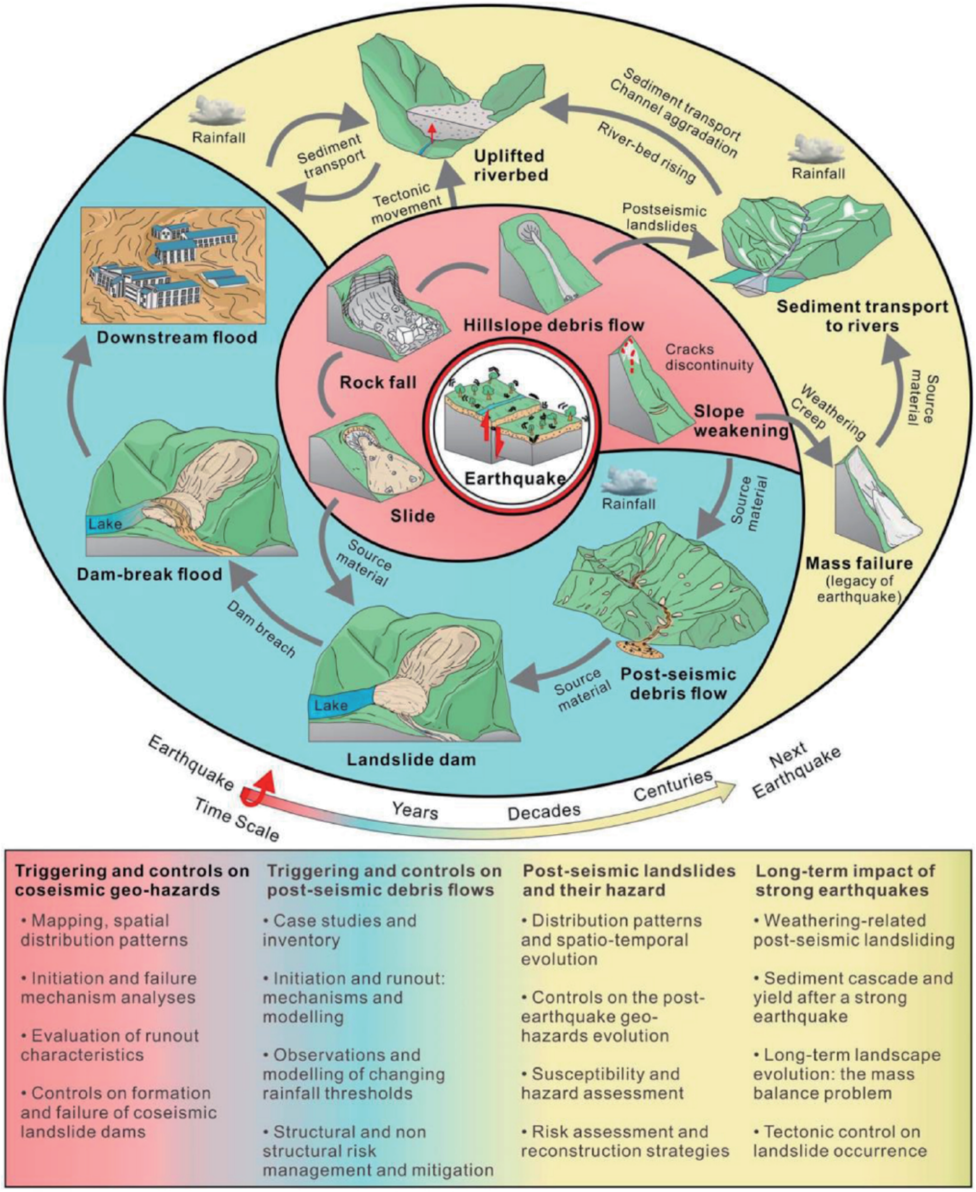
78 https://www.preventionweb.net/english/hyogo/gar/2013/en/home/download.html

79 https://www.preventionweb.net/english/hyogo/gar/2015/en/home/

80 https://ecapra.org/

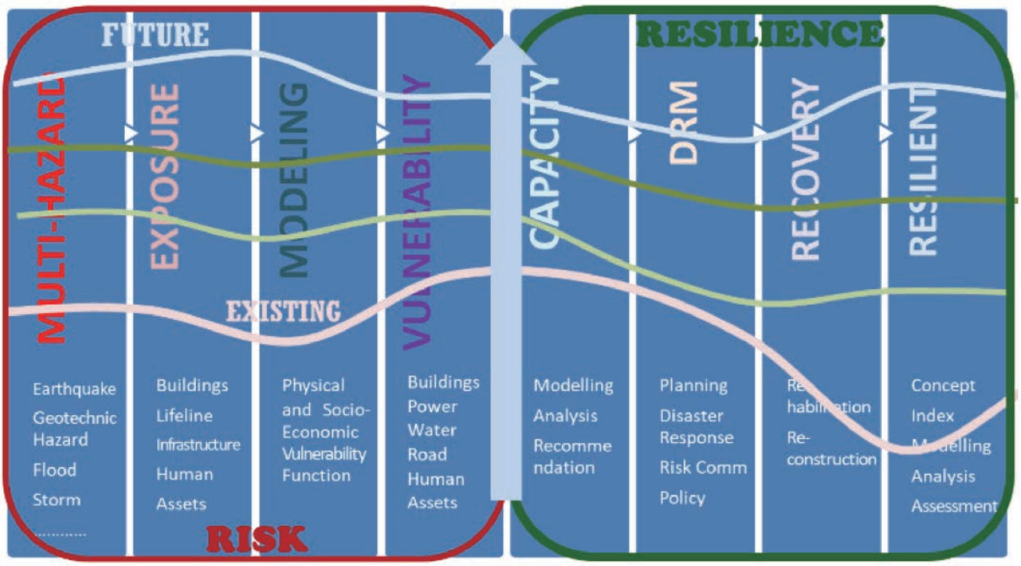
81 https://repositorio.gestiondelriesgo.gov.co/handle/20.500.11762/27179

Figure 8: **Chains of geologic hazards triggered by a strong continental earthquake and reviewed in this work. Causal relations between hazards are indicated. Red background shows different types of coseismic landslides; blue background indicates the post-seismic cascade of hazards in days to years later; and yellow background represents the long-term impact of an earthquake, years to decades later, and perhaps longer.**



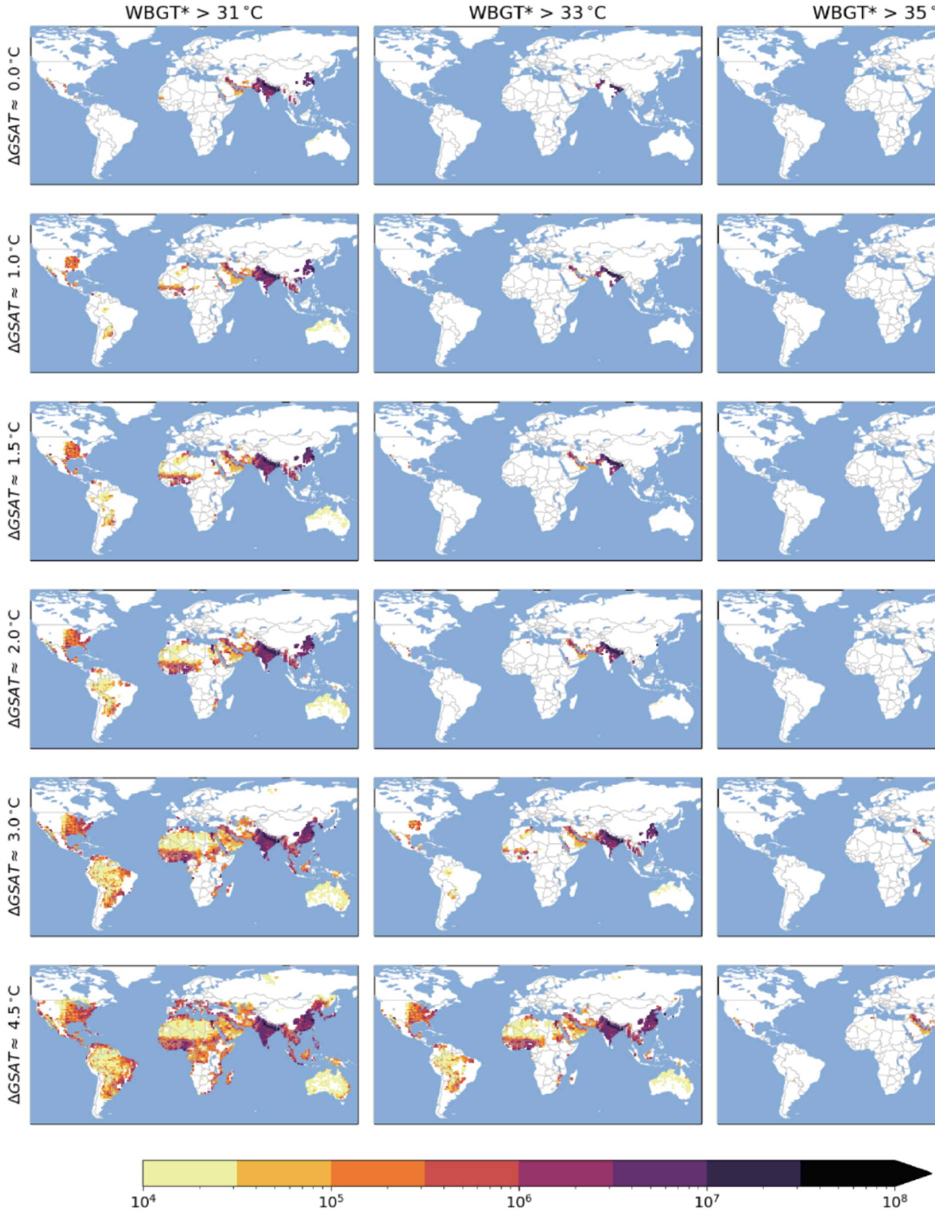
Currently an integrated and comprehensive Natural Hazards Risk and Resilience Model (Figure 9) for Iran is under development by **IRDR NC- Iran** targeting the quantification of actual risk (physical, social and economic loss); as well as definition of the acceptable level of risk and the target resilience with the emphasis on the main urban settlements (Atrachali et al., 2019).

