
WUCHER
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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

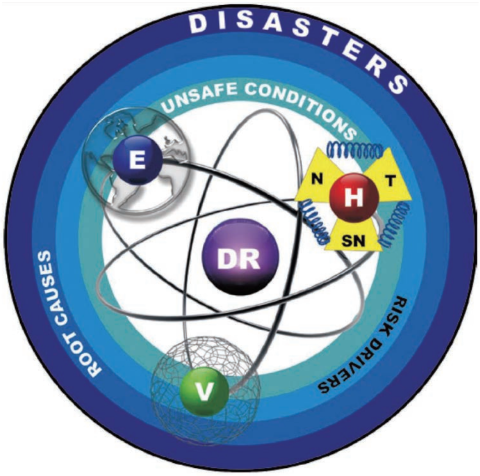
12 http://www.irdrinternational.org/wp-content/uploads/2016/01/FORIN-2-29022016.pdf

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.

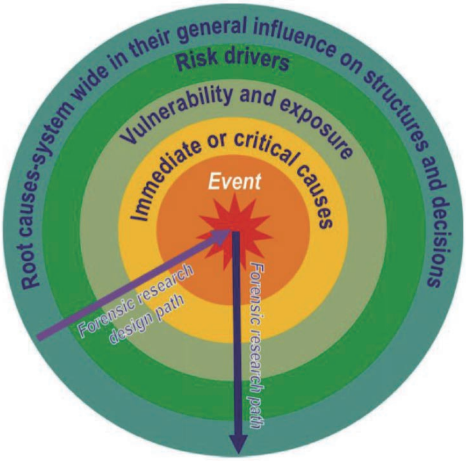
Figure 2-1: The key relationships and processes in the social construction of risk.



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).

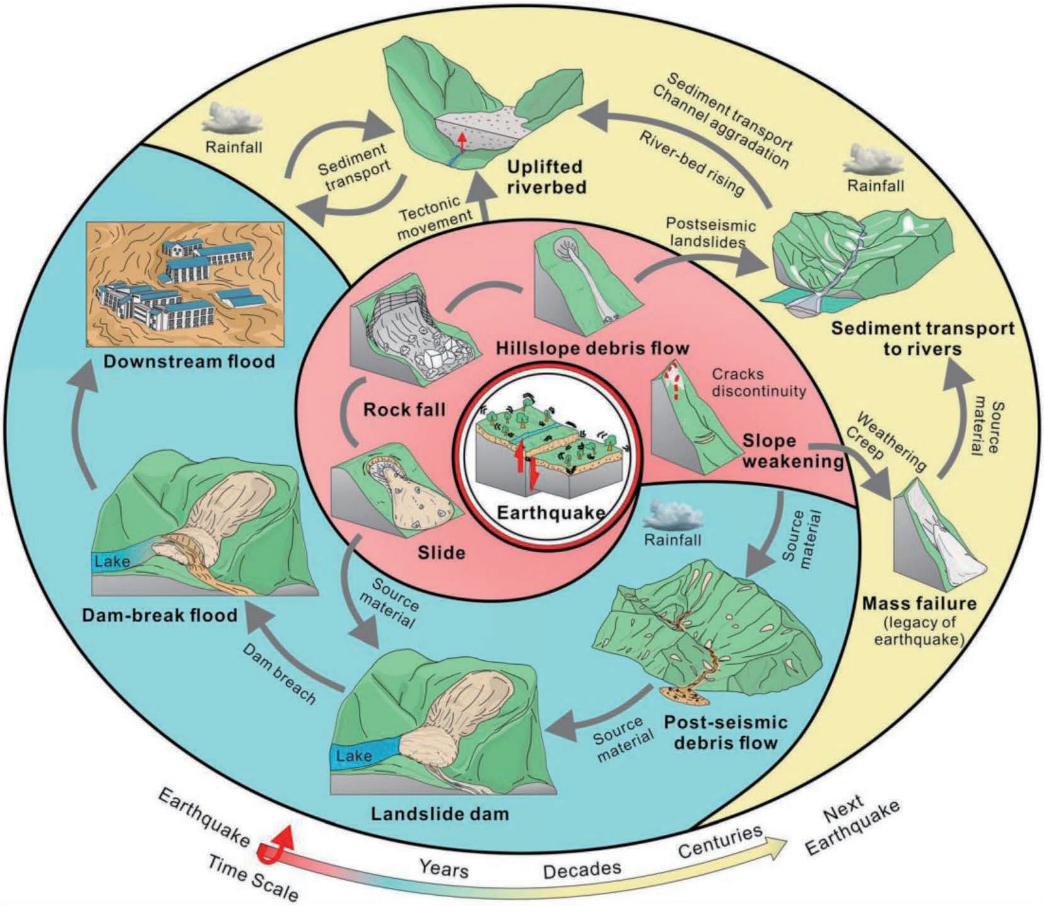
Meta-analysis is an event- or system-based review of the available literature carried out to identify and assess consistent and contrasting findings across diverse studies. The research led by the Study Group on the Disaster Vulnerability of Megacities of the International Geographical Union and the 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.

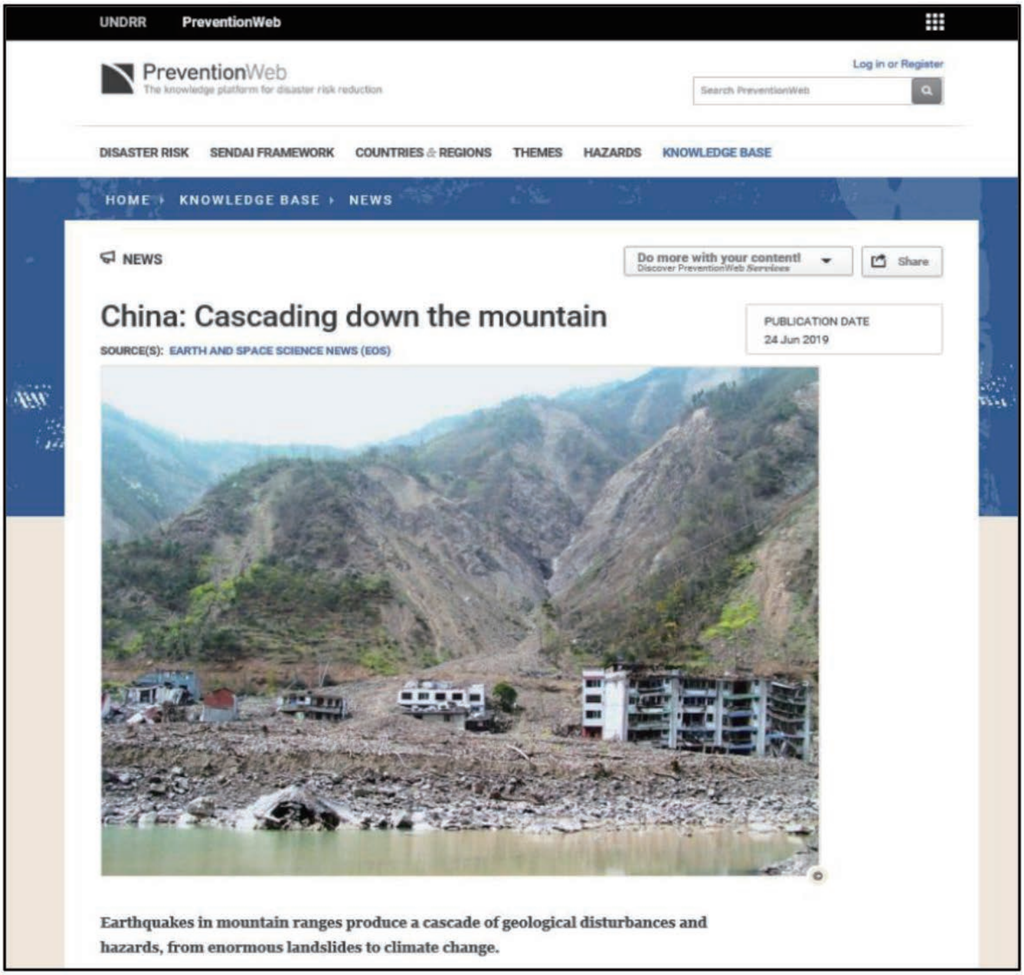
Figure 2-3: Chains of geologic hazards triggered by a strong continental earthquake and reviewed in this work. Causal relations between hazards are indicated. Red background shows different types of coseismic landslides; blue background indicates the post-seismic cascade of hazards (days to years later);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

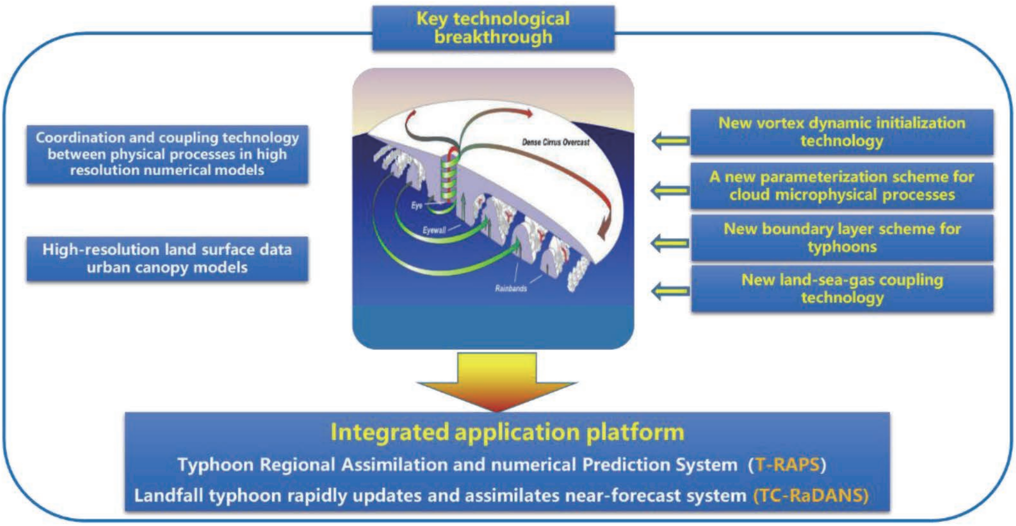
Typhoons trigger a number of natural disasters in China as well as causes serious disaster losses. Till now, how to accurately monitor and forecast the intensity thereof, as well as the typhoon's associated gale and rainstorms have not been completely addressed. In order to meet the requirements of national 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.**



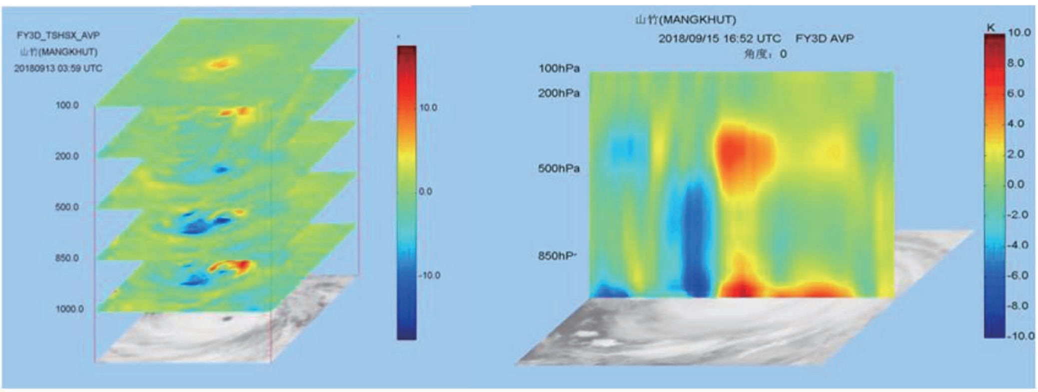
B. Typhoon Vertical Structure Monitoring based on Fengyun Satellite

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.



