
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

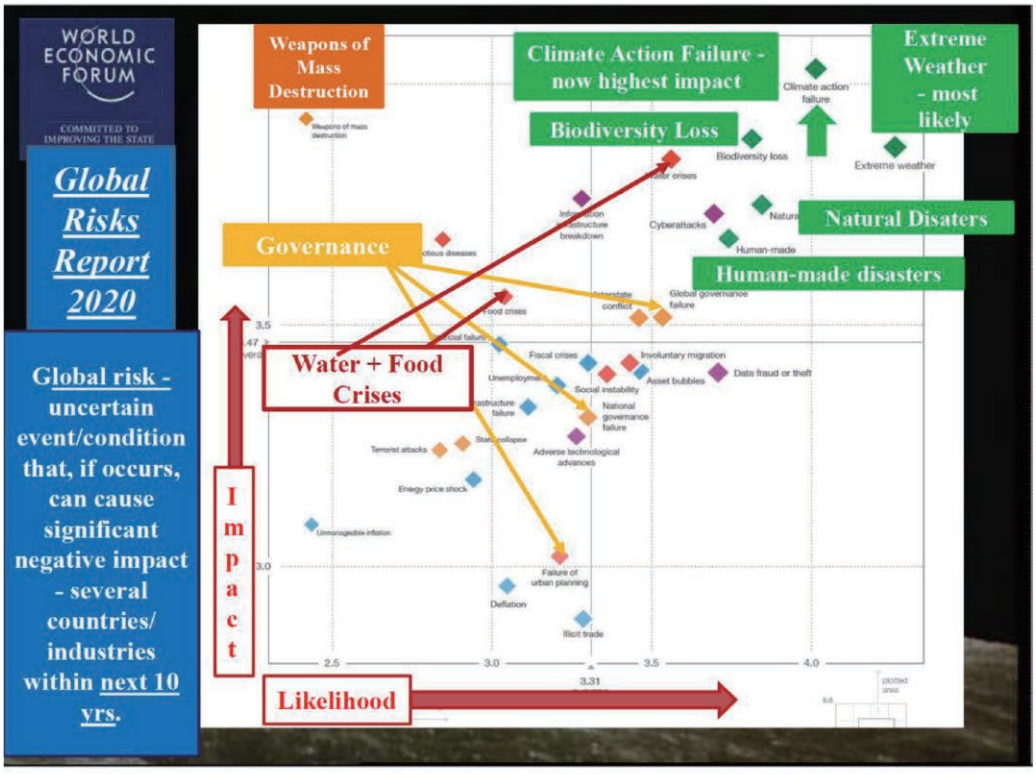
that prevent and reduce hazard exposure and vulnerability to disaster, increase preparedness for response and recovery, and thus strengthen resilience.") and 3 of its 7 global targets ("Reduce disaster mortality, reduce the number of affected people, and reduce disaster damage to critical infrastructure 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.