Figure 9: Integrated and comprehensive Hazard, Vulnerability, Risk and Resilience Model



IRDR ICoE on Risk Interconnectivity and Governance on Weather/Climate Extremes Impact and Public Health (ICoE-RIG-WECEIPHE, China) developed a statistical model based on quantile regression approach to capture the joint distribution of temperature and humidity (Yuan et al., 2020). They found that the intensity of heat stress in a day at a given maximum daily temperature will increase in a warming climate due to the increase of humidity. Li et al. (2020) evaluated future changes in daily compound heat-humidity extremes as a function of increasing global-mean surface air temperature (GSAT). The historical ~1 ℃ of GSAT increase above preindustrial levels has already increased the population annually exposed to at least one day with WBGT exceeding 33 ℃ (the reference safety value for humans at rest per the ISO-7243 standard) from 97 million to 275 million. Maintaining the current population distribution, this exposure is projected to increase to 508 million with 1.5 ℃ of warming, 789 million with 2.0 ℃ of warming, and 1.22 billion with 3.0 ℃ of warming (similar to late-century warming projected based on current mitigation policies).

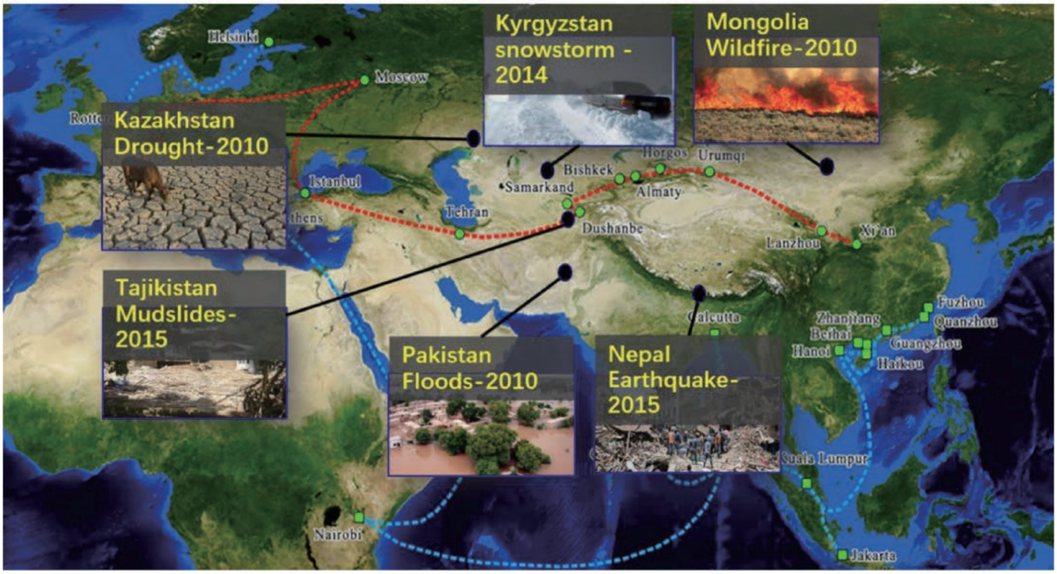
Figure 10: Maps of population affected by at least 1 day per decade of WBGT*max greater than 31°C (left column), 33°C (middle), and 35°C (right). Colours represent population in each nominal 1 degree grid cell. WBGT* statistics is based on output from 40-member CESM-LE RCP8.5 simulations (Li et al., 2020)



3.8 DRR data production and sharing

In order to be able to determine the consequences of environmental hazards and disasters in terms of their impacts and effects, **IRDR NC-China**, taking advantage of a wide variety of earth observation datasets including meteorological satellites (FY series), resource satellites (CBERS series, ZY series), ocean satellites (HY series), environment and disaster reduction satellites (HJ series), and high-resolution satellites (GF series),conducted collaborative researches to develop effective methods, models, and technologies for quick response to disasters. For example, NC-China analysed the systemic risks of various disasters in the completion of new type of urbanization processes, and recommended countermeasures and suggestions. The report was included in the UN Global Assessment Report on Disaster Risk Reduction 2019 (Chen et al., 2019). Besides, NC-China also carried out systemic spatial monitoring to characterize environmental effects of disasters on multi-regional and diversified geomorphology units in the Belt and Road region, and developed key regional disaster products for the areas where disaster statistics data were lacking or in low accuracy, benefiting from the CAS Big Earth Data Science Engineering Program (CASEarth)[82].

Figure 11: **Disaster risk in "One Belt One Road"**



3.9 Multi-scale disaster risk assessment

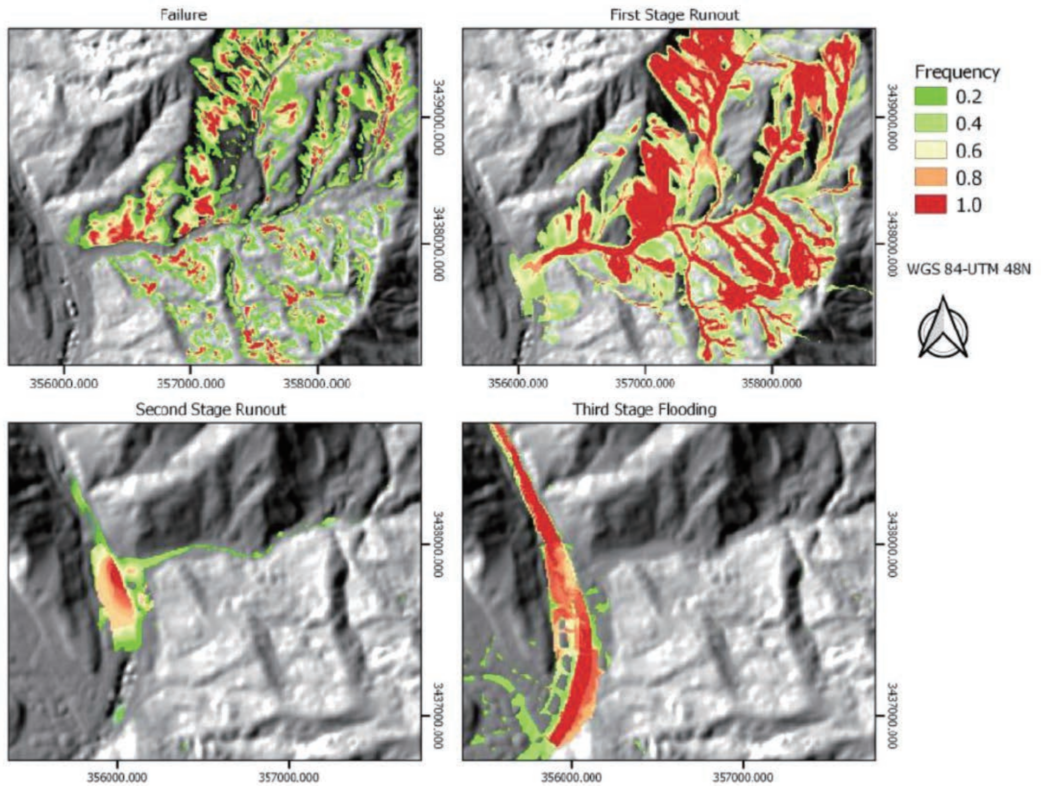
In line with the Sendai Framework and the 2030 Agenda, the Silk Road Disaster Risk Reduction (SiDRR) international research program was launched in 2016 (Lei et al., 2018) with the task of enhancing global actions towards the green and resilient Silk Road by joining forces with over 20 research institutes and scientists globally. As a Flagship Project of IRDR, the SiDRR aims to provide scientific suggestions and support for decision-makers in countries along the Silk Road

