Coordinators

• Rajib Shaw, Keio University
• Animesh Kumar, UNDRR

Key Contributors

• Ailsa Holloway, Auckland University of Technology (New Zealand)
• Joy Jacqueline Pereira, SEADPRI-UKM (Malaysia)
• Mahua Mukherjee, IIT Roorkee (India)
• Rajib Shaw, Keio University (Japan)
• Ranit Chatterjee, Kyoto University (Japan) and RIKA (India)
• Saini Yang, Beijing Normal University (China)
• Shirish Ravan, UNOOSA
• Takako Izumi, Tohoku University (Japan)

Citation


The findings, interpretations, and conclusions expressed in this document do not necessarily reflect the views of UNDRR or of the United Nations Secretariat, partners, and governments, and are based on the inputs received from different contributions received from the science and technology community.

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For additional information, please contact:
United Nations Office for Disaster Risk Reduction (UNDRR)
9-11 Rue de Varembé, 1202 Geneva, Switzerland, Tel: +41 22 917 89 08

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ABOUT THE REPORT

This publication is developed by a group of individuals from the UNDRR Asia-Pacific Science, Technology and Academia Advisory Group (AP-STAAG) with contributions and support from researchers, scientists from different countries in the Asia-Pacific region. The publication is based on a qualitative survey and submission of case studies on application of science and technology for disaster risk reduction specific to four Priorities for Action of the Sendai Framework for Disaster Risk Reduction. A total of 69 responses were received representing government, UN agencies, network of universities and the U-Inspire Alliance. A total of 23 case studies were also received from 11 countries, besides four case studies on specific themes.

The study is presented in three parts:

**Part-1**, based on the survey responses, presents the regional analysis of the progress in Science and Technology roadmap for disaster risk reduction.

**Part-2** of the report presents a regional status update of six selected themes namely; 1) NATECH 2) Eco-DRR 3) Capacities Building in Higher Education 4) Socio-Economic of Resilient Infrastructure 5) Space application 6) Urban Resilience and Climate Change.

**Part-3** includes 27 examples on different themes and actions as listed under the Science and Technology Roadmap. They highlight actions being taken in different countries of the region so to achieve one or more outputs of the roadmap.

The publication is commissioned by the United Nations Office of Disaster Risk Reduction and supported by the U-Inspire Alliance.
The Asia-Pacific region is facing an increase in the number of disasters, leading to immense human, physical, environment and economic losses. The increasing trend of disasters and the growth of new hazard risks throughout Asia and the Pacific due to climate change are reminders of the need to encourage a multi-sectoral approach to mitigate and reduce future risks.

Among the various sectors, science and technology stands out as especially critical to disaster risk reduction; from furthering our understanding of risk, to facilitating informed decision-making, and developing new methods to building resilience and minimizing disaster impacts. Realizing its importance, the Sendai Framework for Disaster Risk Reduction 2015-2030 calls for the integration of science and technology into the implementation of the Framework’s four priorities for action, at the global, regional, national and local levels. This has led the UN Office for Disaster Risk Reduction (UNDRR) to establish the Science and Technology Advisory Group and its regional sub-groups. Guided by their own regional roadmap Asia-Pacific Science, Technology and Academia Advisory Group (AP-STAAG) was created to contextualize global efforts to address the unique needs of the region and to support the coherent implementation of the post-2015 frameworks.

In many regards, Asia-Pacific is already ahead of the world when it comes to utilizing science and technology towards risk reduction. The region is home to a number of universities that have developed curricula and courses around disaster risk reduction and have fostered research among a new generation of scholars. The advancements made in research cut across disciplines to include basic science, engineering and technology, social sciences and humanities, and have led to the development of new knowledge and innovations to support building sustainable and disaster resilient societies.

The Status of Science and Technology report is an attempt to capture some of this progress across geographies, stakeholders and disciplines in the Asia-Pacific region. Specifically, the report examines progress in a number of thematic areas and against the priorities of the Sendai Framework. The report shows that there is plenty of reason for optimism as the region has made strides in capacity building around understanding disaster risks and the dissemination of scientific knowledge to various stakeholders. At the same time, the report highlights areas of concern where more work is needed to integrate knowledge into policy and practice.

The creation of sound policies and scientific applications requires the cooperation of both the scientific community and DRR practitioners. I hope this report will help enrich the discussion on what can be done to strengthen the connection between science and policy. The resulting synergy will mean empowering local communities and practitioners in the field with the best tools and knowledge to accelerate progress towards climate and disaster risk-informed development and save lives.

Loretta Hieber Girardet
Chief, UNDRR Regional Office for Asia and the Pacific
The Science and Technology Roadmap to Support the Implementation of the Sendai Framework for Disaster Risk Reduction was developed in 2016 and subsequently contextualized in 2018 to enhance its coherence with other global frameworks such as the 2030 Agenda for Sustainable Development, Paris Agreement, and the New Urban Agenda. The revised S&T roadmap includes four expected outcomes and 58 actions structured around the four Priority for Actions of the Sendai Framework.

The roadmap is envisioned as a mechanism to foster collaboration among the scientific communities and other stakeholders for the coherence and implementation of methodologies and tools relevant to disaster risk reduction around common priorities and actions. The roadmap is considered a working document, to be periodically reviewed and updated in the event of future evolution of knowledge, new technologies, new Sendai Framework hazards and increasing importance of indigenous and local knowledge as well as citizen science.

The Asia-Pacific Science, Technology and Academia Advisory Group (AP-STAAG), formed shortly after the adoption of the Sendai Framework in 2015, has remained an active regional network of the S&T community in the region. This is evident from the substantive knowledge and research products developed by its members as well as jointly by the group. The organisation of regional gatherings of S&T community, e.g. 2016 in Bangkok and 2018 in Beijing has also strengthened the collaboration to advance the science-policy-practice nexus. The AP-STAAG is pleased to release this report at the 2020 Asia-Pacific S&T Conference on Disaster Risk Reduction, being organized in Kuala Lumpur, Malaysia as well as virtually.

The report finds that the maximum progress in implementation of the S&T roadmap has been made for Priority of Action 2 while the least has been made for Priority of Action 4. Among specific actions, major progress has been made in promoting disaster risk assessment in planning and development while incorporating build back better in insurance policies needs strengthening in future. This progress is in line with the commitments made by the AP-STAAG at the 2019 Global Platform where the AP-STAAG also emphasized the action of investment on developing young professionals in the field of multi-disciplinary disaster risk reduction, exemplified by the central role played by the U-Inspire Alliance in development of this report.

The status report of the S&T Roadmap is, hence, an important step for monitoring the progress in implementation of the Sendai Framework and is expected to advance the disaster risk reduction research agenda further in the Asia-Pacific region.

Rajib Shaw  
Co-Chair, AP-STAAG  
Professor, Graduate School of Media and Governance, Keio University

Animesh Kumar  
Co-Chair, AP-STAAG  
Deputy Chief, UNDRR Regional Office for Asia and the Pacific

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PART 1: REGIONAL ANALYSIS
Implementation of Science and Technology Roadmap in Asia-Pacific: Key Highlights

Priority for action with the most progress in implementation: Priority for Action 2- Strengthening Disaster Risk Governance to Manage Disaster Risk

Priority for action with the least progress in implementation: Priority for Action 4- Enhancing Disaster Preparedness for Effective Response, and to “Build Back Better” in Recovery, Rehabilitation and Reconstruction

Outcome with the most progress in implementation: Outcome 4- Capacity Building

Outcome with the least progress in implementation: Outcome 3- Monitoring and Review

Action with the most progress in implementation: Action 2.3.2- Promote disaster risk assessment in planning and development

Action with the least progress in implementation: Action 4.3.2- Incorporate build back better in insurance policies
The Science and Technology (S&T) Roadmap was one of the key outcomes of the UNDRR Science and Technology Conference, January 2016 in Geneva to support the Implementation of Sendai Framework for Disaster Risk Reduction 2015-2030. The document is envisioned as a mechanism to foster collaboration among the scientific communities and other stakeholders for the coherence and implementation of methodologies and tools relevant to disaster risk reduction around common priorities and actions. Subsequently, the S&T Roadmap has been contextualized and revised by UNDRR Science Technology Advisory Group (STAG) to enhance its relevance and coherence with other relevant agreements including Sustainable Development Goals, Paris Agreement, and the New Urban Agenda.

The ‘Science and Technology Roadmap to Support the Implementation of Sendai Framework for Disaster Risk Reduction 2015-2030’ includes four expected outcomes and fifty-eight actions structured around the four Priorities for Action of the Sendai Framework. The four expected outcomes are namely, assess and update data and knowledge, dissemination, monitoring and review, and capacity building. The implementation of the roadmap needs global, regional and local collaboration, cooperation and commitments from all the stakeholders. The implementation at the regional level highlight the common challenges faced, indigenous and local knowledge of the region and thus aids in better understanding of evolution of knowledge and technologies in the region. The roadmap being a working document will be periodically reviewed and updated; the study of regional implementation of the roadmap will aid in guiding the way ahead and enhancing the regional partnership.