14 https://charim.net

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).

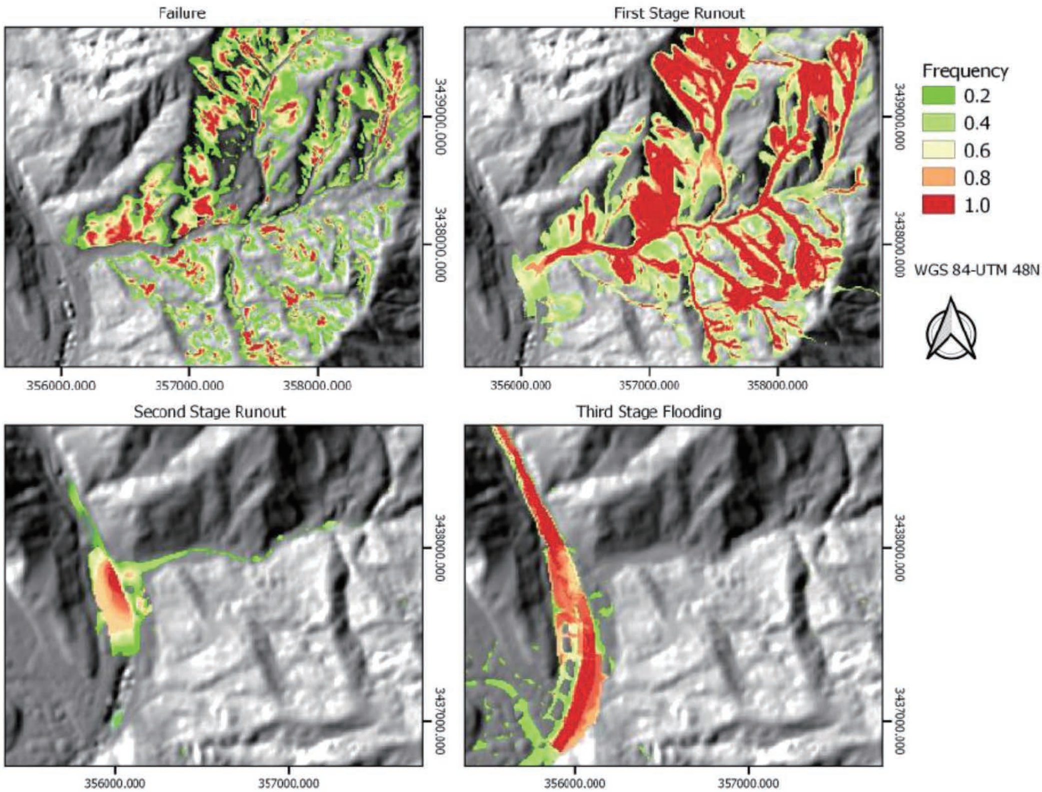
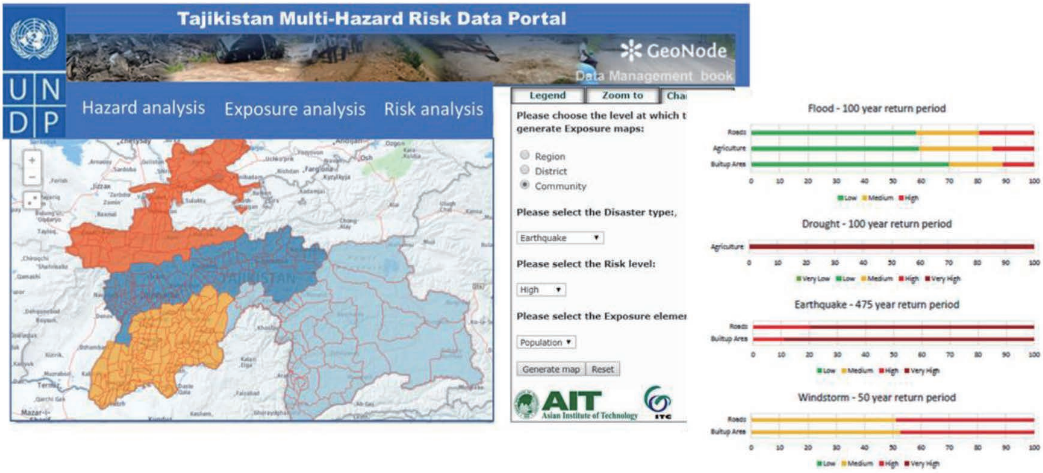


Figure 2-8: **Tajikistan data portal with exposure and risk data for multiple hazards, with links to a Geonode for spatial information (for UNDP, 2020).**



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.

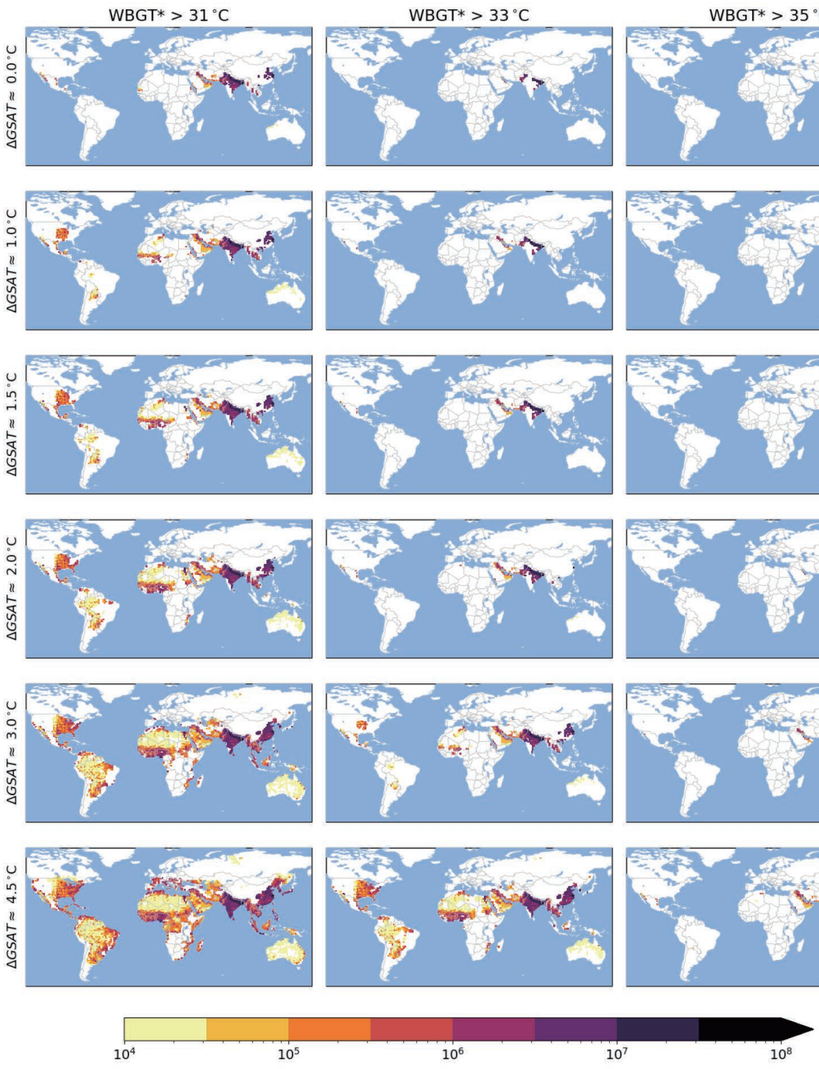
Another exciting project nearing completion is the 'Enhanced probabilistic flood forecasting' which will generate high-resolution, probabilistic two day ahead flood (catchment) forecasts for all of New Zealand. The forecasts are produced by using a complex Bayesian statistical method to create an unbiased 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).

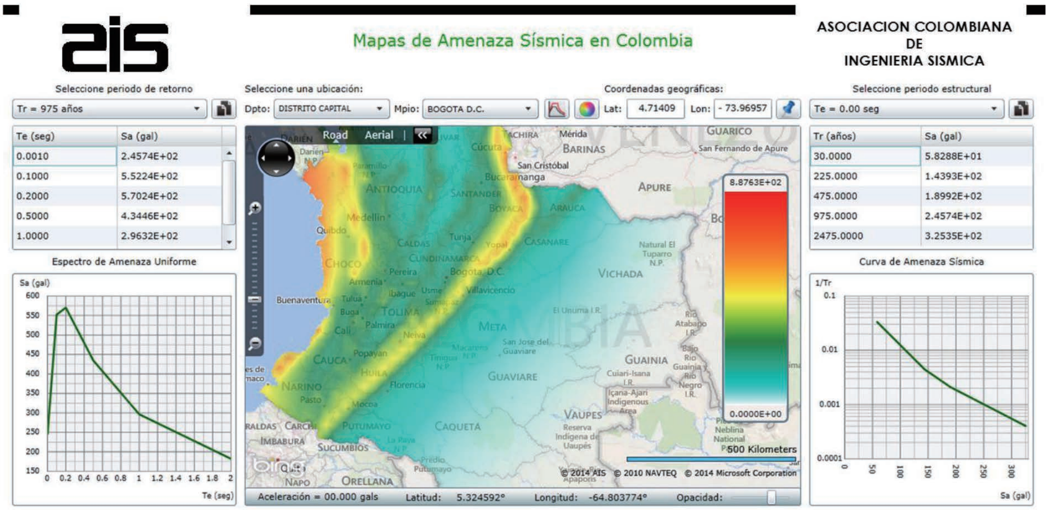


◆ Evaluation of the seismic hazard of Colombia

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.**



16 https://repositorio.gestiondelriesgo.gov.co/handle/20.500.11762/19784

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.