82 http://belt.china.org.cn/index.htm

to minimize disaster losses in their respective economic development. The program mainly assessed five types of hazards and corresponding risks including mass movements, floods, droughts, earthquakes, and ocean hazards at global, regional, local and infrastructure-oriented scales. The research results of SiDRR have been consolidated in the “Atlas of Silk Road Disaster Risk” and “Glance at the Silk Road Disaster Risk”. These two publications provide important references to understand disasters and disaster risk from a multi-stakeholder perspective and aid stakeholders in scientific decision-making in line with the Sendai Framework and SDGs.

A single extreme weather event such as a tropical cyclone or monsoon can compound hazard effects, domino effects of hazard chains. Very often when we look at these situations, we use models for each hazard separately but this is not what stakeholders experience. Hence, **IRDR ICoE in Spatial Decision Support for Integrated Disaster Risk Reduction (IRDR ICoE-SDS IDRR)** is developing a multi-hazard model that can simulate a number of these processes simultaneously, whereby the landscape can change during the event. This model (**openLISEM**, https://blog.utwente.nl/lisem/) is free and opensource and is constantly under development as new areas are simulated (Van Den Bout et al., 2020). Such a model is hard to calibrate but at the time it gives a more realistic perspective on impact of hazard processes.

Figure 12: Example of domino effects simulated with openLISEM in Hongchun (China): First stage are slope failures, developing into debris flows (2nd stage) developing into a debris flow dam in the river (3rd stage) and causing a flash flood (4th stage) (Van Den Bout et al., 2020).



IRDR ICoE on Critical Infrastructures and Strategic Planning (IRDR ICoE-CI&SP, Germany) aims at exploring the resilience of Critical Infrastructures from various perspectives in order to provide a comprehensive platform for this evermore-important topic and to substantially advance the depths and breadths of the currently narrow approaches. In this regard, the analysis of the resilience of Critical Infrastructures, such as energy, water, transport, health services, will not primarily focus on technical details of the respective systems, but rather on cross-cutting and interdisciplinary challenges that are, for example, linked to the identification of interdependencies and cascading risks between Critical Infrastructures or to the shifting governance implications, including new organizational requirements and behavioural adaptations.

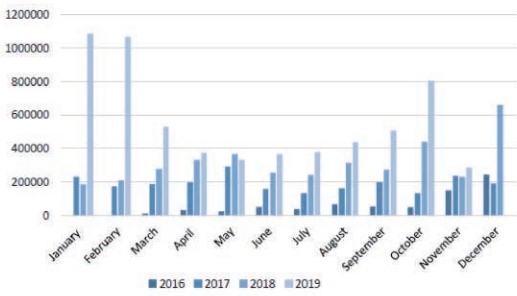
3.10 Knowledge exchange and service

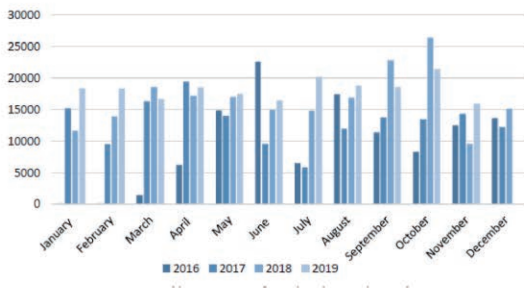
To facilitate knowledge consilience on disaster and environmental risk reduction and to improve disaster resilience ability, an indispensable element of sustainable development, it is important to ensure that all stakeholders involved in disaster risk reduction have access to each other's contributions in various forms. **IRDR NC-Japan** provided such a platform, which is idea-specific in concept and designed to establish a national synthesis reporting system for disaster risk reduction. An internet-based system for collecting, analysing, publishing, re-analysing, critiquing, and reusing data and information for improving disaster resilience, it is a tool to promote "consilience" of knowledge and practice. This concept was first discussed at the Tokyo Resilience Forum 2017, where dozens of experts expressed their opinions and suggestions, acknowledged on the need for this periodic synthesis reports system (Hayashi et al., 2018).

Another important achievement is developing education materials to improve disaster knowledge and guide public response to disasters. For this purpose, the National Disaster Management Research Institute (NDMI) of Republic of Korea (the host of **IRDR NC-Republic of Korea**) developed DRR related education videos guiding public response to accidents from flood damages, a constant risk to human lives in the region during the summer season. In 2016 they also inaugurated a Web-GIS based data sharing tool 'Typhoon Disaster Information System (TCDIS)' to provide a comprehensive and integrated disaster information system. The system not only helps improve understandings of typhoons as natural phenomena and their impacts on the natural and social environment, but further strengthens international cooperation and information sharing of disaster management[83].

Similarly, **IRDR ICoE for Risk Education and Learning (IRDR ICoE-REaL)**, affiliated with the Partners Enhancing Resilience for People

Figure 13: Left: Monthly searches performed on the ORC during Phase IV, Right: Monthly PDF view performed on the ORC during Phase IV.





83 www.tcdis.org

Exposed to Risks (PERIPERI U), launched the Online Resource Centre, a digital database of disaster risk literature, articles, reports and other documentation. The primary goal of this initiative was to offer a platform to students across the partnership to access to disaster-risk related documents and to assist them with their learning and research. With increasing needs for systematic data management, the secretariat recruited a dedicated 'data capturer' in June 2017. This appointment strengthened maintenance support for the Online Research Centre (ORC)[84], as well as increased its capacity to upload and categorize electronic copies of reports, articles and documents onto the site. Since the launch of the ORC in early 2016, over 12.9 million searches have been conducted with over 660 000 PDF viewed (Francioli et al., 2020).

The Centre for Integrated Research on Risk and Resilience (CIRRR), which hosts **IRDR ICoE in Risk Interpretation and Action (IRDR ICoE-RIA, UK)**, brings together researchers from across disciplines in order to explore risk and resilience as ways of understanding and responding to social, ecological and political crises today. ICoE-RIA conducted a series of projects which were funded or partly funded by the Department for International Development (DFID) of UK. For example, the programme Urban ARK, led by King's College London with Professor Mark Pelling as Principal Investigator[85], focused in depth studies on a number of cities in Africa – each presenting different development and hazard contexts: Ibadan (Nigeria), Karonga (Malawi), Nairobi and Mombasa (Kenya), Niamey (Niger), Dakar (Senegal) and Freetown (Sierra Leone). The work highlights urbanisation processes that generate human vulnerability and exposure to a whole spectrum of hazards. Another DFID-funded programme, the Building Resilience and Adaptation to Climate Extremes and Disasters (BRACED), helped people to become more resilient to climate extremes in South and Southeast Asia and in the African Sahel and its neighbouring countries[86]. To improve the integration of disaster risk reduction and climate adaptation methods into development approaches, BRACED seeks to influence policies and practices at the local, national and international levels.

3.11 Connecting science, practice with decision-making

It is important to provide decision-makers with the evidence, information and tools to make the necessary critical decisions. For example, for several years now, **IRDR NC-France** has been implementing territorial management approaches based on risk approaches. These approaches are often "hazard-centered", i.e. depending on the threat of the phenomena (e.g. earthquake, flood, ground movement, explosion, etc.), analysis of the territorial locations exposed to such hazards are characterized and vulnerabilities identified. These approaches strongly rely on the information from specialized hazard maps and prevention maps that are drawn up. In addition, hazards-forecasting approaches, decision-making systems, vulnerability assessments and capacity building have also been further developed and/or established. Others such as **IRDR NC-USA** have undertaken several research initiatives to understand decision-making and disaster management. One example of such is the publication of a report identifying stakeholder values in the context of Hurricane Michael using semi-structured interviews to understand what public and private stakeholders valued during different phases of the hurricane (Zhang, Pathak, & Ganapati, 2019). **IRDR ICoE for Collaborating Centre for Oxford University and CUHK (IRDR ICoE-CCOUC)** published a scientific report in partnership with IRDR and Asia Science Technology and Academia Advisory Group of the

84 http://lib.riskreductionafrica.org/

85 https://www.ucl.ac.uk/bartlett/development/research-projects/2020/nov/urban-africa-risk-knowledge-urban-ark

86 http://www.braced.org/

United Nations Office for Disaster Risk Reduction (UNDRR ASTAAG) titled"Co-designing Disaster Risk Reduction Solutions"in May 2017 which served as one of the core scientific evidence report in health and disaster for policy and decision making at the 2017 UNDRR Fifth Global Platform for Disaster Risk Reduction in Mexico.