An online qualitative survey was conducted in month of November 2019 to assess the progress made in the implementation of the S&T Roadmap in the Asia-Pacific region, by the Asia-Pacific Science, Technology and Academia Advisory Group (AP-STAAG). The questionnaire was designed and disseminated to diverse participants from various countries through.
University and research networks and Youth and Young Professional network (U-Inspire Alliance). The survey outcome specific progress made in achieving different outcomes and actions as laid down in the roadmap.

A total of sixty-nine respondents (fifty males and nineteen females) representing national government, inter-governmental organisations, United Nations organisations, and other stakeholders responded to the questionnaire (Figure 1).

Each survey respondent had to score for each action on a scale of 1 to 5, where 1 represents poor, and 5 represent ‘great’ level of implementation. The averages for each action/ outcome have been used to study the regional implementation of the roadmap. For the purpose of analysis, the average values between 0 and ≤1 have been marked as 1, >1 and ≤2 have been marked as 2 and so on (Tables 1, 2, 3, 4, 5, 6 and Figure 3).

The survey highlights that the participants have varying interest in different Priorities for Action of the Sendai Framework (Figure 2). The highest respondents were for Priority of Action 1 while the least were for priority of Action 3.

Further, to highlight the best practices of applying science and technology in the field of disaster risk reduction, a call for submission was made for case studies on implementation of various actions of the roadmap. A total of 24 case studies from Asia Pacific region were collected to showcase the progress in each of the priorities.

Figure 1: Categories of Participants

Figure 2: Mapping Interest in the Priorities for Action under SFDRR
## Table 1: Regional Implementation of Priority for Action 1
(1-Poor, 2-Fair, 3-Good, 4-Very good, 5-Great)

<table>
<thead>
<tr>
<th>#</th>
<th>Outcomes and Actions under the Roadmap</th>
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</thead>
<tbody>
<tr>
<td>1.1</td>
<td>Assess and update data and knowledge</td>
</tr>
<tr>
<td>1.1.1</td>
<td>Promote integrated and multi-disciplinary research</td>
</tr>
<tr>
<td>1.1.2</td>
<td>Conduct solution-driven research at all levels that involves the users in the earliest stages</td>
</tr>
<tr>
<td>1.1.3</td>
<td>Establish/link existing and update/maintain global databases</td>
</tr>
<tr>
<td>1.1.4</td>
<td>Develop methods, models, scenarios and tools</td>
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<tr>
<td>1.1.5</td>
<td>Integrate risk assessments across sectors</td>
</tr>
<tr>
<td>1.1.6</td>
<td>Promote scientific focus on disaster risk root causes, emerging risks and public health threats, insurance and social protection and safety nets</td>
</tr>
<tr>
<td>1.1.7</td>
<td>Analyse ethics of scientific input</td>
</tr>
<tr>
<td>1.1.8</td>
<td>Adopt a multi-hazard approach that integrates lessons learned, including trans-boundary, biological and technological and Natech hazards</td>
</tr>
<tr>
<td>1.2</td>
<td>Dissemination</td>
</tr>
<tr>
<td>1.2.1</td>
<td>Develop evidence-based research on effective dissemination strategies for informed decision and policy- making</td>
</tr>
<tr>
<td>1.2.2</td>
<td>Promote access to data, information and technology</td>
</tr>
<tr>
<td>1.2.3</td>
<td>Integrate traditional, indigenous and local knowledge and practices</td>
</tr>
<tr>
<td>1.2.4</td>
<td>Develop partnerships between all S&amp;T and DRR stakeholders, and integrate gender equality</td>
</tr>
<tr>
<td>1.3</td>
<td>Monitoring and review</td>
</tr>
<tr>
<td>1.3.1</td>
<td>Link Science and Technology progress to Sendai Monitoring indicators, and report using online voluntary commitment system</td>
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<tr>
<td>1.3.2</td>
<td>Promote coherence in data collection and M&amp;E indicators with SDGs and Paris Agreement</td>
</tr>
<tr>
<td>1.3.3</td>
<td>Develop a liaison group between the DRR community and the major global assessments, such as IPCC 6th Assessment Report and other related assessment</td>
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<tr>
<td>1.4</td>
<td>Capacity building</td>
</tr>
<tr>
<td>1.4.1</td>
<td>Build national and local capacities for the design, implementation and improvement of DRR plans</td>
</tr>
<tr>
<td>1.4.2</td>
<td>Promote inclusiveness, interdisciplinary, and inter-generational participatory approaches</td>
</tr>
<tr>
<td>1.4.3</td>
<td>Develop expertise and personnel to use data, information and technology</td>
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<tr>
<td>1.4.4</td>
<td>Promote the development and use of standards and protocols, including certifications</td>
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<tr>
<td>1.4.5</td>
<td>Utilize knowledge resources of S&amp;T community for effective education programs on disaster risk reduction for scientists, practitioners and communities</td>
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<tr>
<td>1.4.6</td>
<td>Promote systems approaches in understanding disaster for better informed decision</td>
</tr>
</tbody>
</table>
### Regional Implementation of Priority for Action 2: Strengthening Disaster Risk Governance to Manage Disaster Risk

**Table 2: Regional Implementation of Priority for Action 2**  
(1-Poor, 2-Fair, 3-Good, 4-Very good, 5-Great)

<table>
<thead>
<tr>
<th>#</th>
<th>Outcomes and Actions under the Roadmap</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
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<tbody>
<tr>
<td>2.1</td>
<td>Assess and update data and knowledge</td>
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<tr>
<td>2.1.1</td>
<td>Consider root causes of risk and inputs from traditional knowledge for decision-making</td>
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<tr>
<td>2.1.2</td>
<td>Promote disaster risk assessment in spatial planning and development both in public and private sectors and increase participation of civil society for this process</td>
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<tr>
<td>2.1.3</td>
<td>Integrate climate change adaptation &amp; DRR and other relevant sectors (such as well-being, environment, health, economy, etc.) in governance mechanism</td>
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<td>2.1.4</td>
<td>Develop flexible governance system to adapt to emerging risks and climate change</td>
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<td>2.1.5</td>
<td>Promote the assessment of ecosystem-based development options</td>
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<td>2.2</td>
<td>Dissemination</td>
<td></td>
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<tr>
<td>2.2.1</td>
<td>Promote dialogue and networking on DRR between scientists, academia, policy-makers, civil society, media, business and private sectors at regional, national and sub-national level</td>
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<td>2.2.2</td>
<td>Raise scientific awareness and improve understanding</td>
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<tr>
<td>2.2.3</td>
<td>Establish an understandable, practical, evidence based scientific knowledge is needed for all actors</td>
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<td>2.2.4</td>
<td>Improve access to data on DRR generated by international organizations, S&amp;T communities, governments and different levels and stakeholders</td>
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<td>2.3</td>
<td>Monitoring and review</td>
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<td>2.3.1</td>
<td>Strengthen the engagement of S&amp;T in national coordination and promote sub-national implementation.</td>
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<td>2.3.2</td>
<td>Promote disaster risk assessment in planning and development</td>
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<tr>
<td>2.3.3</td>
<td>Promote participatory monitoring mechanism involving civil society organization and local communities</td>
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<td>2.4</td>
<td>Capacity building</td>
<td></td>
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<tr>
<td>2.4.1</td>
<td>Promote dialogue and networking on DRR between scientists and policy-makers, civil society and business</td>
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<tr>
<td>2.4.2</td>
<td>Raise scientific awareness and improve understanding, considering future risk</td>
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### Table 3: Regional Implementation of Priority for Action 3
(1-Poor, 2-Fair, 3-Good, 4-Very good, 5-Great)

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<th>#</th>
<th>Outcomes and Actions under the Roadmap</th>
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<th>3</th>
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<tbody>
<tr>
<td>3.1</td>
<td>Assess and update data and knowledge</td>
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<tr>
<td>3.1.1</td>
<td>Assess &amp; update the status of mainstreaming science &amp; technology in DRR</td>
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<td>3.1.2</td>
<td>Provide funding for science &amp; technology in DRR to enhance knowledge, research, technology transfer</td>
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<td>3.1.3</td>
<td>Assess the impact of investment of S&amp;T in DRR</td>
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<tr>
<td>3.1.4</td>
<td>Include scientists of all disciplines in analyzing investment in DRR as well as climate change adaptation, including loss and damages</td>
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<td>3.1.5</td>
<td>Conduct research, develop tools, explore challenges in S&amp;T in DRR</td>
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<td>3.2</td>
<td>Dissemination</td>
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<tr>
<td>3.2.1</td>
<td>Promote various means of science communication for decision-making &amp; policy makers</td>
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<td>3.2.2</td>
<td>Promote changing roles of science and reflective practices of implementation that will contribute to the effectiveness of disaster risk reduction</td>
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<td>3.3</td>
<td>Monitoring and review</td>
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<tr>
<td>3.3.1</td>
<td>Monitor science &amp; technology investment in DRR as an integral part of national plan &amp; policies</td>
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<tr>
<td>3.3.2</td>
<td>Collect information on voluntary evaluation of S&amp;T investment achievements periodically in collaboration with S&amp;T partners</td>
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<td>3.3.3</td>
<td>Support innovations in earth observation and geospatial data for risk profiling and decision making</td>
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<tr>
<td>3.4</td>
<td>Capacity building</td>
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<tr>
<td>3.4.1</td>
<td>Encourage &amp; enhance capacity of stakeholders in DRR to increase investment in science &amp; technology</td>
<td></td>
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</tbody>
</table>