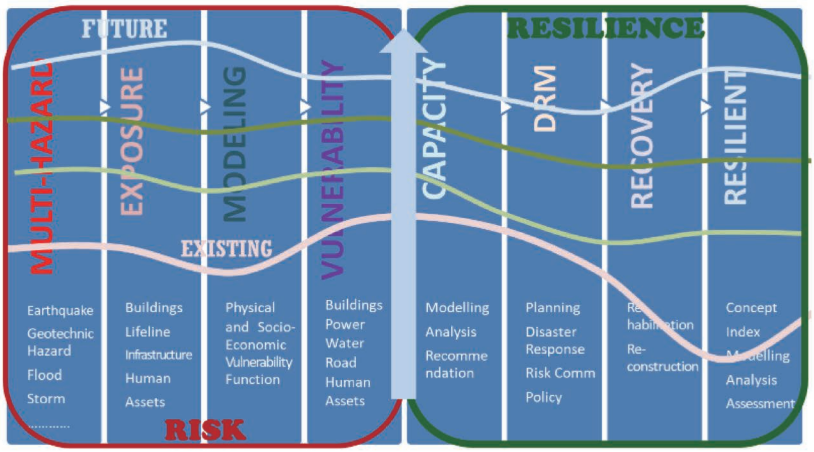
--By **IRDR NC-France**

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:

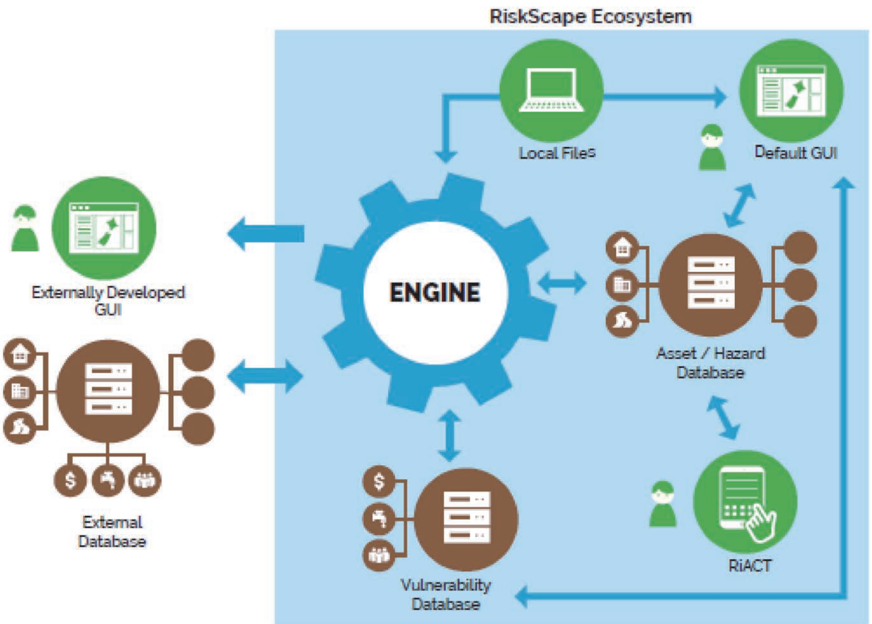
1. Integrated and comprehensive resilience approach;
2. Multi-hazard approach;
3. Consideration of urban and regional interdependency;
4. Tangible, implementable and feasible actions;
5. Joint collaboration and partnership;
6. Creation of added values and incentives for all partners;
7. Avoidance of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



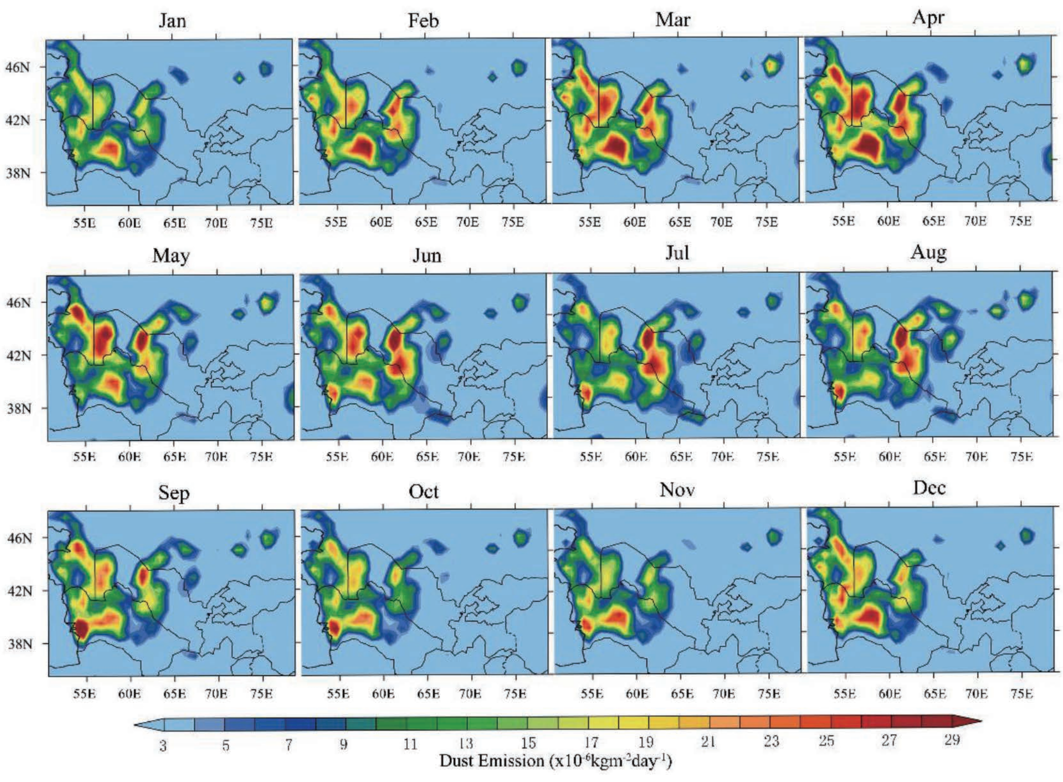
optimization and performance enhancements. Finally, starting in late 2019 and still ongoing is RiskScape's work on building a customized user interface to respond to the specific requirements from the vast array of users.

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).



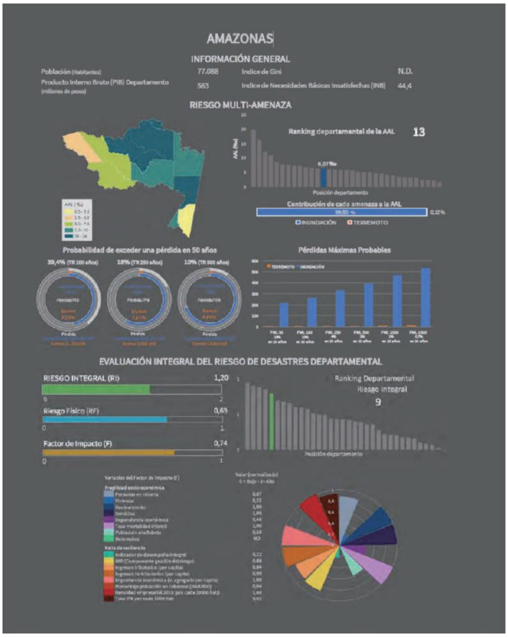
IRDR NC-China use monthly dust aerosol data and meteorological data to analyze the variation trend of dust storm events over Central Asia from 1980 to 2019, and to explore events' association with surface conditions, temperature, and climate indices based on multiple long-term datasets. Main findings 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.

19 https://library.wmo.int/doc_num.php?explnum_id=10555

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.

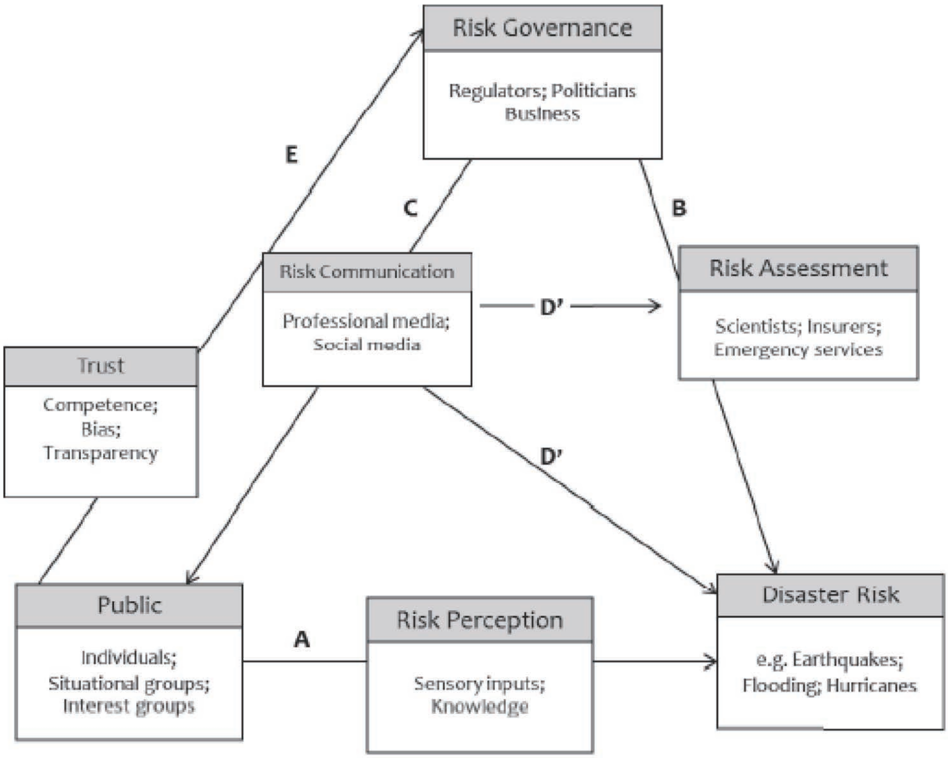
2. *Community building*: Providing an international focal point for pure and applied research, and building a community for risk management professionals working on risk perception, communication and governance including professionals working in resilience building and assessment. Activities include 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*).

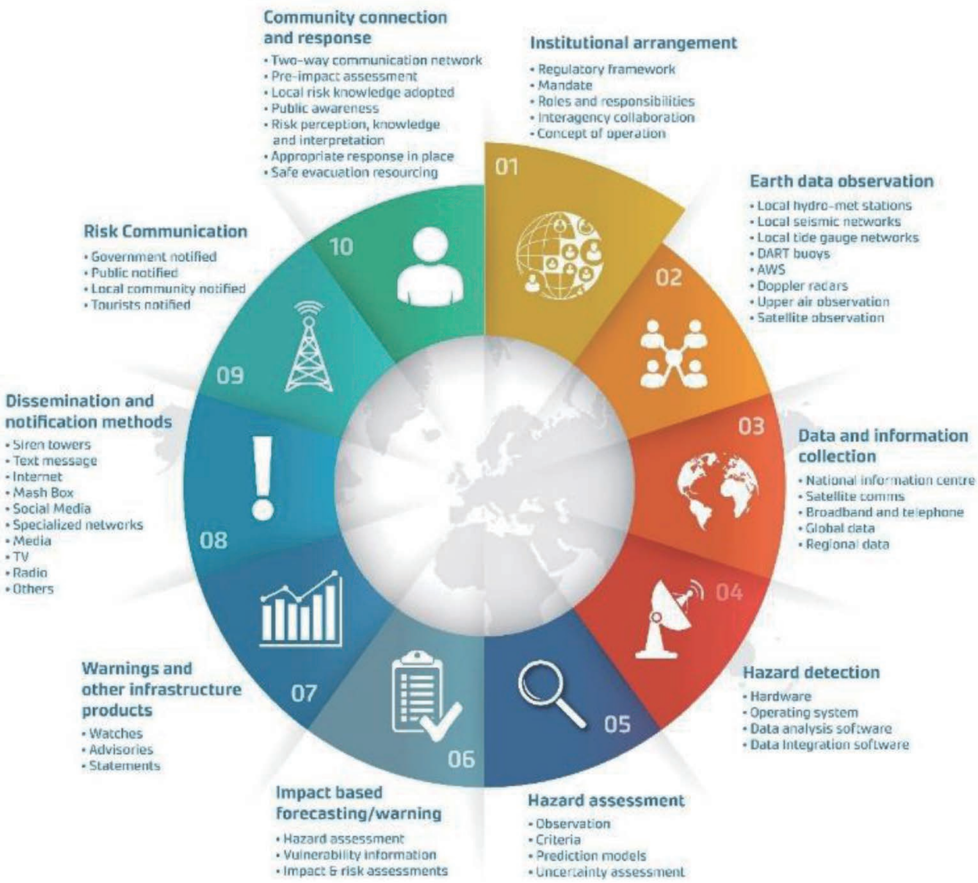
An effective early warning system not only enables timely responses to natural hazards and extreme events but also development planning that can take risk reduction into account. Furthermore, beyond the application in emergency situations, early warnings also apply to changing climatic trends and the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