Scientific networks are also critical in communicating and sharing important information with different stakeholders. **IRDR ICoE-Taipei** aims to build such networks that integrate scientific knowledge, policies, and practices, and seeks to connect young and senior scholars, decision-makers, and stakeholders. Towards this goal, the ICoE-Taipei, focusing on the "Communication and engagement"and"Capacity building"components of the"4 +2 formula" developed by IRDR and delivered through the STMG Statement (refer to Section 1.2), extended these two formulae into concrete tasks. These tasks include building the capacity for countries in the Asia-Pacific region, facilitating collaborative research, and establishing an effective open platform to connect scientists, engineers, government officers, practitioners, and stakeholders to roadmap Sendai Framework priorities (Table 2).

Planning for the future is also critically important for decision makers and to facilitate disaster preparedness. **IRDR NC-Australia** held an extensive discussion on the best knowledge to deal with the extreme hazards in the future that are of a nature and scale beyond our current experience during the June 2019 12th Australasian Natural Hazards Management Conference and worked through a strategic view on the current availability of such knowledge. A summary of the discussions during the conference extends the collective strategic view for scientific

Table 2. 2011-2019 IRDR ICoE-Taipei Activity Roadmap for the Implementation of SFDRR[87]

SFDRR / IRDR ICoE-Taipei	Priority 1: Understanding disaster risk	Priority 2: Strengthening disaster risk governance to manage disaster risk	Priority 3: Investing in DRR for resilience	Priority 4: Enhancing disaster preparedness for effective response and to "Build Back Better" in recovery, rehabilitation and reconstruction
Capacity Building	• TW-NDRMA 2016 • AI-SOCD 2017 • AI-LRR&TS 2018 • TC-EHRA 2018 • AI-Hi-ASAP 2019 • AI-Hi-ASAP 2020	• TW-SAMD 2015	• TW-MFSWRST 2016	• AI-DATA 2012 • AI-FORIN 2012 • AI-DRRLM 2015 • AI-KBA 2017 • AI-SOCD heat 2018 • TC-EEW 2019 • TC-LIHM 2019 • AI-ACV 2019
Collaborative Research	• Seed Grant: AI-LRR&TS • Seed Grant: TC-EHRA • Seed Grant: AI-SOCD 2017 • Seed Grant: AI-Hi-ASAP 2019	• Seed Grant: AI-Hi-ASAP 2020		• Seed Grant: AI-DRRLM • Seed Grant: AI-SOCD heat • Seed Grant: AI-KBA 2017 • Flagship Project
Networking	• Young Scientists Conference • Workshop on Exposure Assessment	• PARR Fellowship • Workshop to Strengthen Scientific Advisory Capacities • Relevant Meetings	• CAR II 2011 • Flagship Project • Relevant Meetings • PIAD	• WSS-ISSC Seminar • PIAD • Relevant Meetings
Others	• Visiting Scholar	• SAB meeting • Visiting Scholar	• WSS-ISSC Seminar	• Report: FORIN case study • Article: Improved Evacuation Procedures • Article: Improved Evacuation Procedures

Note: AI-Advanced Institutes, TW-Training Workshops, TC-Training Courses

87 http://www.cfss.sinica.edu.tw/index.asp?url=102&cno=8

Figure 14: The DBKL officers are being trained to use the Kuala Lumpur Multi-hazard Platform as part of their routine operations.

research to improve decision-making to prepare for the future we are likely to encounter (Bates, 2020).

3.12 Risk assessment and planning in urban context

Urban areas are complex environments with interconnected services networks feeding economic growth but also facilitating stability and supporting large human settlements. With both high concentration of population and capital, planning for disasters in urban areas is more complicated and highly essential to ensure minimal mortality, economic losses and disruption of essential services. Kuala Lumpur Multi-hazard Platform, developed by **IRDR ICoE for Disaster Risk and Climate Extremes (IRDR ICoE-SEADPRI-UKM)**, which is now operational at the Emergency Response Department of Kuala Lumpur, Malaysia and provides forecasts of rainfall, temperature, wind, humidity, air quality levels at the street level, is a good example of disaster risk management, and a key product of the project titled "Disaster Resilient Cities - Forecasting Local Level Climate Extremes and Physical Hazards for Kuala Lumpur" (Pereira et al., 2019)(Figure 14). This open-access multi-hazard platform with crowd-sourcing capability will be a game changer in promoting transformative action to build community resilience as the climate changes (Pereira & Hunt, 2019). It is supposed to serve as an important legacy of the IRDR Program in the region.

Another important contribution is that of **IRDR NC-Germany** through the German Committee for Disaster Reduction (DKKV), which designed the Risk Assessment Model Simulation for Emergency Training Exercise (RAMSETE) "serious game" series. The exercises focus on the challenges highlighted by the Enhancing Synergies for disaster PRevention in the EurOpean Union (ESPREssO) project (Lauta et al., 2018). A series of RAMSETE have been published aiming to maximize the security and well-being of the population of a fictional country by integrating DRR and CCA policies, to manage a cross-border natural crisis, and to addresses three main challenges: 1) Find ways to make national and European approaches to DRR, CCA and resilience more coherent; 2) Improve risk management by bridging the gap between research and policy/law; 3) The management of cross-border crises is to be made more efficient.
In 1998, a mega-flood swept through China's major river basins, including the Yangtze, Songhua, Nen, Min, and Pearl Rivers, which caused 4150 deaths, and led to total economic losses of USD 70 billion (in 2015 USD). In 2016, the middle and lower reaches of the Yangtze River suffered the worst flooding since 1999, involving

5 provinces. China is expected to suffer two-thirds of the global direct production losses caused by floods, totalling USD389 billion during 2016-2035 (Willner et al., 2018). In order to curbing losses from floods, **IRDR NC-China** put forward to pay high attentions to post-disaster reconstruction and actively advance the comprehensive water governance mode of human-water harmony; take the approach of systematic governance for middle and small rivers and change ‘passive governance’ to ‘positive governance’; strengthen the basic research (Cheng et al., 2018). Novel flood adaptation policies are required to address the (uncertain) future challenges. Such policies should be based on a well-established and up-to-date risk assessment, which accounts for future changes in climate and socioeconomic conditions (Du et al., 2019).

3.13 “Build back better”: learning from catastrophes and disasters

The Christchurch earthquake in February 2011 was a turning point for both researchers and policy makers. **IRDR NC-New Zealand**, the global leader in the development of post-disaster recovery indicators, published a Canterbury Wellbeing Index and Survey and contributed to international recovery knowledge(Morgan et al., 2015). The Canterbury earthquakes also highlighted the pivotal role provided by Iwi and Māori stakeholders in recovery efforts (Kenney & Phibbs, 2015). A research program examining the impacts of liquefaction, soil profiles and triggering factors was initiated. Researchers have updated the Detailed Seismic Assessment Guidelines for building materials, and developed Guidelines for Earthquake Geotechnical Engineering Practice in New Zealand. The lessons from Christchurch were put to good use following the 2016 Kaikoura Earthquake[88].

Figure 15: **Left: Dislodged boulders near the RSA clubrooms following the Feb 2011 Christchurch earthquake. Photo: Margaret Low, GNS Science; Right: Rockfall following the Christchurch earthquake. Photo: GNS Science.**

88 https://www.naturalhazards.org.nz

After Nepal was stricken by a magnitude 7.8 earthquake on 25 April 2015, the National Reconstruction Authority (NRA) of Nepal (the host of **IRDR NC-Nepal**) envisioned the "establishment of well-planned, resilient settlements and a prosperous society". The NRA has been leading and coordinating multi-hazard resilient reconstruction, retrofitting and restoration of damaged infrastructures and houses, as per the Sendai Framework that recognizes the post-disaster reconstruction as an opportunity to build back better. It is identifying appropriate sites to resettle displaced communities, building resilient communities and developing opportunities for economic growth[89]. In addition, **IRDR ICoE for National Society for Earthquake Technology- Nepal (IRDR ICoE-NSET)** developed a "Shake Table Demonstration and Landslide Demonstrator" (Figure 16). This is an awareness tool used for demonstrating and convincing people on the effectiveness of earthquake- and landslide-resistant construction practices. Following the principle of "Seeing is Believing", NSET successfully organized more than 100 demonstrations in more than 10 Asian countries including in Japan during the UN World Conference on DRR in 2015[90].