### Table 4: Regional Implementation of Priority for Action 4
(1-Poor, 2-Fair, 3-Good, 4-Very good, 5-Great)

<table>
<thead>
<tr>
<th>#</th>
<th>Outcomes and Actions under the Roadmap</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.1</td>
<td>Assess and update data and knowledge</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>4.1.1</td>
<td>Promote multi hazards early warning systems with improved climate information, aerial and spatial data, emergency response services and communication to end users</td>
<td></td>
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<tr>
<td>4.1.2</td>
<td>Develop and share best practices in new threats and risks (including infectious diseases) to inform preparedness planning.</td>
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<tr>
<td>4.1.3</td>
<td>Identify, collect and analyze case studies and assess options to strengthen recovery and rebuilding efforts.</td>
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<tr>
<td>4.1.4</td>
<td>Collaborate with the humanitarian community in exploring best practice for survivor led response and reconstruction</td>
<td></td>
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</tbody>
</table>
4.2 Dissemination

4.2.1 Develop, disseminate information and practices on contingency planning and protection of critical infrastructure including the promotion of build back better approach in recovery, rehabilitation and reconstruction

4.2.2 Inform national disaster risk reduction plans and strategies that focus on community preparedness and awareness, including the needs of women, children, people living with a disability and the elderly in vulnerable situations

4.2.3 Review and share build back better indicators among the relevant stakeholders

4.3 Monitoring and review

4.3.1 Identify and address the need for, and gaps in, early warning systems in the least developed countries and the small island developing states

4.3.2 Incorporate build back better in insurance policies

4.4 Capacity building

4.4.1 Institutionalize effective recovery and reconstruction as strategies to reduce risk and promote resilient developments.

4.4.2 Promote science based decision making for resettlement processes.

4.4.3 Generate and utilize scientific information to gain prior public consensus on post disaster actions and to enable their smooth implementation after a disaster

Overall Analysis

The overall status of the regional implementation of the S&T Roadmap is good. The progress made under Priority for Action 2 Strengthening Disaster Risk Governance to Manage Disaster Risk is very good while the remaining three priorities progress score is good (Tables 5 and 6). Under the Priority for Action 2, maximum progress has been made towards promoting disaster risk assessment in planning and development while least progress is made in considering root causes of risk and inputs from

Table 5: Overall Regional Implementation of Priority for Action
(1-Poor, 2-Fair, 3-Good, 4-Very good, 5-Great)
Table 6: Implementation Status Matrix of Outcome per Priority for Action

<table>
<thead>
<tr>
<th>Priority for Action 1</th>
<th>Priority for Action 2</th>
<th>Priority for Action 3</th>
<th>Priority for Action 4</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Outcome 1: Data and Knowledge</td>
<td>2.84</td>
<td>2.97</td>
<td>2.85</td>
<td>3.00</td>
</tr>
<tr>
<td>Outcome 2: Dissemination</td>
<td>2.96</td>
<td>3.12</td>
<td>3.00</td>
<td>2.82</td>
</tr>
<tr>
<td>Outcome 3: Monitoring and review</td>
<td>2.68</td>
<td>3.15</td>
<td>2.97</td>
<td>2.48</td>
</tr>
<tr>
<td>Outcome 4: Capacity building</td>
<td>3.18</td>
<td>2.95</td>
<td>3.14</td>
<td>2.63</td>
</tr>
<tr>
<td>Average</td>
<td>2.94</td>
<td>3.05</td>
<td>2.93</td>
<td>2.77</td>
</tr>
</tbody>
</table>

Legend (Poor, Fair, Good, Very good, Great)

Figure 3: Outcome-wise Progress in Implementation
traditional knowledge for decision making. The Priority for Action 4 has recorded the least progress in implementation amongst all.

Outcome 1- ‘Access and Update Data and Knowledge’ has witnessed good progress across all the Priority for Action; maximum being for Priority for Action 4 and least for Priority for Action 1. Thus, highlighting the need for better data and knowledge management using S&T tools to enhance the understanding of disaster risk.

Outcome 2- ‘Dissemination’ has the highest score for Priority for Action 2 which focuses on strengthening disaster risk governance to manage disaster risk. Priority for Action 4 which stress on enhancing disaster preparedness for effective response and building back better has witnessed least progress in dissemination. This may be attributed a lower progress made in reviewing and sharing build back better indicators among relevant stakeholders and also in developing and disseminating of relevant information and practices (action 4.2.3 and 4.2.1 respectively).

Outcome 3- ‘Monitoring and Review’ has recorded maximum progress in Priority for Action 2 and minimum in Priority for Action 4. Further, of all the outcomes, outcome 3 has witnessed maximum variation in average values for different Priority for Action, possibly highlighting the varied challenges/ practicality in its implementation across different actions.

Outcome 4- ‘Capacity Building’, the best implemented outcome, has recorded the most progress under Priority for Action 1 and the least under Priority for Action 4.
PART 2: THEMATIC REGIONAL STATUS
Introduction

Natural hazards/disasters often trigger a series of other disaster events which increase the complexity and cumulative impact of the disaster event. NATECH is one such event where, natural hazards (earthquakes, typhoons, landslides etc.) leads to triggering of technological disaster events. The NATECH events though have low probability but, in the past, have had significant impacts. This compounding impact of NATECH event is due that fact that socio-economic and environmental conditions of the industrial site and the surrounding areas may have been drastically altered by the natural hazard-induced disasters. Furthermore, the resource availability and deployment may be already overwhelmed in managing the natural hazard-induced disaster. Recent studies suggest a growth in the NATECH events globally emphasizing the need for better understanding and management of such events (Cruz and Suarez-Paba, 2019). Not all NATECH events are caused by a disaster but instead a mere hazard like lightning which might have no profound impact by itself can trigger a technological disaster as a cascading effect.

NATECH events can be broadly categorised under three heads namely, 1. Nature of the triggering natural hazard/disaster; 2. Time of onset; and 3. Site mobility. The categorisation based on the trigger natural hazards is the most routine sub classification approach for a NATECH event (Cruz and Suarez-Paba, 2019). This has two different sub heads of classification; i. Geological; ii. Hydro-meteorological. Where the geological hazards like earthquakes, tsunami, volcanic eruption and landslides can trigger a technological disaster. The 2011 east Japan earthquake and tsunami triggering the Fukushima nuclear disaster is a classic example of this type. The hydro-meteorological hazards like flood, typhoon, lightning, storms and extreme heat or cold have triggered technological disasters in the past. Time of onset is a crucial factor for a NATECH event. In majority of the cases reported so far, technological disasters have been triggered in short span of time following a natural hazard event. One exception

Regional Status of NATECH Risk Reduction

Ranit Chatterjee\textsuperscript{1,2}, Rajib Shaw\textsuperscript{2,3} and Takako Izumi\textsuperscript{4}
1. Kyoto University, Japan
2. Resilience Innovation Knowledge Academy, India
3. Keio University, Japan
4. Tohoku University, Japan

2.1

Regional Status of NATECH Risk Reduction
being a study on drought leading to fire in the gas pipelines and breaches caused by natural weathering. The third categorisation is based on mobility of the NATECH event site. As per the various types of NATECH sites listed by World Health Organisation (WHO, 2018) in their guidelines, majority of the possible sites are immobile in nature but there is considerable chance of a NATECH event being caused while transporting hazardous material. In such cases it is difficult to plan and preposition resources for managing NATECH risks.

**NATECH Risk in Asia Pacific**

The Asia Pacific region is a hotspot of natural hazards with majority of the disaster occurring in this region in the last 25 years. Considering that Asia Pacific region has experienced the highest rate of chemical industry growth across the past 25 years and at the same time urbanizing at a rapid rate, the cumulative risk is higher. Studies have established NATECH events accounts for 3-7% of all releases of hazardous materials reported in the United States, Europe and Japan (Krausmann, et al., 2011). Upward trend of NATECH events have been predicted for Asia Pacific region in future (Ariyanta et al., 2019). For Asia Pacific region, 2011 East Japan Earthquake and Tsunami leading to Fukushima nuclear disaster remains a point of reference but NATECH cases were reported earlier during the 1920 Tokyo, 1995 Kobe Earthquake, and 2004 Indian Ocean Tsunami.

**NATECH Legislations and Guidelines**

The Sendai Framework for Disaster Risk Reduction acknowledged the need to focus on technological hazards and disasters. The Global Assessment Report (GAR) of 2019 included NATECH along with hazards like environment, radiological, nuclear among others. The very first guidelines on chemical accidents was prepared by OECD in 2011. The guiding principles revolve around four pillars of prevention, preparation, response and follow up.