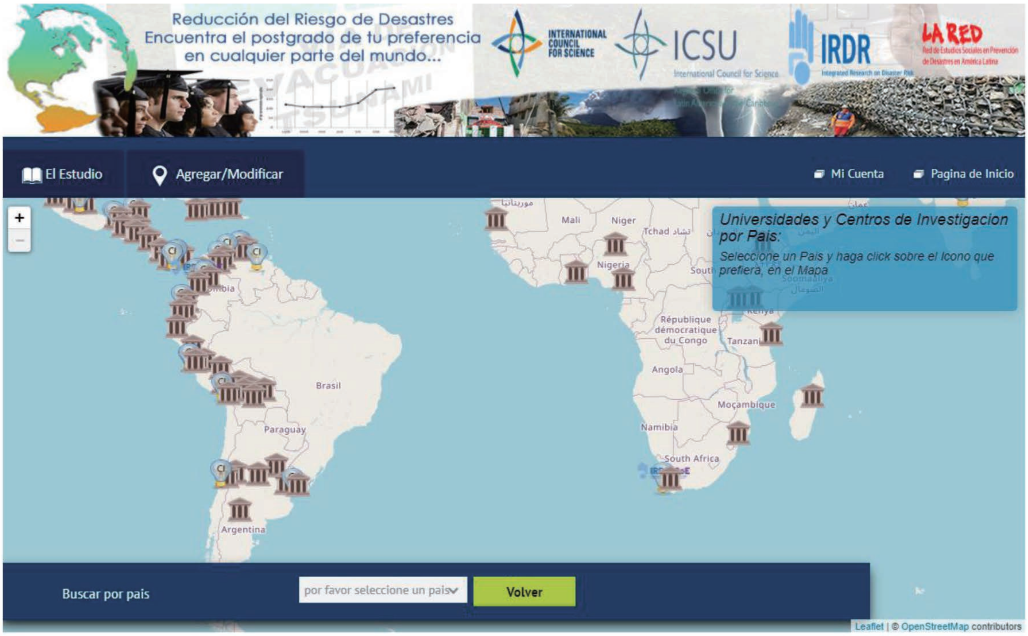
What is needed are honest and comprehensive assessments providing concrete evidence of the capacity and advancements in disaster risk reduction at all scales to determine the current status along the adaptation continuum and whether progress toward “transformation” may be achieved. The necessity is clear,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

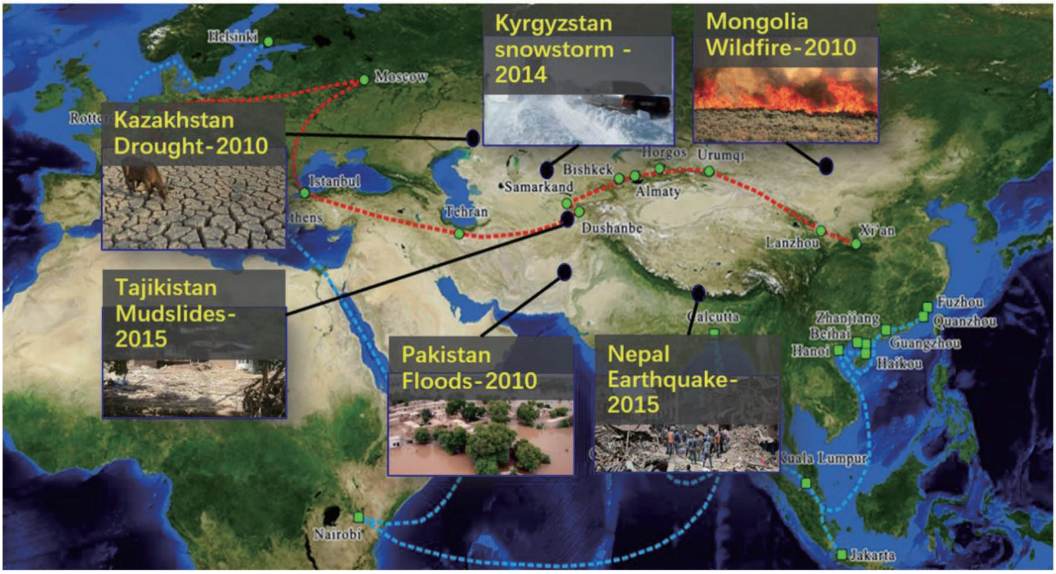
The platform, built specifically to focus on the regional spatial and temporal climate change over entire Belt and Road region and case study areas, aims to reveal the causes and regularity of extreme climate event occurrences, to develop a multi-source earth observation data set and model methodology 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

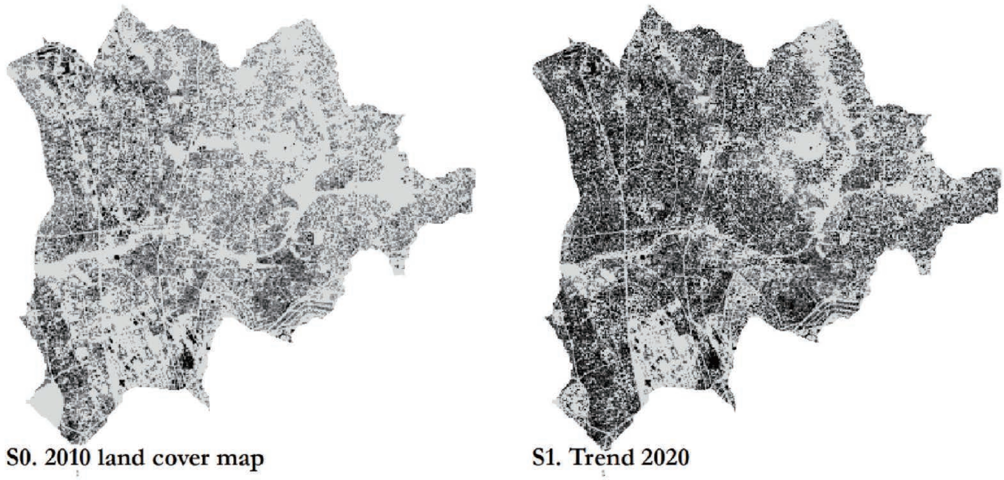
Development is vital for reducing disaster risk, yet many current development models are unsustainable and are instead driving and creating disaster risks. At the same time, disasters can destroy development gains, and many existing disaster risk reduction (DRR) and resilience approaches are not sufficiently 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).

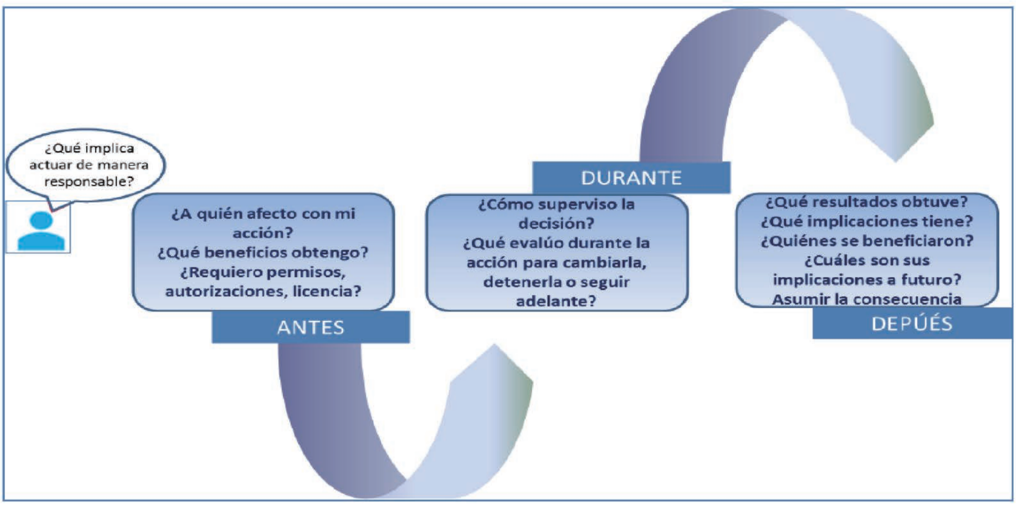


◆ Risk Management: A task for everyone

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



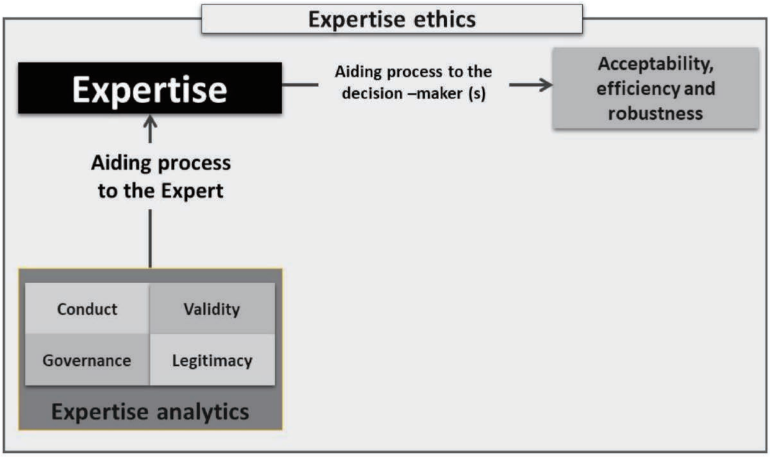
◆ Analytics and Ethics of Disaster Risk Decision-Making in France

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.

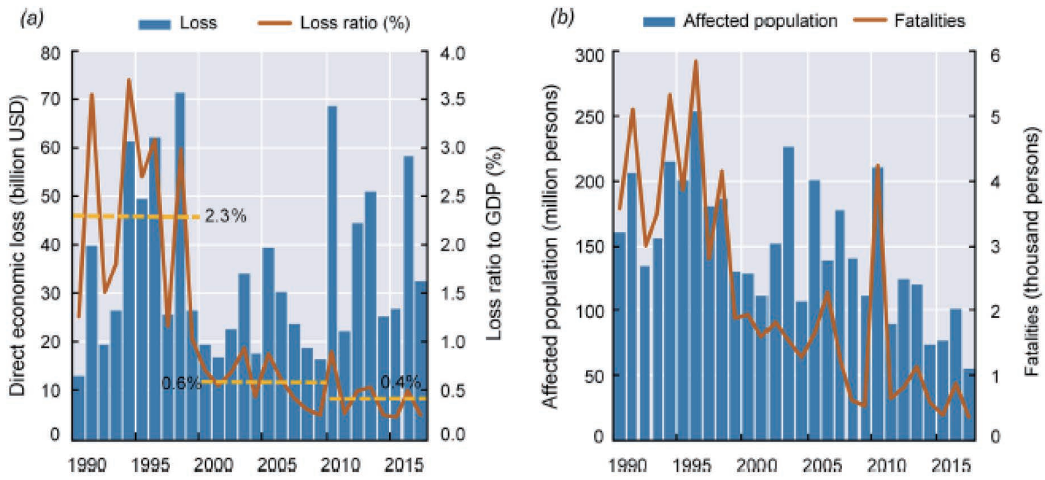
Local vulnerability has been assessed based on extreme disasters such as 1998 Yangtze River flood in China, 2010-2012 Canterbury earthquakes sequence in New Zealand, 2017 Hurricane Maria in USA. Indices, framework, research priorities, vision papers, and so on are provided in order to reduce risk and 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.