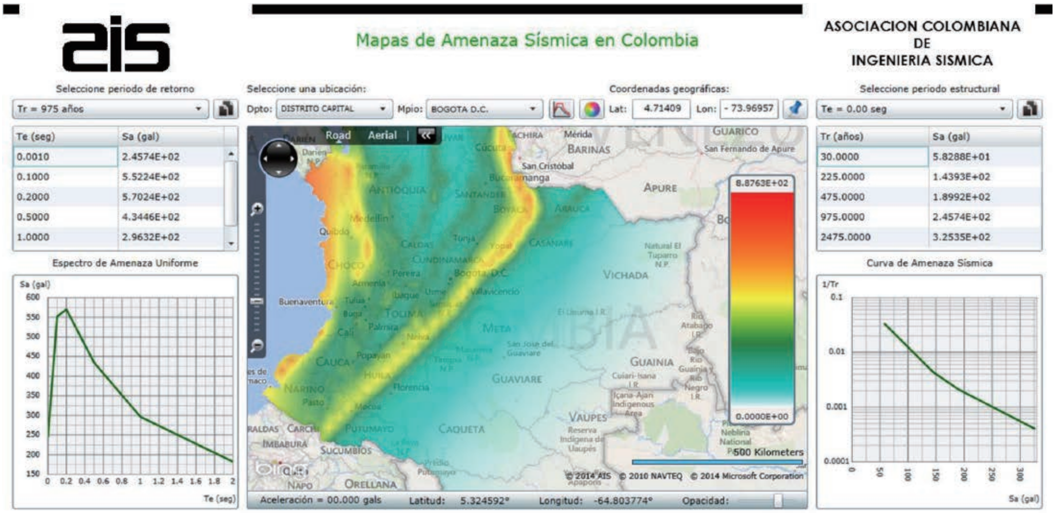
Concerning the general seismic hazard study, **IRDR NC-Colombia** describes a new methodology used to estimate different expected seismic intensities for designing and constructing earthquake-resistant buildings in Colombian territory. The Committee in Colombia (named as AIS-300) has evaluated the seismic hazard at the national level using updated information in

Figure 16: Shake-table demonstration set up of NSET (Source: NSET, Safer Society Report 2018)

89 http://202.45.147.136/np/resources/details/AbZnecDkSg-o91EuriI2HENgq_XAvy_ZYCvQiuiKEao

90 https://www.nset.org.np/nset2012/images/publicationfile/Safer_Society_2018.pdf

Figure 17: **AIS platform to obtain the parameters of the country's seismic threat**



the framework of the update of the Colombian Seismic Design Code of Bridges. In terms of the catalog used, five more years of information and strong motion attenuation ratios calibrated from local records. This update evaluated the seismic hazard with a probabilistic and spectral approach to establish the values of the seismic design coefficients associated, with a probability of exceedance of 7% in 75 years, which is roughly equivalent to an average recurrence period of 975 years[91].

The Indonesian Institute of Sciences (Lembaga Ilmu Pengetahuan Indonesia; LIPI; the host of **IRDR NC-Indonesia**) took part in the Community Preparedness (COMPRESS) Program in 2006-2012. The Indonesian Tsunami Warning System (InaTEWS), landslide warning system and related disaster policies at national and local level came out during this time. InaTEWS is an operational activity carried out by Agency for Meteorology, Climatology and Geophysics as a part of governmental duty which provides meteorology, climatology, and geophysics services including public information, early warning, and specific information (Harig et al., 2020).

IRDR ICoE-DRHBPI, affiliated with the Institute for Catastrophic Loss Reduction (ICLR), also has been addressing priority issues related to the risks for homeowners, such as basement flooding, construction of disaster-resilient homes and enhancing the resilience of existing homes (Kyriazis et al., 2017).

3.14 Assessment of Integrated Research

The concept of IRDR became cleared through series of researches made by the **IRDR AIRDR WG**. Integrated research examines problem - focused, socially - driven research questions that cannot be adequately addressed by one or a small number of research disciplines, or without collaborative problem solving and real - world engagement of non - academics. Integrated research permits a more comprehensive understanding of the construction of a particular disaster situation, context, or problem and also provides policy - relevant information for social interventions designed to reduce risk. An integrated research approach requires diverse epistemologies, theories, and methodologies, with no prior assumptions about the primacy of each in

91 https://repositorio.gestiondelriesgo.gov.co/handle/20.500.11762/19790

addressing the problem.

The need for integrated research follows from the complexity of disaster risk, which cannot be understood comprehensively by a single discipline alone. Integrated research is the foundation and the evidentiary basis for the development of effective disaster risk reduction strategies. The AIRDR WG reviewed the state-of-the-art knowledge about disaster risk. Its results provide an empirical basis for tailoring research agendas and informing the post-Hyogo Framework. The objective is to assess: 1) How does our present understanding of hazards and disaster risk, the result of research undertaken during the past 10 to 20 years, help us understand past and present patterns and trends in disasters? 2) What is well-known within the research community in terms of capacity, technology, tools, methodologies, and translation of findings to actions? What is less well-known in the research and where do these shortcomings come from (e.g., hazards or perils studied, regional understanding, spatial or temporal coverage of topics)? 3) How does our existing scientific knowledge help us to understand disaster risk under conditions where disasters may be increasing in frequency and intensity and where vulnerability and exposure heighten the impacts of disasters?(IRDR_AIRDR_WG, 2014)

3.15 Key innovations in DRR

IRDR DRR-CCA-SDGs WG in collaboration with Tohoku University, Keio University, and United Nations University conducted an online survey from December 2018 to January 2019 to identify 10 most important innovations, from the global to local level, dealing with impacts of climate risks employing improved/expanded livelihood strategies (Izumi et al., 2019). The list of innovations provided options between 30 innovative products (14) and approaches (16) that have already contributed to reducing disaster risks and are considered to be extremely effective at it. The survey involved non-traditional actors such as local communities, SMEs, NGOs and received a total of 228 responses from universities (145), government (30), NGOs (24), the private sector (6), international organizations (16), and others (7). The survey requested to select three innovations considered most effective. The top ten innovations selected were as follows (table 3):

Table 3. The top ten innovations from the global to local level

	Innovations
1	Community-based disaster risk reduction/risk management
2	Hazard mapping
3	GIS and remote sensing
4	Assessments and index approach: Vulnerability assessment, resilience, sustainability
5	Disaster risk insurance
6	National platforms for disaster risk reduction
7	Social networking service/system (SNS)
8	Drones
9	Disaster resilient materials
10	Indigenous DRR technology
11	Crowdsourcing

3.16 Risk Interpretation and Action – Multi-hazard early warning systems

Decision-making under conditions of uncertainty is inadequately described by traditional models of rational choice. Traditional models do not consider how people's interpretations of risks are shaped by their own experiences, personal feelings and values, cultural beliefs and interpersonal and societal dynamics, and how these interpretations of risks affect the choose of actions an individual may take.

To improve the understanding on these matters, one of Flagship Projects **the Risk Interpretation and Action (RIA) WG's** has prioritized is the enhancement of impact-based early warning systems for countries vulnerable to multi-hazards. IRDR, together with the World Meteorological Organization, International Science Council (ISC) and Tonkin and Taylor International, promoted an end-to-end early warning system-based guideline comprised of ten essential elements that work together to create a single, cohesive and robust warning system. Multi-hazard early warning system projects have been commissioned for more than 25 countries including nations in the Caribbean, Africa, South-east Asia, and the Pacific. Multiple nations have successfully implemented or improved their Early Warning System (EWS) using this philosophy.

Figure 18: The concept of multi-hazards early warning systems

The RIA working group made three observations: (1) Risk interpretation and action is not just psychological, but also social and cultural; (2) effective communication of risks is relevant for numerous policy domains, especially with regard to the goal of effectively informing individual decision-making, but there is an ongoing need to shift from risk communication to risk engagement across these domains; and (3) there is a continued need for collective, multiscale, multi-actor, multi- and transdisciplinary exploration of risk interpretation and action, in addition to the need to further explore risk interpretation and action at the individual, psychological scale. Each of these observations previews themes that have been important in disaster risk research historically, as well as in recent advances (Fakhruddin & Bostrom, 2019).