- Preventing the occurrence of incidents involving hazardous materials.
- Preparing for accidents, and mitigating adverse effects of accidents through effective planning.
- Responding to accidents that do occur in order to minimize impact.
- Follow-up to accidents, reporting and analysis.

The Sendai Framework for Disaster Risk Reduction of 2015 extended the definition of risk to include hazards of environmental, technological and biological nature in addition to earlier recognized natural and manmade hazards. Further the framework stressed for sectoral approach while building coherence among various related stakeholders to manage risk. In 2015, OECD came up with addendum number 2 to address natural hazards triggering technological accidents (natechs) adding to the earlier OECD guiding principles for chemical accident prevention, preparedness prepared in 2003. A new chapter was added to NATECH risk to support better management and preparedness. The guidelines focus inclusion of NATECH risk in hazard mapping, adequate training of human resources, regulations and planning, transboundary cooperation, and bettering of warning systems among others.

The UNDRR Word into Action guidelines (2017) emphasizes on NATECH as an emerging hazard risk and is inter-reliant on human, natural and technological systems. Acknowledging the lack of comprehensive NATECH assessment tools, the guidelines lists out quantitative, semi quantitative and qualitative tools (ARIPAR, RAPID-N, PANR) available at present for conducting regional and national risk assessments.

Global Assessment Report (2019) was first to include various hazards for the first time including NATECH linking its impact to social,
Progress in Science and Technology for NATECH Risk Management

A number of research and policy challenges and gaps exist which acts as an impediment for effective NATECH risk reduction such as lack of data on equipment vulnerability against natural hazards, and lack of holistic methodologies for risk assessment. Having said that, in the recent there has been focused and deliberate attempts from the academia and government to close this gap. This section shares some of the recent developments for NATECH risk management.

The Science and Technology Advisory Group of the United Nations Office of Disaster Risk Reduction established a working group in 2017 to facilitate NATECH risk management through various activities including awareness generation. In addition to this, a NATECH subgroup was formed for the Asia Pacific region by Asia Pacific Science and Technology Advisory Group (APSTAG). The NATECH working group of APSTAG had recently meet in 2019 in Sendai to share regional case studies and deliberate on developing a NATECH framework for the Asia Pacific region. In November 2019, a session on NATECH risk management was organised by the APSTAG working group members in the World Bosai Forum to create awareness and share research findings on NATECH. 18 regional cases studies have been identified and analysed leading to the formulation of guiding principles for NATECH risk management and establishment of a regional framework. It was agreed that ARISE platform and its country chapters will be an important driver for driving awareness and NATECH risk reduction initiatives in Asia Pacific region.

Way Forward

NATECH is emerging as an important theme cutting across research, policy making and implementation involving a host of different stakeholders ranging from private sector, governments to academia. The growing interest of the scientific community in NATECH is a precursor for the future to broaden the knowledge horizon and initiate risk management strategies and activities. The need for developing new methodologies, mainstreaming risk assessments into policy making and local level awareness and implementations remains a challenge for the future to tackle.
Regional Status of Ecosystem-based Disaster Risk Reduction

Mahua Mukherjee

1. IIT Roorkee, India

Introduction

The world’s population is projected to reach approximately 10.9 billion in 2050, and the population growth rate is to reduce by 2100, the first time after World War 2 (Cilluffo and Ruiz, 2019). Presently, 55% of the world’s population lives in urban areas, and the urban population is estimated to be 68% by 2050 (UNDESA, 2019). Declining quality of living in urban and rural areas is a significant concern for the majority of countries despite global initiatives on Sustainable development since last century. A shift from Millennium Development Goals (MDGs) (UN, 2000) to the Sustainable Development Goals (SDGs) (UNDP 2015) aims to broader participation of the developed countries to help reducing inequality gap and augment shared responsibilities. Social deprivation, economic disparity and environmental degradation critically reviewed, and collective decision on 17 SDGs taken in Rio+20 Conference in 2012.

Increasing population and rapid urbanisation are driving the threat of rising disaster risk. A paradigm shift in disaster management from rescue and relief to preparedness is found in the Hyogo Framework for Action (HFA, 2005-15); the pro-active disaster risk management advocated in HFA also took cognizance of widespread loss of ecosystems and their contribution towards disaster management. Promotion of risk reduction is the defining contribution of the Sendai Framework for Disaster Risk Reduction 2015-2030 (UNISDR, 2015). Progressive resilience journey of the global community for disaster management recognised increasing climate change-induced extreme events. Scientific investigations of past and future climate are now matured enough to forewarn on different scenario, and accordingly in search of adaptation and mitigation approaches.

Reported increase of natural and man-made hazards together with vulnerability, exposure and coping capacity spirals disaster risks for people, assets, infrastructure services, livelihoods and built-environment. Earthquake and tsunami in the Indian Ocean (2004) and in Japan (2011) left scars beyond recovery. Increasing pattern
of shifting climate is affecting food production and inducing extreme events cascading into flooding, inundation, forest fire, among others. The recent bushfires started in Australia in 2019 is now being debated to have an active link with climate change.

Community, governing councils at different scales, financial and political institutions and infrastructure providers are looking forward to convergence in Disaster Risk Reduction (DRR) and Climate Change Adaptation (CCA) initiatives. Global reports like Global Assessment Report (UNDRR, 2019), AR5- Synthesis Report (IPCC, 2015), 2030 Agenda for Sustainable Development (UN, 2015), New Urban Agenda (UN Habitat-III, 2016), took cognisance of risks due to disaster and climate change. Dialogues between the disaster risk management group and climate change scientists will influence two disconnected dots coming together towards points of converging.

The Nature-based solution (NbS) may emerge as the most opportune platform for confluence. The NbS includes natural management approaches for sustainable ecosystems. Ecosystem services (ESS) and resilience services (RS) from nature-based ecosystems are two motive strategies to facilitate the convergence of actions for DRR and CCA for a safer community. Natural elements, by their physical presence in specific geographical terrain, extend contextual ESS services like provision of food and materials, regulating environmental conditions and quality, supporting the flow of energy, nutrients, abiotic and biotic diversity, and cultural services including recreation and eco-tourism. Ecosystem-based disaster risk reduction (Eco-DRR) is an approach to risk reduction based on natural ecosystems and communities. Knowledge about individual ecosystems like mountain, coastal, dryland has helped to acceptance of the approach. In urban areas with spiralled complexity, development of Blue-Green Infrastructure (BGI) can serve the urban ecosystem; networking of existing natural elements can create infrastructure services to complement engineered (grey) infrastructure used for civic quality of living. The BGI is a sustainable option for future-ready infrastructure; it may help governing councils at national and sub-national levels to achieve several targets of SDGs and Sendai Framework priority actions.

**Definitions**

**Natural Solutions (NS) or Nature-based Solutions (NbS)** – “actions to protect, sustainably manage, and restore natural or modified ecosystems that address societal challenges effectively and adaptively, simultaneously providing human well-being and biodiversity benefits” (Cohen-Shacham et al. 2016).

**Eco-DRR** – Eco-DRR is the sustainable management, conservation and restoration of ecosystems to reduce disaster risk, intending to achieve sustainable and resilient development.

**Blue-Green Infrastructure (BGI)** – Any semi-/open area hosting network of multifunctional, natural and semi-natural green and blue features and processes to provide complementary or alternative ecosystem services such as water purification, air quality, space for recreation, and add value to spaces with the ability to offer resiliency against extreme weather events (heat island), or disasters (flooding) and climate change mitigation and adaptation (UNISDR, 2017: 96; Mukherjee and Takara, 2018). A BGI can be a significant component of Eco-DRR.

Blue elements include pond, stream, spring, river and creek corridors, delta, estuaries, waterways and wetlands, water tanks. Small private gardens to public parks, school/business establishments/institutional complexes/community open space, permeable plazas/squares/parking/pedestrian/cycle path, green roof and wall, sports field and cemeteries, forest reserves, urban agriculture farms and orchards, streets, primary transport...
(road, rail and tram) corridors with green edges including pedestrian path-, cycle- and waterways, unused land parcel for future development are typical examples of green elements.

**Benefits of Eco-DRR**

The Eco-DRR approach helps during mitigation and preparation phase through its ecosystem services (ESS) and response and recovery phases with its resilience services (RS). Healthy Ecosystem offers triple-bottom-line services, i.e. social, economic and environmental ESS benefits. Social ESS benefits tended by the ecosystem are increased social interaction, community livability, increased visibility of vulnerable groups, recreational opportunities, aesthetic enjoyments through reflection of season/ weather/ time of the day, sensory appreciation like visual, natural sounds and olfactory connect; alternate water-based transport, physical and psychological wellbeing, place-making, walkability, landscaping and attractiveness and educational opportunities about nature and its processes. Cultural and heritage value which imbibes attachments, meanings and symbolism to the relation between space and user, comfort and safety, security for air, water and food are few diverse parameters which ecosystems can augment. Essential life-skills, knowledge, and aptitudes are imparted through activities in natural spaces.