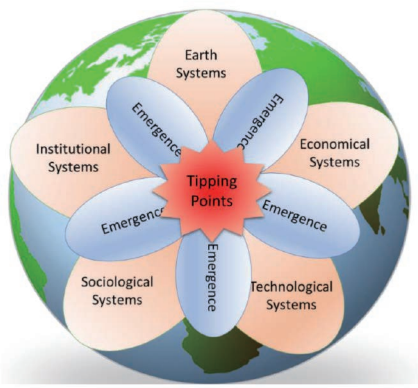
O3.2 Effective approaches to risk reduction

◆ 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

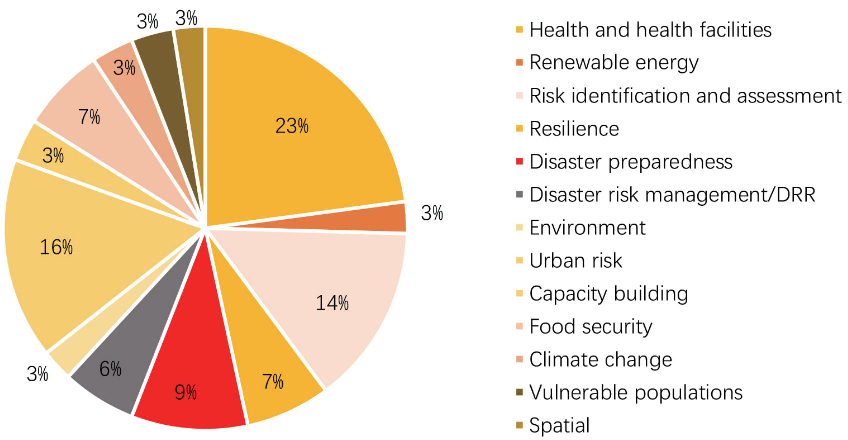
Network (ADRRN[26]) and UN agencies and donors, NSET is also able to dispatch teams of professionals and building construction technicians (masons) to different earthquake affected areas in Gujarat, Banda Aceh, Bam, and Pakistan, sharing their experiences in capacity enhancement for earthquake response 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

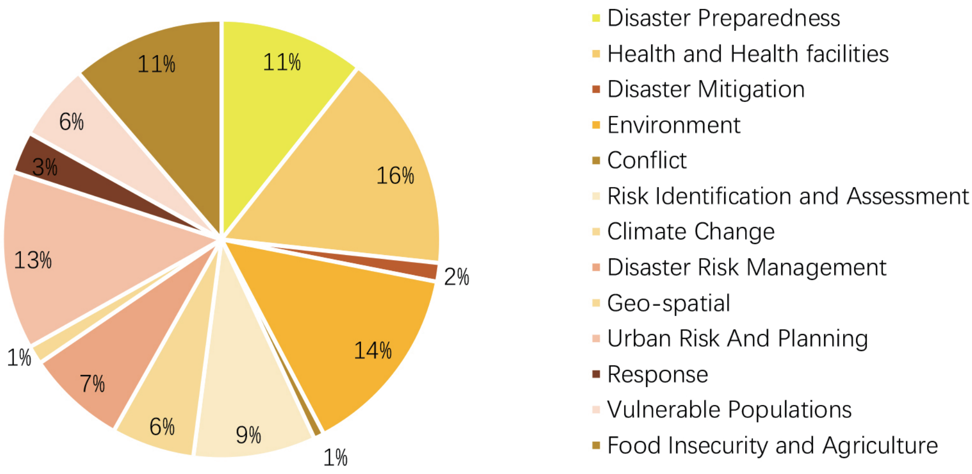
A major Focus of the **PERIPERI U** partners is the generating and communication of applied research outputs related to the risks and vulnerabilities in African countries. Between 2016 – 2019, PERIPERI U partners produced 83 publications and reports focused on disaster risk related issues. These included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

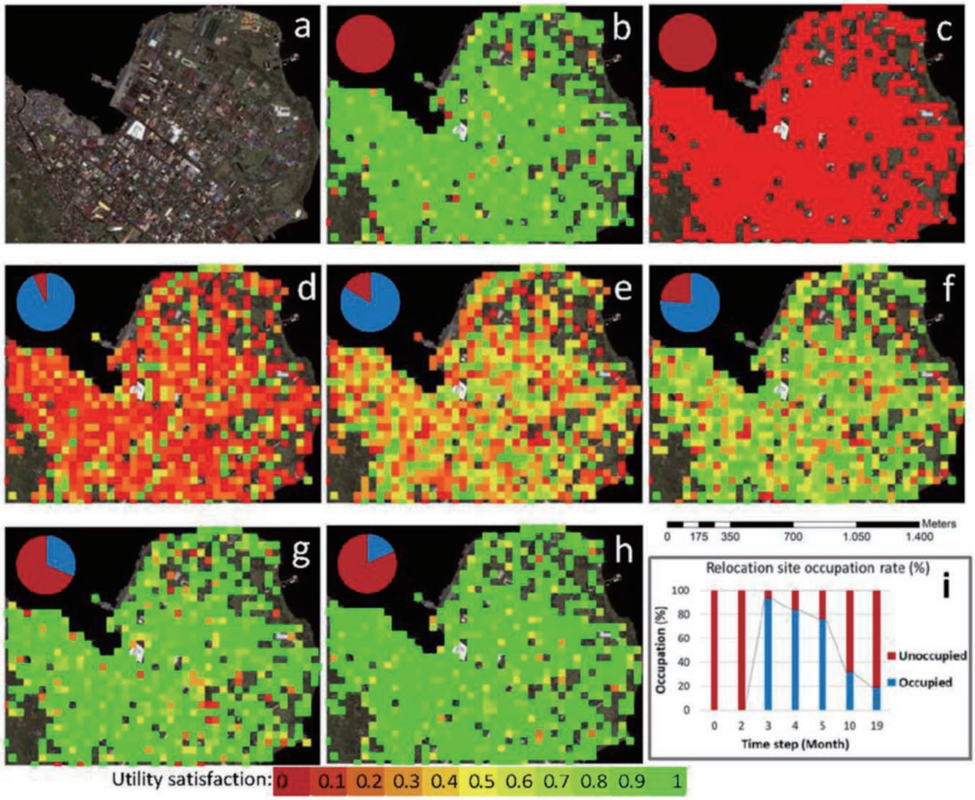
1) Extreme event attribution: unraveling the complexity of the causes and effects of the impact of extreme events, where climate change, urbanization, scarcity of resources all play a role. This will help bring into focus the most important processes leading to better resilience.

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.

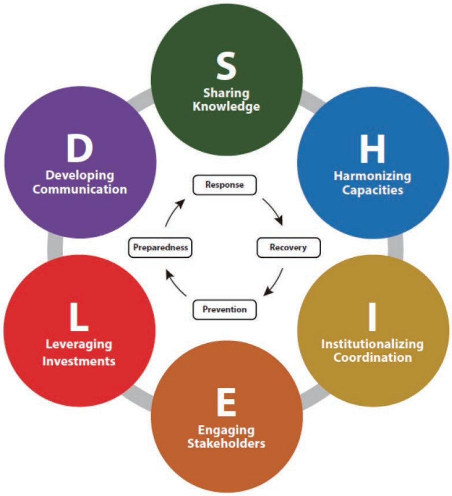
T1.1 Map capacity for disaster reduction.

◆ 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.

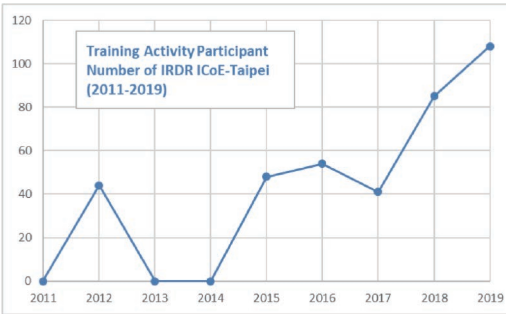
B. DRR researches based on interdisciplinary strength

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/

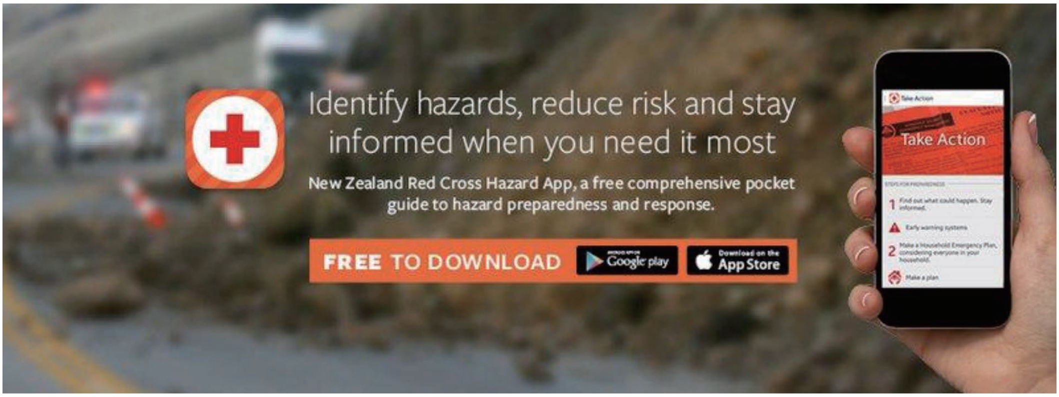
IRDR ICoE-Taipei allocates another part of its resources to inviting scholars to visit and share their experiences and insight as it encourages the exchange of ideas and information among scientists from different disciplines between the research institutes. This visiting program is open to all applicants, 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

◆ 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

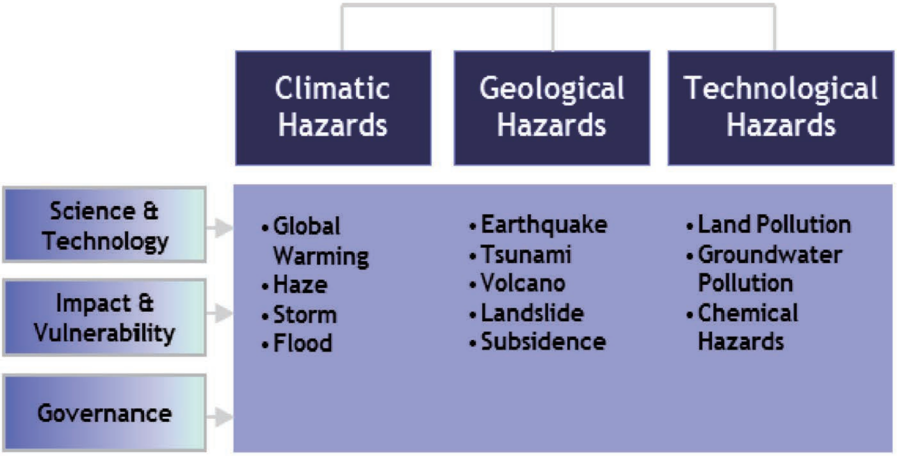
Date	International Activities Conducted or Co-sponsored by ICoE-Taipei	Seed Grant
APR, 2011	Cities at Risk: Building Adaptive Capacities for Managing Climate Change Risks in Asian Coastal Cities (CAR II)	
MAR, 2012	Advanced Institute on Forensic Investigations of Disasters – Southeast Asia (AI-FORIN)	
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.