3.17 Mobilization of and investment in young professionals

The IRDR Young Scientists Programme was first conceived in 2014 with a World Social Sciences Fellows Workshop at the IRDR ICoE-CR, and formally started in 2016, with applications accepted twice a year. Already 162 young researchers from 46 countries have been involved in this programme, including 43 female researchers following 4 batches of selection. The academic background of these young scientists ranges from traditional disciplines such as Geography, Biology, Engineering, Computer Science, Architecture, Anthropology, Economy, and Law, to the integrated and cross-cutting disciplines such as Disaster Risk Management, Climate Change and Adaption, Social Resilience, DRR Communications, Disaster and Emergency Health, and Disaster Nursing. The application proposals accepted by IRDR focus on the mechanisms of disaster processes, and the development of a comprehensive understanding of disaster risk, community resilience, and public awareness.

The IRDR Young Scientists Programme establishes a network for the capacity building of a new generation of DRR specialists and researchers. Not only are the participants active in their respective research fields, but they are also contributing to communicating DRR knowledge to local communities. IRDR encourages young scientists to build and promote regional and national DRR young scientists' networks. The IRDR has connected young researchers to its network of professionals and practitioners, and encouraged them to participate in IRDR-related training programmes. Some IRDR young scientists have published their research results in academic books or special reports in collaboration with IRDR Scientific Committee members (e.g., Sword-Daniels et al., 2016) and IRDR partners such as the UN Major Group for Children & Youth (UNMGCY). More than 40 of these young researchers since 2016 have joined training programmes organized by the IRDR ICoEs, such as ICoE-Taipei and ICoE-CCOUC in Hong Kong, and the IRDR partnership with the Digital Belt and Road (DBAR) programme of CAS. Together with UNESCO and IDMR of Sichuan University, the U-INSPIRE Alliance was established and several national chapters were also organized, with IRDR young scientists playing leading roles in their establishment.

4 IRDR capacity building for DRR Science

In IRDR Science Plan, capacity building is considered as one of the cross-cutting themes. Capacity or capability can be defined as a combination of all the strengths and resources available within a community, nation or region that can reduce the level of risk, or the effects of a disaster. It includes physical, institutional, social or economic means such as financial, political and technological resources, as well as skilled personal or collective attributes such as leadership and management at different levels and sectors of the society. Capacity building aims to develop knowledge, human skills and societal infrastructures within a community, nation or region in order to reduce the level of risk. Over the last ten years, IRDR indevoured the capacity development for DRR science in two dimensions: 1) through a structure approach, IRDR developed a science community to connect IRDR Science Plan with Sendai Framework by concrete actions. 2) through diffusion of knowledge and technical solutions to enhance DRR institutions and individuals in countries and communities.

4.1 Capacity within IRDR

IRDR is co-sponsored by the International Science Council (ISC, which was created in 2018 as the result of a merger between the ICSU and the ISSC) and the United Nations Office for Disaster Risk Reduction (UNDRR, former acronym is UNISDR). The execution of IRDR programme promotion, coordination and related functions is undertaken by the IRDR IPO. The IPO is located in Beijing, China and is hosted by the Aerospace Information Research Institute (AIR, formerly the Institute of Remote Sensing and Digital Earth (RADI)) of the CAS. Funding is provided by the CAST.

IRDR is governed by a Scientific Committee (SC) set up by and on behalf of the Co-Sponsors. In the past ten years, IRDR SC embraced in total 41 outstanding experts from a diverse range of disciplines with regional and gender balance. Its responsibilities are to define, develop and prioritise plans for the IRDR, guide its programming, budgeting and implementation, establish a mechanism for oversight of programme activities, and disseminate and publicise its results on behalf of the co-sponsors.

13 IRDR National Committees (NCs) and one Regional Committee (RC) were established to support and supplement IRDR's research initiatives, and help to establish or further develop crucial links between national disaster risk reduction programmes and activities within an international framework. NCs and RC helped foster the much-needed interdisciplinary approach to disaster risk reduction within national scientific and policy-making communities, and served as important national focal points between disciplinary scientific unions and associations.

16 institutions joined IRDR as ICoEs and provided regional and research foci for the IRDR programme. In particular, each established ICoE enabled regional scientific activities through geographically-focused contributions based on more localised inputs, and by being visible centres of research to motivate participation in the IRDR programme.

IRDR established six Working Groups (WGs), to meet IRDR's research objectives and cross-cutting themes and to formulate new methods in addressing the shortcomings of current disaster risk research. 162 young scientists joined the IRDR Young Scientists Programme, an initiative started from 2016 to promote capacity building of young professionals and to encourage them to undertake innovative and needs-based research which strengthens science-policy and science-practice links.

4.2 Institutional capacity, technical trainings and Partners

Working with ISC, UNDRR and partners

IRDR collaborates with other ISC Interdisciplinary Bodies (IBs), members and regional offices on numerous DRR activities. There is a close and long-term collaboration between IRDR and CODATA through IRDR DATA Working Group. A large number of policy briefs, webinars, workshops on the DRR data issues have been developed in collaboration and a regular DRR and Open Data Newsletter is published. IRDR, Future Earth and World Climate Research Programme (WCRP) have been involved in the discussions that led to the creation of the Knowledge Action Network on Emergent Risk and Extreme Events, with some IRDR scientists still involved as the members of Development Team and co-chairs of Working Groups. One example of joint activities between IRDR and WCRP was a 3-week advanced course entitled "Institute of Advanced Studies in Climate Extremes and Risk Management" for 39 young researchers from 17 countries (Figure 19). IRDR SC members and ICoEs have also worked with the DRR working groups of ISC regional offices in Latin America

Figure 19: Group discussions and research communications

and the Caribbean and in Asia Pacific on several projects and events. In particular, IRDR and ISC ROAP successfully helped 12 countries in this region to develop the Science Technology Plan for Disaster Risk Reduction for implementing the Sendai Framework.

Besides UNDRR and its branches, IRDR works with other UN agencies to addressing DRR among multi-stakeholders. IRDR has worked hand in hand with UNDRR STAG to coordinate scientific inputs into the Sendai Process. IRDR has organized science and policy dialogues with the support of UNDRR and ISC in the bi-annual global and regional platforms, regional ministerial conferences and regional science and technology conferences on DRR. Together with the UNDRR regional office in Asia and Pacific and AP-STAG, IRDR and academic stakeholders examined the Science and Technology Status for the implantation of Sendai Framework every two years. As to other UN agencies, for example, IRDR cooperates with UN-SPIDER to promote the digital technology and space data sharing and applying in DRR, with UNESCO to protect World Heritage properties through DRR solutions, and with WMO on the development of International Network on Multi-hazard Early Warning Systems (INMHEWS).

IRDR also signed agreements or memorandum of understanding with parties from different sectors to better conduct the DRR research and practice. IRDR and Disaster Risk Reduction Knowledge Service Sub-Platform (DRRKS), International Knowledge Centre for Engineering Sciences and Technology of the Auspices of UNESCO signed a MoU to promote the DRR data and knowledge sharing. IRDR helped World Vision review the theories and methodologies adopted in its community DRR practice and training. START International Inc. provided seed funding for young researchers through joint projects initiated by IRDR ICoEs. In the Belt and Road Region, IRDR collaborated with Silk Road Disaster Risk Reduction and Digital Belt and Road on science and technology capacity building through transboundary research activities and DRR data sharing.

Essential roles of IRDR NCs and ICoEs in capacity building

IRDR NCs and ICoEs are deeply engaged in DRR capacity building on research and practice at the regional, national and local levels. They provide DRR knowledge and solutions through educational events and trainings targeted towards researchers, decision-makers, investors, and the public to strengthen science and technology capacity and increase DRR awareness. Since 2012, ICoE-Taipei has held twelve Advanced Institutes (AIs) focusing on integrated approach and hosted more than 300 scientists and/or practitioners in these training courses. Between 2016 – 2019, ICoE REaL (based in South

Africa) through its host Periperi U expanded its academic programmes and modules boosting the consortium's academic portfolio to 47 offerings. A particular milestone for PERIPERI U was achieving 40.6% female student representation across its various academic offerings, as a major challenge in a field which has been largely dominated by men and across a continent in which women's participation in academia still face many obstacles and challenges (Figure 20). NC China together with CAS-TWAS Centre of Excellence on Space Technology for Disaster Mitigation (SDIM) provided a series of remote sensing technology trainings for over 150 early career young scientists from developing countries. NC Nepal implemented several specific Community Based Disaster Risk Management (CBDRM) programs through NSET and NRA of Nepal on the localization of DRR to link science, technology and national and global policy frameworks to the last mile. NC-Iran provided a "Safe Schools, Resilient Communities" Programme to raise awareness of resilience at local level and engage local communities in DRR activities and empower them to become prepared to respond to potential earthquakes(Amini-Hosseini & Izadkhah, 2020).