The economic benefits are more tangible, and assessed for direct and indirect benefits; e.g. ESS, business due to perceived attractiveness, health-care expenditure and local job creation. TEEB (2010) initiated ESS assessment for air pollution, storm water runoff, wastewater treatment, carbon sequestration and storage needs a mention. Presence of the natural elements within proximity enhances economic attractiveness of commercial precincts, amenity value, residential property values, and opportunities for tourism and economy regeneration. Savings in healthcare expenditure in terms of improved physical, mental and social health is a consequence of well-designed and maintained blue-green elements.

Environmental benefit from natural ecosystems is widely acknowledged; ecological processes enrich the biotic and abiotic community, through connectivity ensures a flow of energy, water, species and material. In urban areas, ecosystems influence micro-, local or mesoscale environmental impacts depending on its nature, size, and efficiency. Strategies like landscaping, shading, evapotranspiration, removal of pollution and storage of carbon results in reduced energy use and a healthy society. Urban agriculture helps citizens in the fresh food supply, getting species back in habitat, local economy generation and waste recycling.

Resilience services, RS, offered by nature-based ecosystems in addition to ESS, made NbS a noticeable approach in disaster management. Regulating services like climate modification, water management and coping capacity building are unique attributes of the NbS, which helps it to act as a resilience tool during mitigation and preparedness phase. It becomes a significant backdrop for art and literature, can host exhibitions and festivals, facilitates wellness and fitness principles. Like the proximity parameter for amenity value, resilience services are green assets with limited direct costs even for maintenance and can be adjudged for communities’ willingness to pay.

In the event of hazards striking a place, natural ecosystems act as a buffer and provide the first line of defences in case of a cyclone or flooding; and thus acknowledged as powerful resilience tool. In case of earthquake and landslide events, the blue-green spaces used as alternative or redundant space for rescue, relief and rehabilitation operations. Again preservation and conservation of blue-green elements shall get due priority during reconstruction after any disaster so that in future they can be integrated into resilience mission to reduce risk. Natural ecosystems help in substantially decrease the direct economic losses caused by disasters, including water-related disasters, with a focus on protecting the poor and people in vulnerable situations, damage to critical infrastructure and number of disruptions to essential services, attributed to disasters.

Eco-DRR enhances the preparedness of the community for disastrous events using nature as stakeholder; it provides resilience in case of any eventuality. Its characteristics of multi-functionality, connectivity, resource efficiency and resilience provide advantages over grey
Multi-functionality refers to delivering multiple benefits by occupying a single space. Connectivity adds value by linking and connecting green assets to people and services based on green engineering systems. Inclusion of natural processes endorses the BGI as resource-efficient; it provides an opportunity for sustainable livelihoods. Bouncing back to normalcy without losing lives, assets, services, time and livelihood is resilience. The BGI extends resilience measure to urban heat, heatwave, flooding, drought, pollution, and biodiversity loss to help in managing disaster Risk and climate change-induced events.

**Strategic Mainstreaming of Eco-DRR**

The Eco-DRR planning scale can be varying; region-, city-, neighbourhood-, building- and site- level action plan development depends on geo-environmental parameters, impending risks, health and fragmentation status of blue-green elements, and financial layout. Protective strategy for healthy ecosystem shall differ from a defensive strategy to control isolated and shrunk blue-green elements. Policy for Eco-DRR

Expansions and redevelopment after disaster events necessarily provide an opportunity for the Eco-DRR. Integration at regional/ local development plan can effectively make use of benefits of NbS for resilience capacity building instead of any ad-hoc decision. Expansions and redevelopment after disaster events necessarily provide an opportunity for the Eco-DRR. Inclusive Eco-DRR planning will not only help to foster climate resilience but also encourage the participation of women, youth and local and marginalised communities.

Tangible benefits of Eco-DRR are frequently assessed qualitatively. The Economics of Ecosystems and Biodiversity (TEEB, 2010) initiated assessment prototypes for ESS to make nature's contribution accounted for; services like air pollution reduction, storm water runoff reduction, and carbon sequestration and storage needs a mention. Similar initiatives to assess resilience services, to develop indicators to augment implementation and efficiency measure, technical details and monitoring protocols are required.

In urban areas, advocacy for rights of way of BGI like other engineered infrastructure, policy framing, standards and technical design details and specifications, ground implementation, and maintenance can improve awareness and implementation of NbS. Case studies on BGI inclusion from cities across the globe will help to learn lessons on blue-green elements’ contexts (both success and failures), the role of policy and associated technological interventions.

**Way Forward**

To take forward the efforts of Eco-DRR, the following action plan is suggested:

- Review existing initiatives and develop Eco-DRR Mainstreaming Framework suitable for policy interventions in the Asia-Pacific region
- Develop arguments in favour of eco-based approaches for CCA and DRR
- Engage in discussion to achieve Resilience Infrastructure status and Rights of way for BGI in urban areas
- Develop socio-economic and environmental cost-benefit analysis models to assess resilience services of NbS for acceptance among diverse stakeholders
- Preparation of Standards, technical design details, Detailed Project Report (DPR) proforma for Ecological Engineering
- Collect success/ failure stories/evidence of implementation of Eco-DRR from the Asia-Pacific region, and compile in terms of a publication
- Knowledge and technological support/ facilitation group for planning and implementation of plans and projects based on Eco-DRR approach
- Engage in policy dialogue with regional organisations (like ASEAN) and selected country governments in the Asia-Pacific region to provide financial and technical support for the formulation and implementation of Eco-DRR plans at a national and sub-national level
- Work closely with IUCN, UNEP and other Inter-governmental agencies.
Introduction

Asia and the Pacific encompass regions characterised by high and interlinked levels of disaster risk. Despite sustained, concerted efforts and investments by national governments, regional bodies, international agencies, academic/science groupings and civil society organisations, both regions foresee intensifying and increasingly complex risk configurations into the 21st Century. These risks are driven by powerful and interlinked global forces, that include wide-ranging environmental change (including climate change), urbanisation, growing economic interdependence and increased population mobility.

Such concern resonates globally, with urgency for enhanced management of disaster risk underlined in the 2015 landmark agreements, the Sendai Framework, 2030 Agenda for Sustainable Development and Paris Agreement, as well as 2016’s Agenda for Humanity and New Urban Agenda. Regionally, the role of disaster risk reduction as a development imperative has been repeatedly stressed, most recently at the 2018 Asian Ministerial Conference on Disaster Risk Reduction in Ulanbantaar, Mongolia. The field will receive heightened attention in 2020 at the forthcoming Asia-Pacific Ministerial Conference on Disaster Risk Reduction to be hosted in Brisbane, Australia.

Both implicit and explicit calls for strengthened attention to disaster risk and resilience is the need for new skill-sets that are ‘future-fit’ for development under rapidly changing and interlinked global risk conditions. This especially applies to developing countries and those in fragile contexts (e.g. SIDS, LLDCs, LDCs, (post)-conflict areas and young democracies) that face complex, interlinked pressures and threats. However, it is equally relevant to both regions’ more economically developed economies, many of which anticipate rising disaster losses due to climate change.

Ailsa Holloway

1 Auckland University of Technology, New Zealand

1 Small island developing states
2 Land-locked developing countries
3 Least-developed countries
This brief discussion document presents argument for **fast-tracking the skilled capacity** to address Asia and Pacific’s changing risk profile into the 21st Century. It foregrounds the urgency to better harness the higher education enterprise as a purposeful investment in resilience-building across both regions. This is so that civil society, as well as government services and the private sector in Asian and the Pacific regions are not ‘caught short’ in the near future, lacking the requisite skills, research capacity and expertise to navigate conditions of increasing risk that compromise development commitments and investments.

**Skilled Human Capital Development for Disaster Risk Reduction in Asia and the Pacific: Role of Higher Education**

Many of Asia and the Pacific’s more developed economies have already prioritised the advancement of skilled human capital to strengthen disaster risk and resilience capacity. These investments, primarily through national higher education and research institutions, have included support for post-graduate research and science in risk-related fields, as well as tertiary-level cap-

pacity building across a wide range of professions. A similar pattern has emerged in mid-level developing and some least developed countries, including Bangladesh, Indonesia, Malaysia, the Philippines and Sri Lanka, where (sub) national universities increasingly play pivotal roles in providing skilled expertise in advancing disaster risk-related science, policy and practice.

Such investments augment more than three decades of capacity-building efforts through complementary regional initiatives. Examples include sustained engagement by the Asian Disaster Preparedness Centre (ADPC) in Bangkok, Thailand and the Asian Disaster Reduction Centre (ADRC) in Kobe, Japan. They also include sup-

port by the APRU-IRIDeS Multi-Hazard Program whose hub is in Sendai Japan, and UNDRR’s Global Education and Training Institute for DRR in Incheon, Korea.