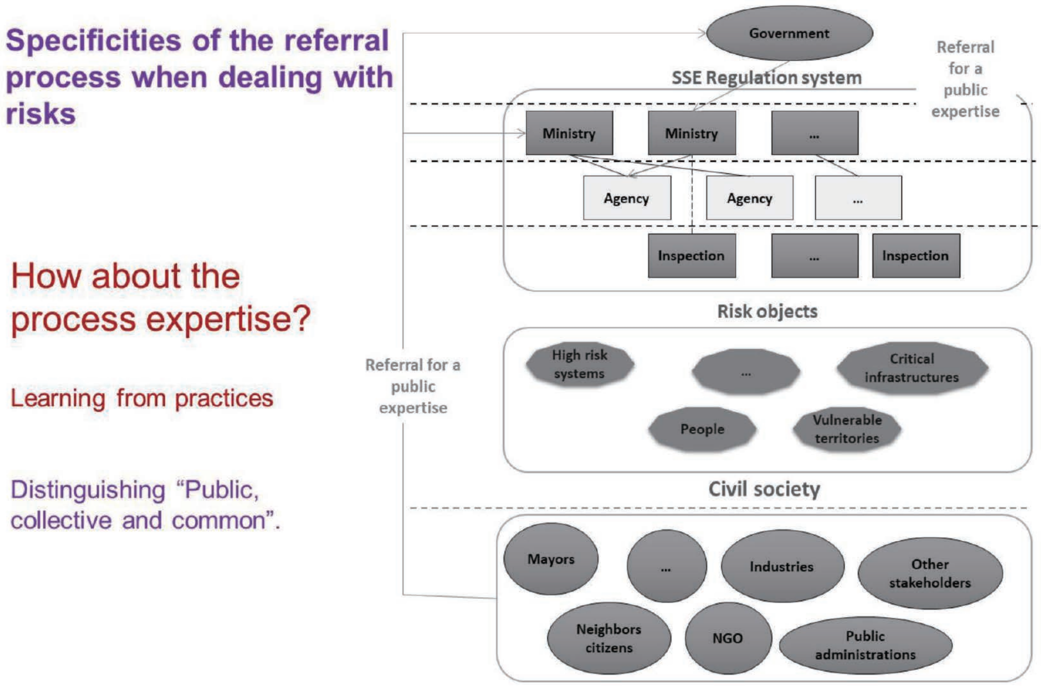
IRDR ICoE-SEADPRI-UKM serves as the coordinating centre for the Asian Network on Climate Science and Technology (ANCST[32]), a self-organised virtual network that links researchers working on climate science of importance to Asia, established in 2013 with seed-funding from the Cambridge Malaysian Education 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

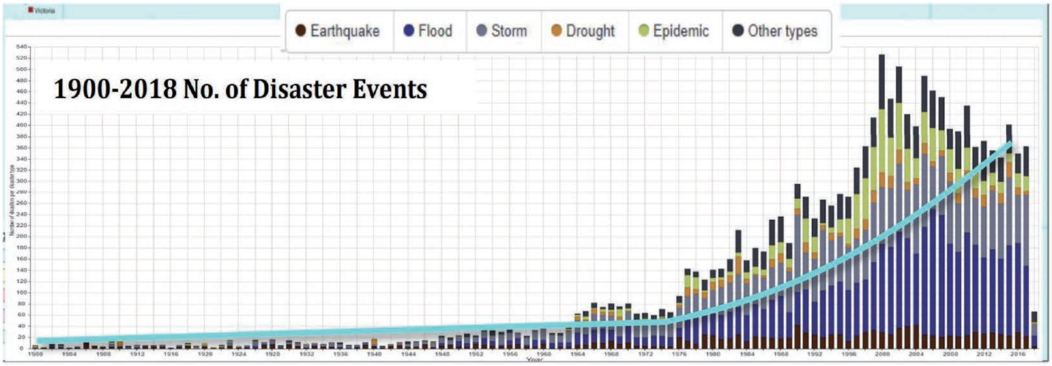
A wide range of hazards, including earthquakes, tornadoes, and multi-hazard, at different scales occurred in different geographical regions. Case studies aim to analyse crises or disasters caused by natural phenomena to draw lessons for the future. NCs and ICoEs from America (Canada and Colombia), Asia (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

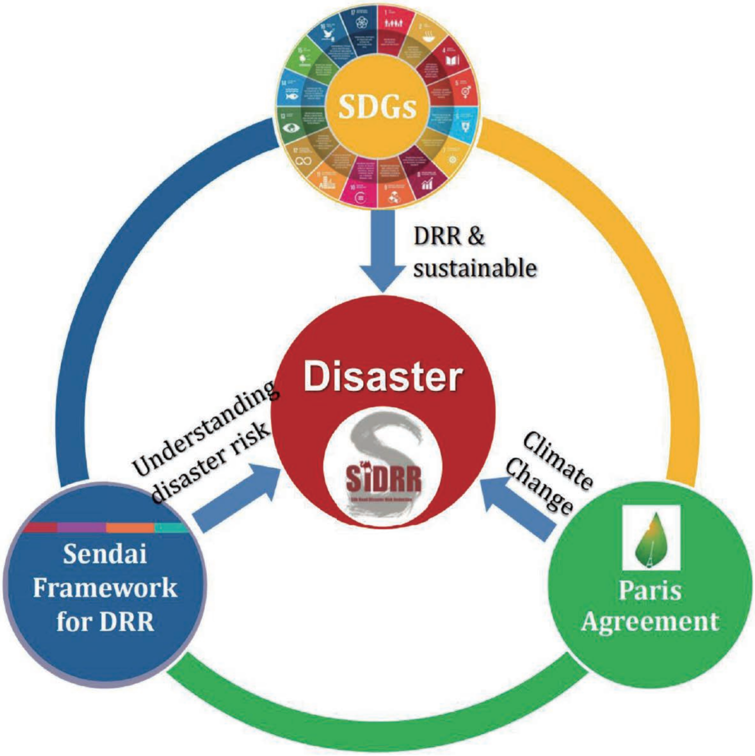
The Silk Road, which links four ancient civilizations, is a well-known ancient trade and cultural exchange route. The modern Silk Road, which inherits the spirit of the ancient Silk Road, encompassing a vast area with more than 140 countries and nearly 66% of the world's population (Cui et al., 2017; 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).

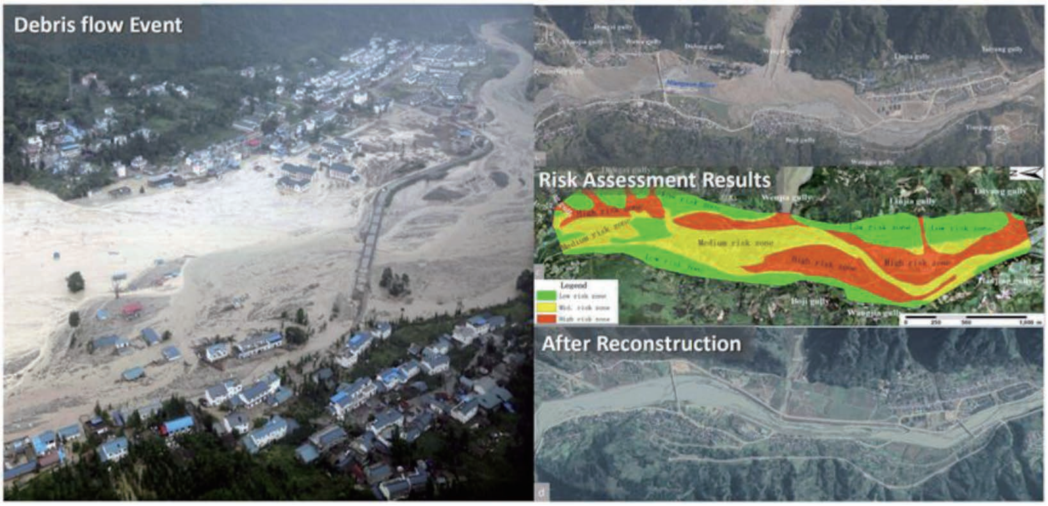
In line with the Sendai Framework and the UN's SDGs 2030 Agenda, the **Silk Road Disaster Risk Reduction (SiDRR)** was launched in 2016 as an international research program on disaster risk reduction (Lei et al., 2018), with the goal of enhancing global actions towards a greener and more resilient Silk 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.



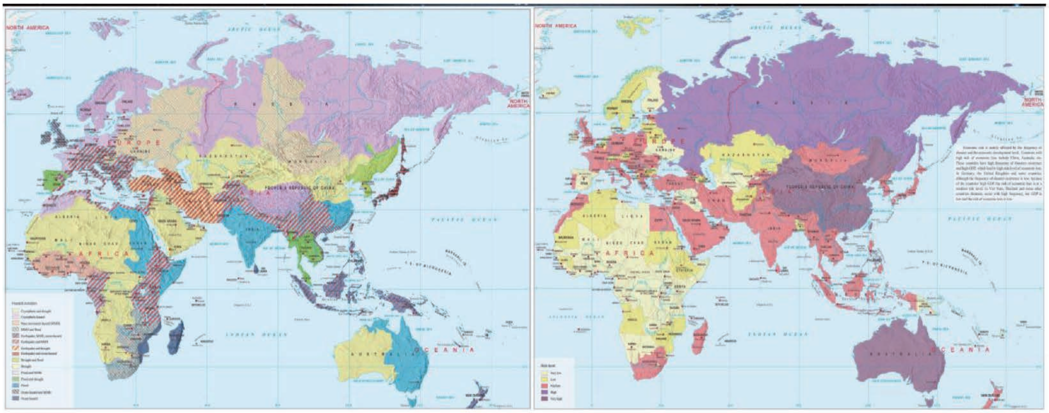
B. Atlas of Silk Road Disaster Risk and Glance at Silk Road Disaster Risk

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.

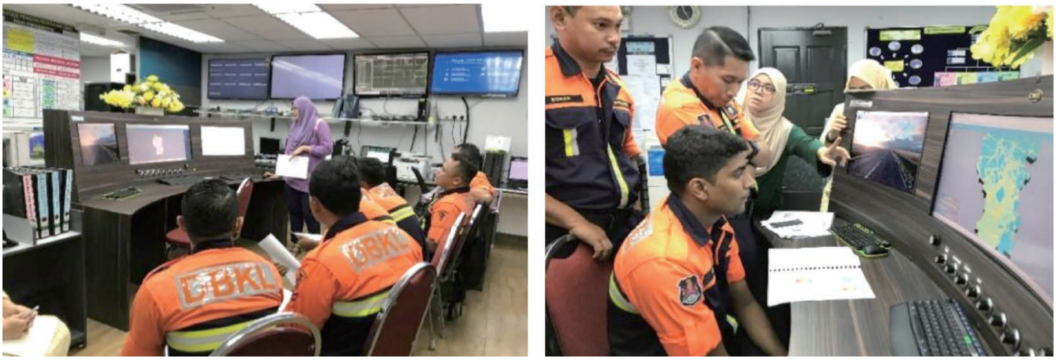
D. Establishment of the Alliance of International Science Organizations on Disaster Risk Reduction

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.