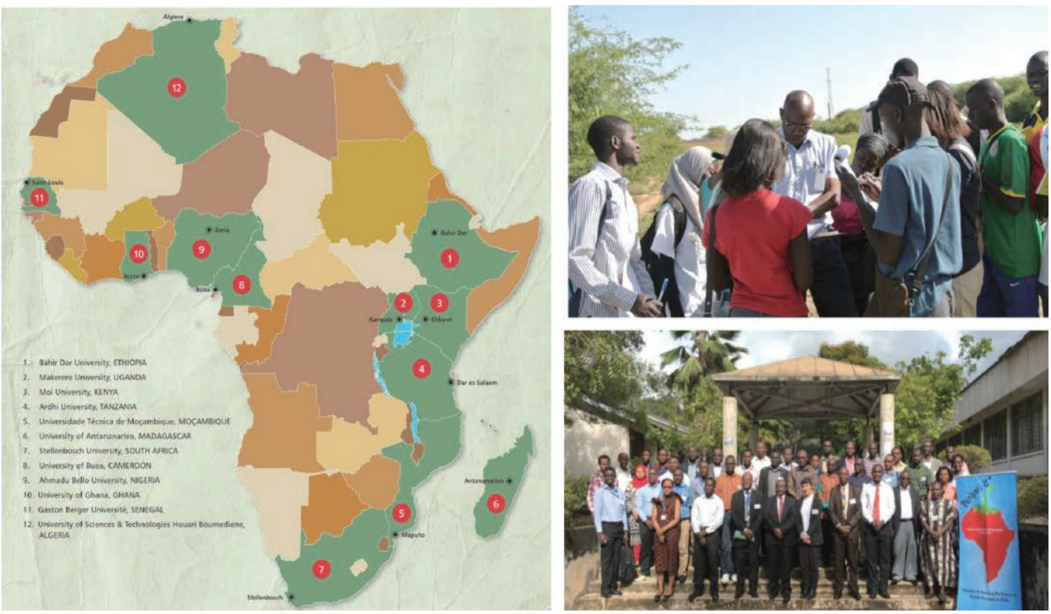
NC-Australia has hosted a series of free public forum on the International Day for Disaster Reduction (13 October) since 2014 focusing on the latest research, policies and practices targeted at reducing the number of people affected by natural disasters around the world.

5 Gaps and Challenges

5.1 The legacy envisaged

In the IRDR Science Plan, the legacy of the IRDR programme would be "an enhanced capacity around the world to address hazards and make informed decisions on actions to reduce their impacts. This would include a shift in focus from response–recovery towards prevention–mitigation strategies, and the building of resilience and reduction of risk, and learning from experience and avoidance of past mistakes". An important part of the legacy would be the repository of coordinated and integrated global data and information sets across hazards and disciplines that would be of continuing availability and value to communities at all levels, from local to global.

Figure 20: Periperi U partner universities and the activities



IRDR makes great efforts in framing and establishing an integrated approaching to disaster risk. The community and the research cover the natural, socio-economic, health and engineering sciences. Through its actions and capacity building, IRDR has to some extent shaped some global and local discussion on the multi-stakeholders' engagement in DRR.

The global science landscape on DRR and the context has changed rapidly. One of the key revolutions is the formulation of Sendai Framework and other important global frameworks in particular SDGs, Paris Agreements, New Urban Agenda. The IRDR Science Plan was formed at an early stage of Hyogo Framework, and strongly reflected its alignment with HFA with a keen focus on hazard research. However, the trend has now changed to resilience related research, and focus more on the socio-economic context. Complex, cascading disasters, climate risks become more prominent in recent years, and policy research on these has become increasingly important. Though IRDR adjusted its strategy and actions in the second half of the decade, it still faces new challenges to reorient itself toward 2030 and beyond.

5.2 Research Gaps: new uncertainty and new agenda

As was underlined at the Global Platform for Disaster Risk Reduction in May 2019, the world is increasingly threatened by the occurrence of both familiar and unfamiliar transboundary, systemic and cascading hazards and disaster risks in a hyperconnected and rapidly changing world. In the brief period since 2019, we have witnessed extensive wildfires, extreme weather events, outbreaks of desert locusts crossing continents and, worst of all, the Covid-19 pandemic. The pandemic in particular has clearly highlighted the underlying vulnerabilities ingrained in our social, economic and financial systems, thereby supporting the call of the Sendai Framework for a new, more comprehensive, multi-hazard and systemic approach to disaster risk reduction and resilience. The need for science and its application for evidence informed policies and related legal and regulatory frameworks and action across all sectors and communities has never been greater.

In the oversight committee meeting of2019, ISC and UNDRR suggested the development of a global research agenda to guide the work of scientists, researchers, academics, technical institutions in both the public and private sectors, and to build the evidence base needed for risk-informed decision-making in all geographies, sectors and scales. The Agenda proposed new strategic areas of cooperation in DRR science and policy, namely in: Data and knowledge; New and existing technologies – development, application and access; Scientific understanding on increasing risks and uncertainties; Science, policy and society engagement, dialogue and action; Institutional capacity development; Collaborative global and regional governance of transboundary risks; and Private sector impetus towards DRR.

5.3 Challenges and lessons learnt in IRDR programme management

The 2016 IRDR Mid-term Review panel's overall assessment of the IRDR programme was that upon its establishment, IRDR was a well-conceptualized, timely and innovative - potentially even pioneering - initiative in the increasingly important domain of disaster risk reduction. Its design was ambitious. It reflected the effort needed to bring to fruition a global research program that had to promote and demonstrate new ways of thinking and working in order to influence policies and practices that benefit societies and vulnerable communities around the world.

Meanwhile, the Review delivered a critical assessment of the achievements of the programme to date, and in particular, the limited scientific outputs demonstrating the value of integrated research for disaster risk reduction, issues with the governance and management arrangements of the programme, and a lack of funding beyond the core funding for the secretariat to support impactful scientific activities. The

Review urged to take actions to enhance IRDR NCs and ICoEs in the overall programme delivery.

The Review Panel made five key suggestions: 1) Adjust the program scope and direction, 2) Improve the business model, 3) Sharpen governance, 4) Improve management, 5) Move towards collective impact. The panel further suggested that more direct and regular interactions between the sponsors, the IPO, the scientific committee chair and the host was needed.

Furthermore, while lack of regular project funding remains a critical problem, the roles and position of NCs and ICoEs in the programme governance has not been fully addressed. Due to NCs' and ICoEs' institutional capacity and functions in DRR practice, their opinions on the development of IRDR and the research strategic areas should be fully considered and adopted. The current operational management and decision-making in IRDR mainly through Scientific Committee Meeting has affected to certain degree the full participation of NCs and ICoEs. A new form of programme management needs to be envisaged to ensure all elements of IRDR community engaged in the decision-making process of the programme development.

In the past decade, IRDR essentially functioned as a network that promote community building and collaboration across scientists from a range of countries and disciplines. Some have suggested that IRDR would have been the "IPCC" in DRR community with resourcing and expanded science community to delve into the unresolved issues of DRR to inform the GAR and other UN agendas such as the New Urban Agenda and Paris Climate Agreement. The role of any research performing organization should be enhanced when operation and management mechanisms are improved. At the same time, new organisations or groups have emerged such as the Risk KAN, and UNDRR has also established Scientific and Technical Advisory Groups at the global and regional levels. This requires IRDR to conduct a strategic assessment of research gaps in DRR and an institutional mapping to re-position itself and promote better synergies with existing initiatives.

6 Further remarks

The purpose of this compilation is to give a comprehensive reflection IRDR's 10-years of work, both achievements and identifying gaps and challenges from missing components. It is hoped that the Compilation will serve as the main reference for all who want to have an overall understanding what IRDR is, and how it has worked over the past decade. Recording the past 10 years of this international endeavour with transparency and accountability, the Compilation aims to recapitulate the programme achievements and lessons learnt. It is hoped these can be used as a basis toward designing the future IRDR 2.0 if the new global DRR Research Agenda currently under development be endorsed by ISC and UNDRR as well as international scientific communities.

The information summarized in this IRDR Compilation has shown that, over a span of 10 years, the research communities in DRR have been stimulated by the calls of ISC and UNDRR through IRDR, and produced tangible results and undertaken a broad range of actions toward the overall IRDR objectives which are aligned with the priorities and targets of Sendai Framework.