Despite these efforts however, progress has not been even across all Asian and Pacific states. Many of the countries most exposed to complex, recurrent and interlinked threats still lack the very foundational capabilities in skilled human capital to meet their day-to-day development needs – let alone access to the evolved, future-ready and cross-disciplinary skill-sets that underpin the aspirations of the Sendai Framework and the 2030 Sustainable Development Agenda.

Such shortcomings were underlined at the September 2019 ASEAN High Level Meeting on Human Capital Development. The deliberations particularly underscored the need for accelerated investment in people, especially children and youth to address entrenched disparities in ‘life expectancy, job productivity, and education quality across the region’ despite rapid economic growth. Similar calls for strengthened human capital were made in the Pacific and at APEC, where APRU foregrounded the urgency for new skill-sets across the region to optimise opportunities in an increasingly digital global economy.

As elsewhere, higher education and research institutions in both regions are crucial actors in advancing disaster risk reduction. As elsewhere, higher education and research institutions in both regions are crucial actors in advancing disaster risk reduction. They are at the forefront of advancing contextually grounded disaster risk knowledge and scholarship, as well as relevant and robust disaster risk-related science policy advice and innovation. They also carry the remit for sustainably supplying the skilled human resources that underpin (sub) national and local disaster risk-related service delivery by government, the private sector and civil society organisations.

Asia and the Pacific’s more developed economies have long institutionalised these capabilities for vigorous university involvement in the disaster risk and resilience domains. Yet, similar actions have not occurred in its most at-risk, least developed states – those that stand to benefit most from investment in the national institutions tasked with building skilled human capital. Bangladesh and Nepal represent noteworthy exceptions, with established disaster risk-related post-graduate programmes, while other countries across the
region have introduced disaster risk-related post-graduate programmes, often aligned to the environmental or engineering fields.

Way Forward

The following path is proposed for strengthening the skilled human capacities for DRR:

1. Overview

This slow pace of institutionalising the disaster risk field in universities and other tertiary institutions is not limited to Asia and the Pacific. Despite high demand for HEI DRR services in many regions, especially by many local and (sub) national authorities, the disaster risk domain still gains traction across the global higher education enterprise. This is due to its status as a relatively new domain of scholarship with a complex, cross-disciplinary identity. While academic fields such as geography or engineering have long given attention to natural hazards (as one example), the wider disaster risk domain crosses a diverse range of disciplines, and incorporates applied, as well as conceptual elements. This is challenging for higher education institutions, both for teaching and research.

The proposed approach below seeks to address these challenges through two complementary and mutually reinforcing pathways. The first aims to accelerate the pace of higher education engagement in the disaster risk domain (across multiple fields and knowledge domains). The second prioritises purposeful development of tertiary-level disaster risk-related higher education and research capacity in high-risk countries either lacking, or with insufficient access to tertiary education services in this field.

In this context, the approach comprises two complementary components:

- Policy advocacy to bridge the higher education and disaster risk domains at regional and (sub) national scales.
- Academic integration and embedding of the disaster risk domain in higher education programmes/institutions (with focus on high risk developing and least developed countries).

2. Policy Advocacy to Bridge the Higher Education and Disaster Risk Domains

The policy advocacy pathway comprises a three-way thrust. It seeks to profile the potential of the disaster risk domain in sharpening and strengthening higher education’s contribution to sustainable development. Similarly, it seeks to foreground the wide-ranging benefits of strategically investing in higher education to advance disaster risk reduction and resilience building. This pathway also aims at prioritising disaster risk-related tertiary education investment in those states with high and accelerating disaster risk levels, but constrained HEI capacity to meet (sub) national demands.

a) Profile Potential of the Disaster Risk Domain in Advancing Scholarship for Sustainable Development

This policy focus would emphasise advancing disaster risk-related education and research as legitimate domains of incisive, cross-disciplinary scholarship for HEIs, Ministries of Education and within national science agendas.

The first aims to accelerate the pace of higher education engagement in the disaster risk domain (across multiple fields and knowledge domains).

It would require specific advocacy with ministers of higher education, development partners and professional accreditation bodies to advance and support (sub) national HEIs to take this forward materially. As in other fields, strategic alliances involving higher education institutions can play key roles in advancing disaster risk-related scholarship – for instance, the successful Periperi U partnership in Africa, that has introduced a transformative suite of academic programmes related to disaster risk reduction. (See https://www.riskreductionafrica.org/).
b) Profile the Contribution of Higher Education in Advancing DRR

This policy focus aims at promoting the higher education enterprise as a crucial player in DRR education, capacity building and research, reframing HEI engagement from its current and under-utilised position (especially in least developed countries). This would include incorporating scope to update targeted higher education programmes as an explicit component of post-disaster recovery and resilience-building post-disaster, introduce new degree programmes, as well as mechanisms for career-pathing or internships of graduates into government or NGO employment for retention of skilled youth.

c) Profile Specific Urgency for Embedding Skilled Capacity Development in Selected High-Risk Developing and Least Developed, At-Risk Countries (e.g. Afghanistan, Cambodia, Lao PDR, Myanmar, Solomon Islands, Timor Leste, Tuvalu, Vanuatu)

This policy focus aims at crafting a systematic, coherent regional approach to advancing higher education capability in the disaster risk and resilience domains in at-risk countries, including mobilising national and regional support and resources, as well as intergovernmental, multilateral and bilateral mechanisms.

3. Academic Integration and Embedding of the Disaster Risk Domain in Higher Education Programmes/ Institutions (focus on high risk developing and least developed countries)

This pathway involves a two-way thrust for HEI engagement across Asia and the Pacific. It explicitly acknowledges that issues of risk and resilience are not ring-fenced within the emergency and disaster management domains, but sit front and centre in both regions’ prospects for sustainable development. The first HEI thrust proposes a more purposive integration of the disaster risk and resilience domains across a wider range of disciplines and professions. The second thrust calls for a strategic regional plan to introduce disaster risk-related scholarship into one HEI in four-six high-risk countries across both regions.

a) More Purposive Integration of the Disaster Risk and Resilience Domains Across a Wider Range of Disciplines and Professions

This focus foregrounds the need for greater disciplinary diversification beyond the historic tendency for the disaster risk field to be situated within environmental, engineering and geosciences or the emergency management professions. Investing in building future-ready skills and expertise implies a more deliberate incorporation of DR-related content/modules in fields as diverse as agri-sciences, development studies, health sciences/professions, economics and the tourism/hospitality industry. It also implies creation of new cross-disciplinary course configurations, along with opportunities for student progression from secondary school through post-graduate studies.

b) Development of A Strategic Regional Plan to Introduce Disaster Risk-Related Scholarship into One HEI in Four-Six High-Risk Countries

This focus aims to fast-track HEI capacity in four-six at-risk developing and least developed countries with high and accelerating disaster risk levels, but constrained HEI capacity to meet (sub) national demands. It anticipates a wide portfolio of potential interventions, including scholarship support to fast-track disaster risk teaching and research capacity, staff and student exchange visits between tertiary institutions, opportunities to participate in regional and global DRR science and policy events, funding support for curriculum development, and material support for equipment, as well as software.

Conclusion

Asia and the Pacific’s increasingly complex risk environment calls for accelerated investment in skill-sets and expertise that are ‘future-fit’. A shift in higher education policy framing, combined with fast-tracked human capital in the disaster risk and resilience fields could (within five years) advance national capacity, even in both regions’ high-risk, least developed countries.

1 Afghanistan, Bangladesh, Cambodia, Bhutan, Kiribati, Lao PDR, Myanmar, Nepal, Solomon Islands, Timor Leste, Tuvalu, Vanuatu, Yemen
Regional Status of Resilient Infrastructure

Introduction

Infrastructure includes power grid network, transportation network, communication network, water supply network, which consists of the lifeline system supporting the efficient performance of the whole society (Li et al., 2005). In the context of disaster risk, resilience refers to “the ability of a system, community or society exposed to hazards to resist, absorb, accommodate, adapt to, transform and recover from the effects of a hazard in a timely and efficient manner, including the preservation and restoration of its essential basic structures and functions through risk management” (UNDRR Terminology, 2017). Resilient infrastructure is about infrastructure which has the ability to reduce the magnitude, impact, or duration of a disruption (NIAC, 2009). Topological connectivity, the largest connected component, under the losses of links and nodes is especially relevant to the robustness of a system, representing the function of mutual navigability under shocks (Kitsak et al., 2018). Infrastructure faces various threats involving man-made hazards and natural hazards. A lot of works has been devoted to reveal the robustness of the infrastructure system against man-made hazards. New understanding is required for robustness of infrastructure system under natural hazards such as floods, earthquakes and typhoons. The robustness of road networks of China and the United States with millions of intersections and roads at varying altitudes under three scenarios of flood are studied (Wang, et al., 2019). To improve the robustness of a supply distribution system, a randomized local rewiring approach are proposed (Zhao, et al., 2011).

Resourcefulness is the capacity to identify problems, establish priorities, and mobilize resource when condition exist that threaten to disrupt some element, structure, system or other unit of analysis (Bruneau and Reinhorn, 2007). Resourcefulness can also be understood as the ability to mobilize resource services in emergencies. It is useful to view robustness and rapidity as the desired ends of resilience-enhancing measures. In resourceful societies...
the insufficient planning and policies will lead to longer recovery times. Resourcefulness and robustness are also linked that may reduce the loss of the initial investment and enhance resilience. The retrofitting investment is an investment that pays benefits both axes.