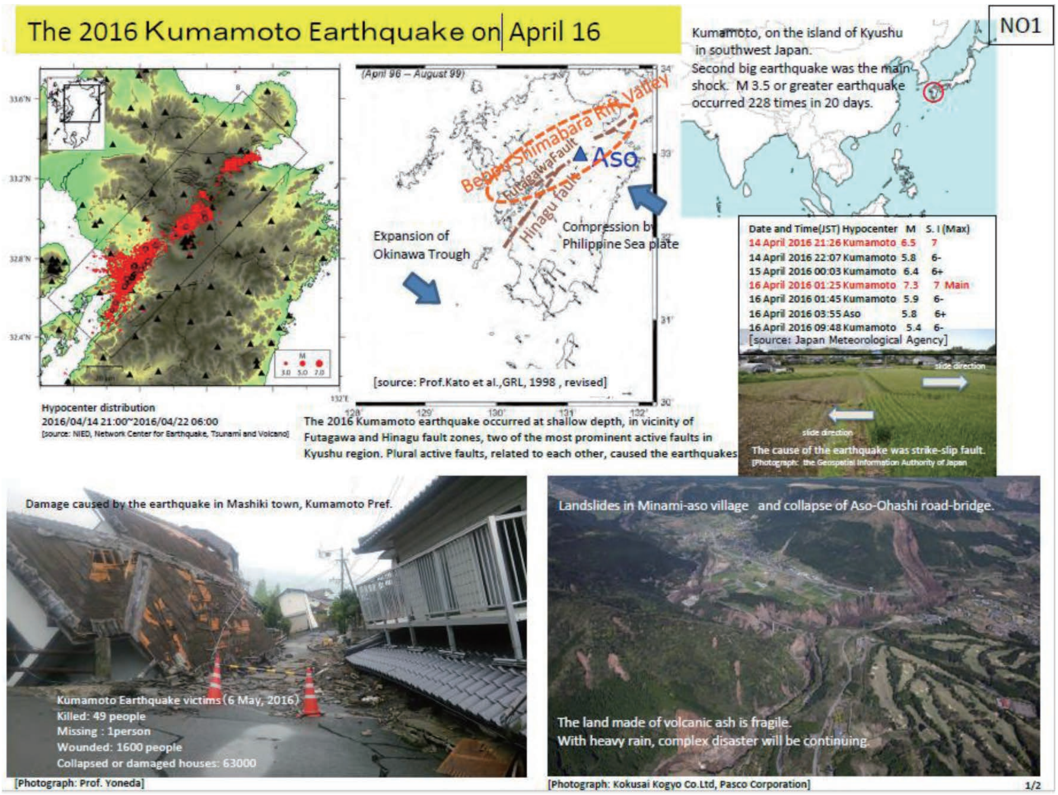
In the academic world, trends have been towards increasing specialization, with integration weakened as a result. To mitigate against such a trend, members of the Science Council of Japan (SCJ) and 47 academic societies (later 55) established JANET-DR which covers social sciences, life sciences, natural 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

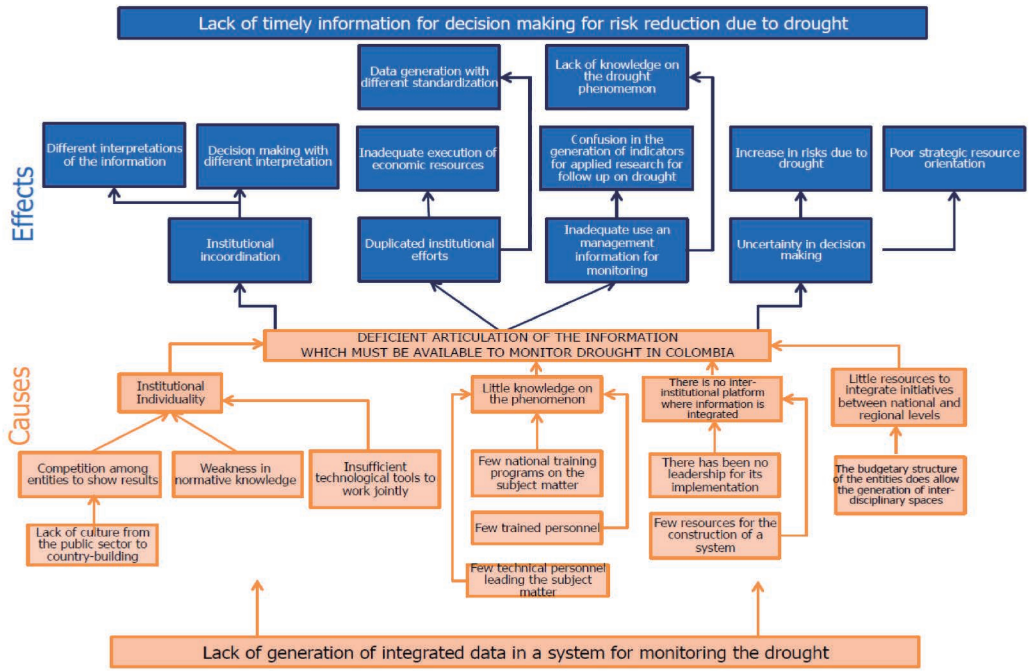
Climate prediction and climate variability in Colombia became a central theme in the government agenda. Lessons learned from past events of the El Niño-La Niña Southern Oscillation (ENSO) have shown the path to research the influence of this phenomena in Colombia. While El Niño reduces rainfall, especially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

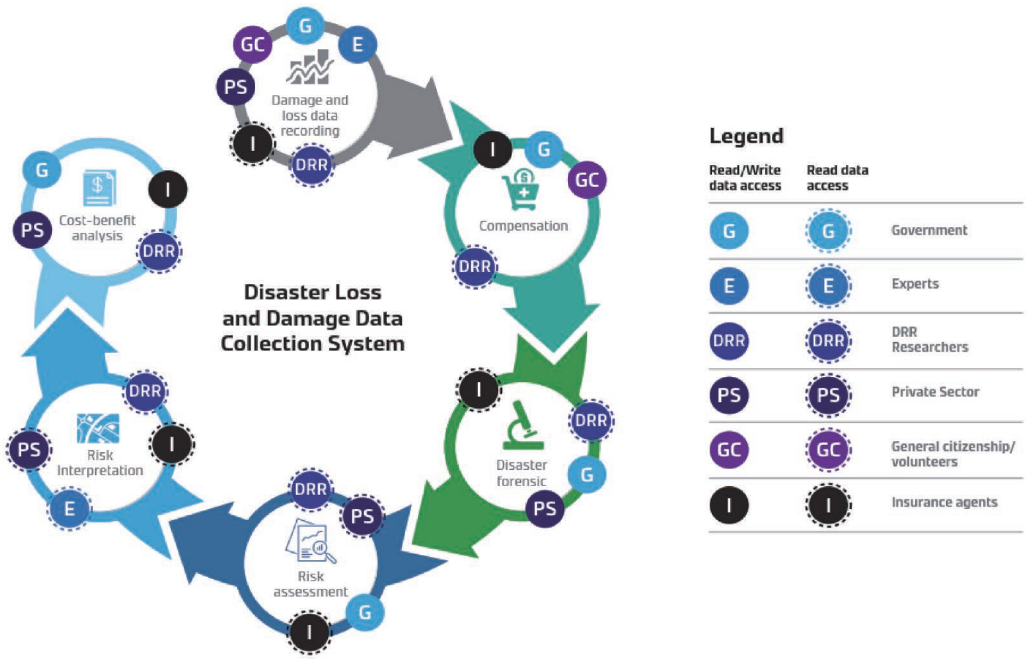
The DATA project has identified the following specific project objectives:

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 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).

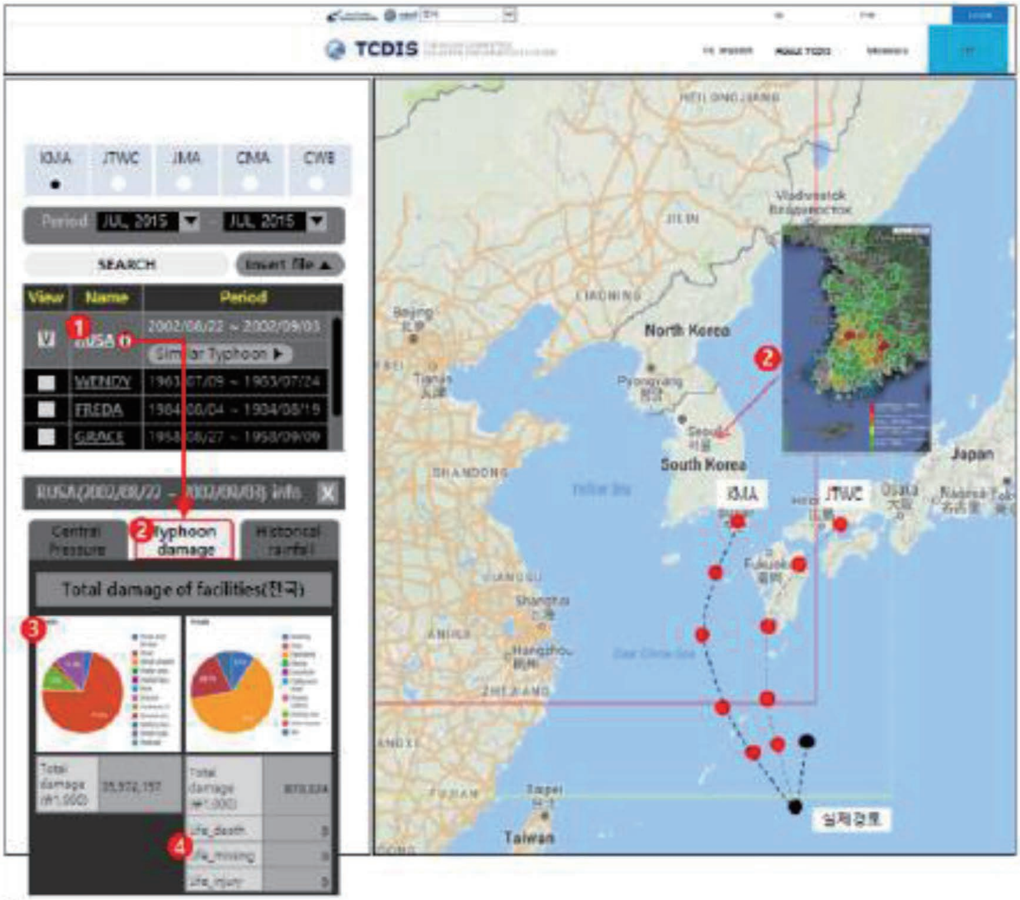
◆ Typhoon Disaster Information System (TCDIS)

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.