Although not a research-intensive programme, some work of IRDR through its own leadership or in cooperation with its partners has had global significance. These include the development of the 2014 Peril Classifications and Definitions, one of the bases for new work of the Sendai Hazard categories and terminologies, and FORIN, a broadly adopted methodology to look at the integrated underlying courses of disasters. The re-contextualized ST DRR Roadmap developed together with STAG in 2018-2019 will help DRR research institutions to align their effort with Sendai Framework further and facilitate the reporting. IRDR has also made series of important policy recommendations on subject related to climate change, urban resilience, social impacts, science policy and support toward risk science, and technical contributions in inception and development regional multi-hazard early warning systems.

It is important to underline that IRDR has been a programme with actions at regional, national and community levels and over thematic risk domains. Although not often reported on in the past, IRDR NCs and ICoEs have been demonstrated to play strong roles in connecting global agenda to national and regional needs and contexts. Among other roles, NCs are best placed in assisting countries in their reporting toward the implementation of Sendai Framework, and ICoEs are both producers of knowledge and capacity builders in different regions and fields. A strong sign of youth engagement in DRR and building safe and resilient societies has been demonstrated through IRDR Young Scientists scheme.

Meanwhile important lessons have also been learnt in terms of programme governance, operation, resource mobilization and uses, synergies and partnership development. This comes with the growing demands for understanding systemic, cascading and transboundary risks and concerns, and aspirations for common safety, resilience and sustainability in our societies.

Together, these serve as building blocks toward a future stage of international cooperation in DRR and risk science, as the mission started in 2010 in IRDR is not yet fully accomplished.

References

Amini-Hosseini, K., & Izadkhah, Y. O. (2020). From "Earthquake and safety" school drills to "safe school-resilient communities": A continuous attempt for promoting community-based disaster risk management in Iran. *International Journal of Disaster Risk Reduction*, 45, 101512.

Atrachali, M., Ghafory-Ashtiany, M., Amini-Hosseini, K., & Arian-Moghaddam, S. (2019). Toward quantification of seismic resilience in Iran: Developing an integrated indicator system. *International Journal of Disaster Risk Reduction*, 39, 101231.

Bates, J. (2020). *Cascading extreme weather beyond our experience: are we ready?* Retrieved from 12th Australasian Natural Hazards Management Conference https://www.bnhcrc.com.au/publications/biblio/bnh-6743

Chen, F., Guo, H., & Shirazi, Z. (2019). *Disaster risks and response strategies in process of urbanization in China*. Retrieved from Contributing Paper to GAR 2019: https://www.undrr.org/publication/disaster-risks-and-response-strategies-process-urbanization-china

Cheng, X., Wan, H., Huang, S., Li, C., & Zhang, H. (2018). Lessons learned from the 2016 Yangtze River flood in Anhui province, China. *International Journal of River Basin Management*, 16(3), 307-314.

Du, S., Cheng, X., Huang, Q., Chen, R., Ward, P. J., & Aerts, J. C. J. H. (2019). Brief communication: Rethinking the 1998 China floods to prepare for a nonstationary future. *Nat. Hazards Earth Syst. Sci., 19*(3), 715-719.

Fakhruddin, B., & Bostrom, A. (2019). *Integrated Research on Disaster Risk (IRDR)*. Retrieved from Contributing Paper to GAR 2019:

Fan, X., Scaringi, G., Tanyas, H., Hales, T., Jibson, R., Allstadt, K., Zhang, L., Evans, S., Li, G., Pei, X., Korup, O., West, A., Westen, C. J., Hovius, N., & Xu, C. (2019). Supporting Information for: Earthquake induced chains of geologic hazards: patterns, mechanisms, and impacts. *Reviews of Geophysics*, 57, 421-503.

Francioli, A., de Kock, C., & Fortune, G. (2020). PERIPERI U (*Partners Enhancing Resilience for People Exposed to Risks) Final Program Results Report Project (Period 26 May 2016 – 25 November 2019)*. Retrieved from PERIPERI U Secretariat Office, Research Alliance for Disaster and Risk Reduction (RADAR), Stellenbosch University, SOUTH AFRICA:

Harig, S., Immerz, A., Weniza, Griffin, J., Weber, B., Babeyko, A., Rakowsky, N., Hartanto, D., Nurokhim, A., Handayani, T., & Weber, R. (2020). The Tsunami Scenario Database of the Indonesia Tsunami Early Warning System (InaTEWS): Evolution of the Coverage and the Involved Modeling Approaches. *Pure and Applied Geophysics, 177*(3), 1379-1401.

Hayashi, H., Shaw, R., & Doherty, B. (2018). Exploring the possibility of an online synthesis system for disaster risk reduction as a tool to promote "Consilience" of knowledge and practice. *Journal of Disaster Research, 13*(7), 1213-1221.

IRDR. (2014). Peril Classification and Hazard Glossary. 24.

IRDR_AIRDR_WG. (2014). *Guide to Assessing IRDR*. Retrieved from IRDR AIRDR Publication No. 1:

Izumi, T., Shaw, R., Ishiwatari, M., Djalante, R., & Komino, T. (2019). 30 innovations for disaster risk reduction. 84.

Kenney, C. K., & Phibbs, S. (2015). A Māori love story: Community-led disaster management in response to the Ōtautahi (Christchurch) earthquakes as a framework for action. *International Journal of Disaster Risk Reduction*, 14, 46-55.

Kyriazis, J., Zizzo, L., & Sandink, D. (2017). Assessing local mandatory measures to reduce flood risk and inflow & infiltration in existing homes. Retrieved from https://www.iclr.org/wp-content/uploads/PDFS/assessing-local-mandatory-measures-to-reduce-flood-fisk-and-inflow-infiltration-in-existing-homes.pdf

Lauta, K. C., Albris, K., Zuccaro, G., & Grandjean, G. (2018). *ESPREssO Enhancing Risk Management Capabilities Guidelines*. Retrieved from www.espressoproject.eu

Lei, Y., Peng, C., Regmi, A., Murray, V., Pasuto, A., Titti, G., Shafique, M., & Priyadarshana, T. (2018). An international program on Silk Road Disaster Risk Reduction–a Belt and Road initiative (2016–2020). *Journal of Mountain Science*, 15, 1383-1396.

Li, D., Yuan, J., & Kopp, R. E. (2020). Escalating global exposure to compound heat-humidity extremes with warming. *Environmental Research Letters*, 15(6), 064003.

Morgan, J., Begg, A., Beaven, S., Schluter, P., Jamieson, K., Johal, S., Johnston, D., & Sparrow, M. (2015). Monitoring wellbeing during recovery from the 2010–2011 Canterbury earthquakes: The CERA wellbeing survey. *International Journal of Disaster Risk Reduction*, 14, 96-103.

Oliver-Smith, A., Alcántara-Ayala, I., Burton, I., & Lavell, A. M. (2016). Forensic Investigations of Disasters (FORIN): *a conceptual framework and guide to research (IRDR FORIN Publication No.2).* Retrieved from http://www.irdrinternational.org/2016/01/21/irdr-publishes-the-forin-project-a-conceptual-framework-and-guide-to-research-2/

Pereira, J. J., & Hunt, J. C. R. (2019). *Climate Science & Technology in Asia: Current Status and Future Needs. Report of the Workshop on Status of Climate Science and Technology in Asia, 15-16 November 2018, Kuala Lumpur, Malaysia. LESTARI Publisher, Bangi, Malaysia*. Retrieved from LESTARI Publisher, Bangi, Malaysia:

Pereira, J. J., Pulhin, J. M., Nyda, C., Trong, T. D., & Khadijah, S. (2019). Appraising slow onset hazards for loss and damage: Case studies in Southeast Asia. . *APN Science Bulletin, 9*(1), 45-51.

The Institute for Catastrophic Loss Reduction. (2019). Flood Mapping in Canada. Retrieved from https://www.iclr.org/wp-content/uploads/2019/09/ICLR_Flood-mapping_2019.pdf

Van Den Bout, B., Van Asch, T. W. J., Hu, W., Tang, C., Mavrouli, O., Jetten, V. G., & Van Westen, C. J. (2020). Towards a model for structured mass movements: the OpenLISEM Hazard model 2.0 a. *Geoscientific Model Development Discussions*, 1-31.

Willner, S. N., Otto, C., & Levermann, A. (2018). Global economic response to river floods. *Nature Climate Change*, 8(7), 594-598.

Yuan, J., Stein, M. L., & Kopp, R. E. (2020). The evolving distribution of relative humidity conditional upon daily maximum temperature in a warming climate. *Journal of Geophysical Research: Atmospheres*, 125(19), e2019JD032100.