Rapid recovery is the ability to return to and/or reconstitute normal operations as quickly and efficiently as possible after a disruption. Components of rapid recovery include drafted contingency plans, competent emergency operations, and the means to get the right people and resources to the right place (NIAC, 2009). In the areas where disasters frequently occur, various recovery strategies are introduced to enhance recovery efficiency of highway network in China under typhoon (Hu, et al., 2016). Various studies on disaster/accident control and road selection of emergency evacuation have been conducted in order to prevent accidents from earthquakes, typhoons, floods, and other hazards. There have been studies to investigate disaster prevention measures for evacuation plans and to develop methods to reduce the evacuation time (Duanmu et al., 2011; Urbanik, 2000; Cova et al., 2003; Do et al., 2016; Zhang et al, 2014). In the developed countries of Asia (e.g. Japan), national and local governments cooperate to establish infrastructure related disaster restoration plans, to designate certain major roads for both emergency evacuation and transportation, and to train and prepare personnel on how best to respond in order to minimize the damage from disasters (Lee, 2013; Do, 2018).

Resourcefulness and robustness are also linked that may reduce the loss of the initial investment and enhance resilience. The retrofitting investment is an investment that pays benefits both axes.

Highlights on Resilience Infrastructure

1. **Disaster-Resilient Infrastructure Design:** In the context of climate change, appropriate design, operation, and maintenance is the first step to build more resilient infrastructure systems (Hallegatte, Rentschler, & Rozenberg, 2019). Building codes and engineering design standards are expected to be updated to take climate change and disaster risks into account (Lu, 2019). Several national standards organizations have produced risk management guidelines that include climate change and resilience considerations for infrastructure (Council of Standards Australia 2013). In general, for each hazard and infrastructure system, governments or regulations always define a minimum standard of resistance. Based on these regulations, the infrastructure designer can determine the design standards utilized. For instance, considering the occasional eccentricity effect of an earthquake in Egypt, the landmark tower designed by China State Construction Engineering Corporation was improved from design phrase, as its centroid offset value was 2% higher than the domestic and international codes.

2. **Investment in Infrastructure:** The solutions for countries to increase the resilience of their infrastructure systems is to build new assets and maintain old assets well (Hallegatte, et al., 2019). These solutions require a huge investment in infrastructure. The application of the concept was demonstrated through two cases: Christchurch, New Zealand and Sichuan, China. Magnitude 7.1 earthquake occurred and induced huge damage to power system in Christchurch and the surrounding area. With $6 million investment on transmission and distribution infrastructure, $30 million to $50 million in direct asset replacement costs are reduced (Kestrel Group., 2011). On May 12, 2008, the magnitude of 8.0 Wenchuan earthquake occurred and caused damage in infrastructure and public service facilities, with a total loss of 61.2 billion yuan in highway infrastructure. A recovery plan for resilient transportation was carried out with an investment of around 120 billion yuan (including railways). It is important for other regions to learn from these cases to invest more for building resilient infrastructure.
3. **Technical Innovation Scientific Argumentation:** Market failures, bottlenecks, as well as lack of innovation result in that nearly 40% of the $9 trillion USD invested in infrastructure each year is poorly spent. Technological innovation will greatly improve the evaluation effect and recovery speed, thus indirectly improving the robustness of infrastructure. The application of the concept was demonstrated through two cases: Tohoku of Japan and Sanyuan Bridge of Beijing. Japan planned a paradigm change towards a decentralized, participatory place governance to improve the efficiency of management, improving management and infrastructure efficiency. The Beijing Municipal Commission of Transport finalized a rapid overhaul plan for the replacement of the superstructure of the Sanyuan Bridge using an innovative technology. It took only 43 hours to complete the overall replacement of a large bridge deck structure in a megacity, which is a new record of urban transport infrastructure recovery.

4. **Disaster Risk Reduction Knowledge Service System:** The knowledge service system focuses on the needs of the target users and can produce tailored services as a linkage between science-technology and practice. Resilient infrastructure is still a new concept to governments, developers and public. Knowledge service systems, which can offer continuous data sharing, map service, organization service etc.; are a special type of infrastructure, which safeguard more successful applications on resilient infrastructure. The International Knowledge Centre for Engineering Sciences and Technology (IKCEST) established the Disaster Risk Reduction Knowledge Service System (DRRKS) in response to the world demand for disaster prevention and mitigation. DRRKS provides plenty of knowledge services and also formulates global metadata standards and establish a global meta-database for disasters by consolidating the data from different kinds of disasters, as well as integrate cross-disciplinary, cross-field, and cross-region data resources for multi-hazards. In addition, DRRKS carries out education, training, and technology exchange on disaster risk reduction for end users.

### Building Resilient Infrastructure

1. **Localized Resilience Requirements:** Standards and regulations of building resilient infrastructure need to account for local conditions, including geophysical hazards, environmental and socioeconomic trends. Resilience-related standards must balance the trade-offs between simplicity and enforceability (Hallegatte, Rentschler, & Rozenberg, 2019). With the innovation of new technology and materials, periodical review and update of these regulations is needed. For example, the application of high-strength materials utilized in the Central Business District (CBD) project (Phase I) undertaken by the China State Construction Engineering Corporation (CSCEC) was beneficial for reducing the weight of building, saving building materials, and also strengthening seismic resistance.

2. **Developing an Adaptational Technical Standards and Indicators:** Since the 20th century, with continuous climate change and the development of economics and critical infrastructure (CI), the intensity and losses of natural hazards have been rising. The infrastruc-
3. **Continuous Improvement of Management and Technological Innovation:** Clear responsibility for infrastructure management and coordination among various departments is necessary. Multiple arguments need to be made to provide scientific support for innovation before adopting new approaches. Specific responsibility for crisis management and emergency drills for unexpected situations is also a way to improve the management efficiency. Besides, communicating with local residents in time will be helpful in order to get better support from them.

4. **Sharing of DRR Knowledge and Technology:** Platforms which continuously share technology, data, and education services for disaster prevention and mitigation can help the advocacy and the practice of resilient infrastructure, meantime, they are an important infrastructure as well. The construction of shared resources, application of knowledge services, and case-sharing of disaster prevention and mitigation will help multi-stakeholders to better understand and promote the international experience of resilience infrastructure.

**Conclusion**

In the context of global climate change, infrastructure must be designed or improved to be more resilient. Some good examples of resilient infrastructure in Asia-Pacific regions over past years are collected and presented in this status report. There are many examples of smart investments, which make infrastructure more resilient and economically robust around the region. In general, highlights of resilient infrastructure lie in disaster-resilient infrastructure design, infrastructure investment, technical innovation and scientific argumentation, and disaster risk reduction knowledge service.

To enhance the infrastructure resilience, the resilience-related regulations and standards must be localized and regularly reviewed, scientific technical standards and indicators are required in planning to meet the requirement of changing environment. For the long-term sustainable development, continuous improvement of management and technological innovation and knowledge sharing are essential.
Regional Status of Space Application in DRR

Shirish Ravan

1. Head, Beijing Office, UN-SPIDER Programme of the United Nations Office for Outer Space Affairs (UNOOSA)

Introduction

Although countries are better prepared for natural hazards than they were years before, there has been a marked increase in extreme weather events such as storms and heavy rain. Asia is particularly struck by disasters and 86 per cent of all people reported as affected by climate-related disasters between 1998 and 2017 were located on the continent. Cyclone Fani and Typhoon Mangkhut are just two examples of extremely powerful storms that recently hit the region. Sometimes such extreme weather can generate manmade disasters such as Monsoon rain causing a hydroelectric dam to collapse in Laos on 23 July 2018 that left more than 6000 homeless and hundreds unaccounted. This increasing number of disasters has fuelled the need for greater international collaboration for the collection, sharing, and analysis of space-based data among the agencies which typically operate satellites and organizations concerned with climate change and disaster risk reduction (DRR). The need for the Earth observation and geospatial data is also critical for monitoring targets the Sendai Framework for Disaster Risk Reduction.