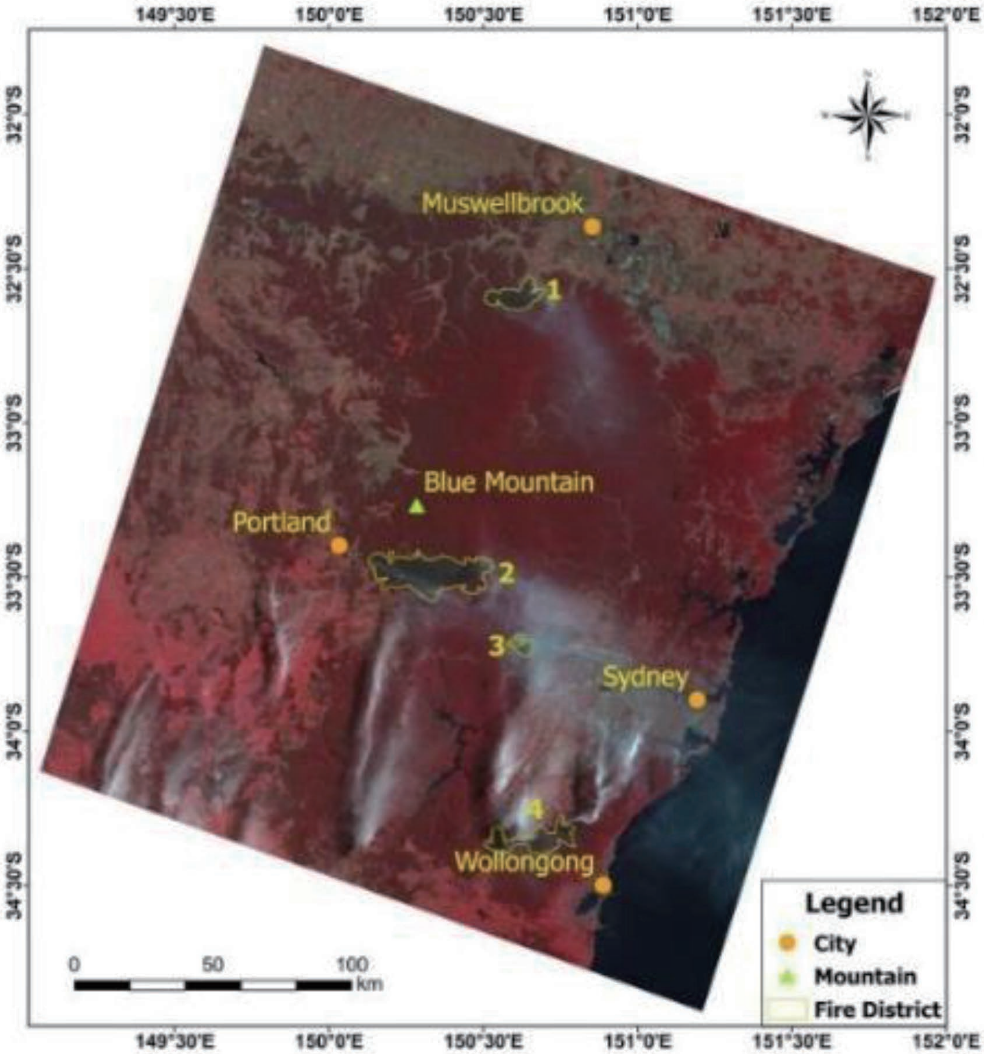


Figure 2-58: **GF images of Kal Mochan Temple in Kathmandu during 2015 Nepal Earthquake (Image from RADI, CAS).**

(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

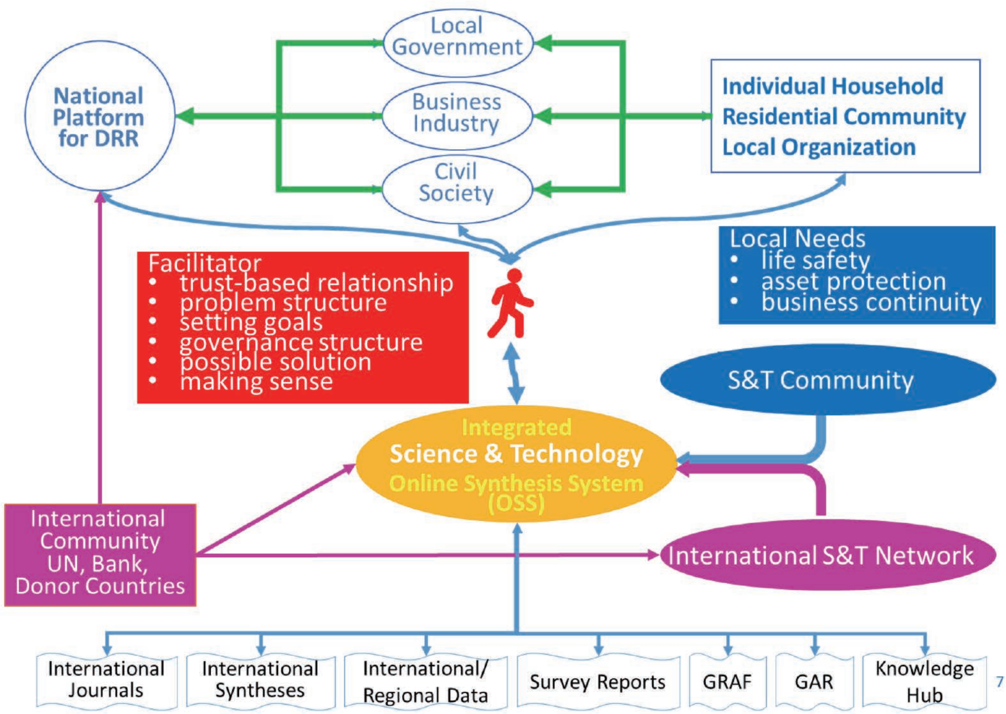
45 http://wci.t.u-tokyo.ac.jp/ResilienceForum2017/pdf/WG7_Periodic%20Synthesis.pdf

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. 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 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).**

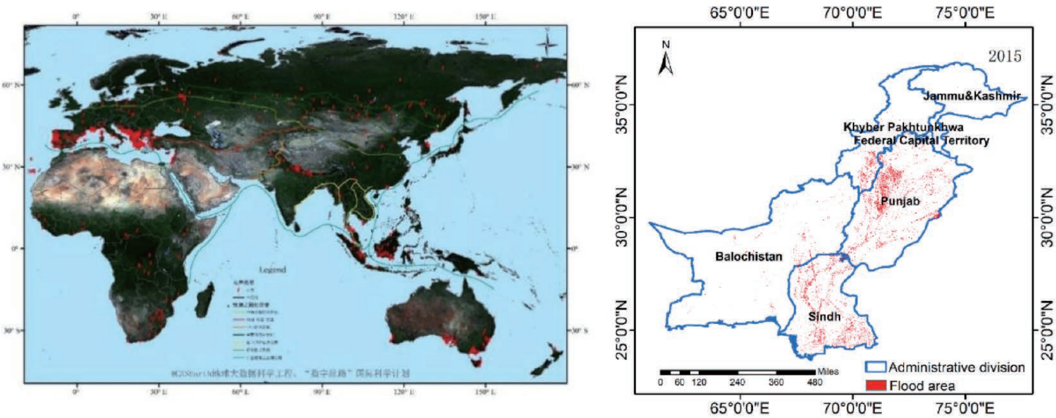


Figure 2-61: **Research report on DRR include in GAR 2019.**

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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:

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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.

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

◆ 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

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. 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.

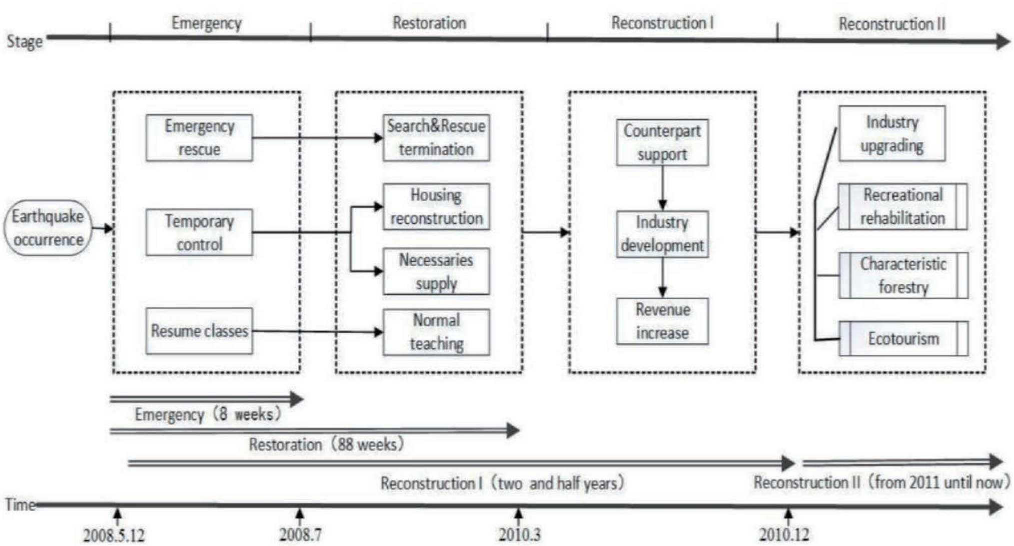
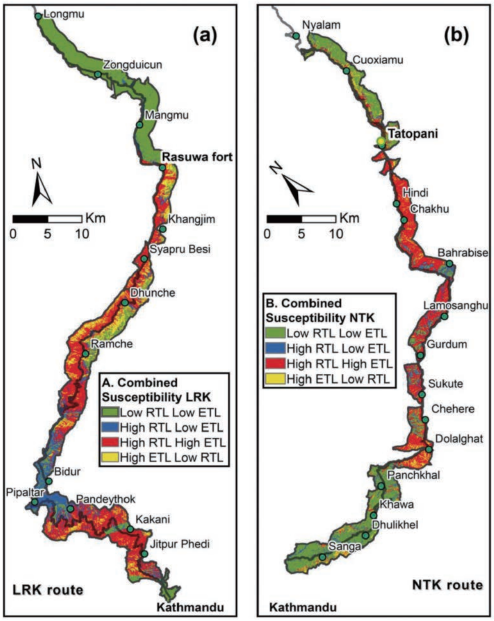


Figure 2-64: Combined rainfall and earthquake triggered landslides susceptibility maps for the two important China-Nepal economic highway road corridors (LRK and NRK).



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.

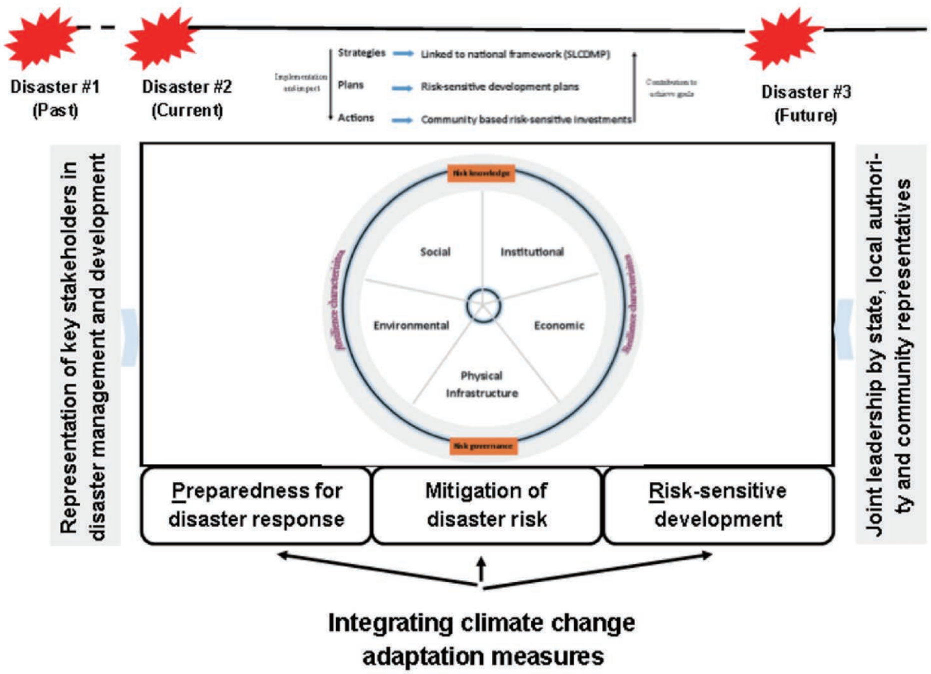
Kaushal Raj Gnyawali from Nepal contributed to the IRDR objectives 1.1, 1.2 and 3.1 and Sendai Target D and F, undertaking a comprehensive mapping of areas susceptible to landslides along the China-Nepal highway corridors, and with both transboundary and infrastructure risks addressed. The work is also 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: 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

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