UN Efforts to Promote the Use of Space-based Technologies in DRR in Asia and the Pacific

The United Nations Platform for Space-based Information for Disaster Management Emergency Response (UN-SPIDER), a programme of the Office for Outer Space Affairs (UNOOSA), has supported countries all over the world, in particular developing countries, in accessing and making use of space technologies for addressing natural and technological disasters, and in implementing the Sendai Framework. The UN-SPIDER Programme Office in Beijing has been working with national stakeholders as well as regional and international organizations to strengthen disaster management capacities in Asia and the Pacific region (www.un-spider.org). United Nations Social and Economic Commission for Asia and the Pacific (ESCAP), through its Space Applications Section and United Nations Training and Research Institute (UNITAR), through its UN Operational Satellite Applications Programme (UNOSAT) also offer
Outreach to Promote Space-based Technologies in DRR in Asia and the Pacific

1. Engagement with International Agencies:
The greater outreach is generated in the region by the UN-SPIDER and other programmes through a partnership with the following international agencies/initiatives:

- Asian Ministerial Conference on Disaster Risk Reduction
- Asia-Pacific Partnership on Disaster Risk Reduction (APPDRR) organized by the United Nations Office for Disaster Risk Reduction (UNDRR)
- Committee on Disaster Risk Reduction of the United Nations Economic and Social Commission for Asia and the Pacific (UN ESCAP)
- Intergovernmental Consultative Committee on the Regional Space Applications Programme for Sustainable Development (RESAP)
- Asia-Pacific Regional Space Agency Forum (APRSAF)
- Pacific Space Cooperation Organization (APSCO)
- Association of Southeast Asian Nations (ASEAN) Coordinating Centre for Humanitarian Assistance on disaster management (AHA Centre)
- Research and Training Center for Space Technology and Applications supported by the Geo-informatics and Space Technology Agency of Thailand (GISTDA)
- ASEAN Coordinating Centre for Humanitarian Assistance (AHA Centre)
- South Asian Association for Regional Cooperation (SAARC) Disaster Management Centre (Interim Unit)
- Centre for Space Science and Technology Education in Asia and the Pacific (CSSTEAP) (UN-affiliated), Dehradun, India
- Regional Centre for Space Science and Technology Education in Asia and the Pacific (RCSSTEAP) (UN-affiliated), Beijing

2. International Conferences: The annual UN-SPIDER conferences in Beijing, China – the United Nations International Conference on Space-based Technologies for Disaster Risk Reduction – benefitted over 1,000 participants from all over the world in consolidating their actions in the use of Earth observation and other space-based technologies at all stages of disaster management. These conferences review the progress of the use of space-based technologies in various countries and also inspires several countries to take a step towards the use of high technologies.

3. International Capacity-building Efforts: The UN-affiliated Centre for Space Science and Technology Education in Asia and the Pacific (CSSTEAP) based in India offered 2-week training course since 2002 on use of advanced space-based information in Disaster Risk Reduction (DRR). The Regional Centre for Space Science and Technology Education for Asia and the Pacific (RCSSTEAP) based at Beihang University, China hosted one-week-long training programmes in collaboration with UN-SPIDER since 2012.

These conferences review the progress of the use of space-based technologies in various countries and also inspires several countries to take a step towards the use of high technologies.

Status of Space Technology Application in Disaster Risk Reduction in Asia and the Pacific

1. Efforts at the National Level: Through its technical advisory support activities, training courses and annual conferences, the UN-SPIDER has enabled the Member States to use space-based information in disaster management and emergency response. By taking the international expertise to the
countries, UN-SPIDER offered technical advisory missions to the following countries in Asia and the Pacific:

**Asia:** Afghanistan, Bangladesh, Bhutan, Cambodia, India, Indonesia, Lao People’s Democratic Republic, Maldives, Mongolia, Myanmar, Nepal, Sri Lanka, Viet Nam

**The Pacific:** Fiji, Samoa, Solomon Islands

All these countries have received a comprehensive report that assesses the current status of the country and makes recommendations and proposes an action plan to improve the use of space-based information in disaster management. These recommendations and actions are developed after in-depth discussions with the disaster management authorities, UN agencies, regional and international organizations and other stakeholders. As a follow up of the technical advisory missions, national/regional level capacity-building programmes were conducted on the use of space-based technologies in disaster management and emergency response.

**Outcome (based on responses collected from 6 countries)**

**Bangladesh:** The support of UN-SPIDER has helped the Department of Disaster Management and other organizations to enhance their capacity on topics such as damage and loss assessment, and flood hazard and emergency response mapping. The Department developed a standard operating procedure on the “Use of space technology in disaster risk reduction and climate change adaptation in Bangladesh” based on the recommendations of the technical advisory mission. The purpose of the standard operating procedure is to act as a guide to develop space-based technology applications for disaster management in Bangladesh.

**Lao People’s Democratic Republic:** The technical workshop and the high-level advocacy meetings conducted in Lao PDR generated awareness at the decision-making level about the use of space-based information in implementing the Sendai Framework. An informal group, the National Geospatial Information Utilization and Management (LaoNGUM) created during the UN-SPIDER mission is the first voluntary association of its kind that aims at coordinating specific activities related to remote sensing and geographic information systems in the country. LaoNGUM was active during the floods caused by a dam collapse in 2018 as it channelled the maps provided through the International Charter “Space and Major Disasters” to the end-users.

**Myanmar:** The Ministry of Social Welfare, Relief and Resettlement of Myanmar established an emergency operations centre that hosts a section dedicated to the use of Earth observation data as well as satellite imagery and research section. An official trained through UN-SPIDER programmes is leading the activities related to the use of satellite images and mapping. UN-SPIDER is continuing its engagement with the ministry in updating its ‘Action Plan for Disaster Risk Reduction’. The UN-SPIDER, together with UN-HABITAT and UNDP, is working with the Disaster Management Training Centre, based in Myanmar, to develop remote sensing-based training courses. In 2017, the Relief and Response Department became an authorized user of the International Charter “Space and Major Disasters” and will be able to activate the Charter on its own. In 2019, the Ministry of Social Welfare, Relief and Resettlement nominated two officials to attend a postgraduate course in remote sensing and geographic information systems at the United Nations-affiliated Centre for Space Science and Technology Education in Asia and the Pacific based in India.

As a follow up of the technical advisory missions, national/regional level capacity-building programmes were conducted on the use of space-based technologies in disaster management and emergency response.
Nepal: As a result of the 2017 technical advisory mission, the Ministry of Home Affairs included references to remote sensing, geographic information systems and Earth observation-based tools into their 2018 disaster risk reduction policy. Following the UN-SPIDER technical advisory mission, the Ministry also requested that stakeholders develop a unified and inclusive approach to preparing hazard maps with the support of Earth observation. As a further result of the 2017 UN-SPIDER mission, the country’s surveying department approached the United Nations Resident Coordinator’s Office in Nepal to request the support of UN-SPIDER in implementing a national spatial data infrastructure. The process of implementing this infrastructure was discussed during the UN-SPIDER mission in 2017.

Sri Lanka: Key recommendations of the technical advisory mission were useful in preparing disaster management policies and subsequent plans of actions initiated by the Disaster Management Centre of Sri Lanka. Based on the recommendations of UN-SPIDER, the Disaster Management Centre prepared a proposal for a national spatial database infrastructure, which was endorsed by the cabinet. Together with the Survey of Sri Lanka, the Disaster Management Centre is implementing the national spatial database infrastructure (https://geoportal.nsdi.gov.lk/). In 2017, with support from UN-SPIDER, the Disaster Management Centre became an authorized user of the International Charter “Space and Major Disasters”. In 2019, the Disaster Management Centre and UN-SPIDER started a new project aimed at developing a spatial data repository for reporting on the targets of the Sendai Framework.

Viet Nam: Disaster Management, Policy and Technology Centre (DMPTC) of Viet Nam established a geospatial division with the help of staff partly trained through UN-SPIDER. DMPTC signed a bilateral memorandum of understanding with the providers of Earth observation data within the country and the Japan Aerospace Exploration Agency (JAXA) for sharing satellite images during emergencies. UN-SPIDER has worked with DMPTC to mitigate several disaster events by activating the International Charter “Space and Major Disasters” and the Copernicus Emergency Management Service – Mapping for emergency response mapping.

Regional Efforts

South Asia regional initiative - Regional training and workshop in India for countries in South Asia

UNOOSA and the Disaster Management Centre of the South Asia Association of Regional Cooperation – Interim Unit (SAARC DMC), with support from the International Water Management Institute (IWMI) and the Centre for Space Science and Technology Education in Asia and the Pacific, conducted a regional workshop and training session on the “Utilization of space-based and geospatial information for achieving the targets of the Sendai Framework for Disaster Risk Reduction” to enhance cooperation and share best practices among disaster management agencies and experts in SAARC member countries in December 2018.

Outcome

The officials participating in this initiative have become aware of advances in Earth observation and geospatial technologies for disaster risk reduction and emergency response, especially for implementing the Sendai Framework for Disaster Risk Reduction 2015–2030. They also learned about how to develop capabilities to use international mechanisms such as the...
International Charter “Space and Major Disasters,” Sentinel Asia and the Copernicus Emergency Management Service. The participants were also informed about capacity-building opportunities in the region for the utilization of space-based and geospatial information in disaster management.

**South-East Asia: regional initiative - Sharing space-based information: procedural guidelines for disaster emergency response in ASEAN countries**

With support from the United Nations Economic and Social Commission for Asia and the Pacific (UN ESCAP) and the ASEAN Coordinating Centre for Humanitarian Assistance (AHA Centre), UNOOSA conducted four regional workshops on “Geo-referenced Disaster Risk Management Information Systems” involving ASEAN countries to understand the needs of disaster management agencies in terms of using space-based information effectively during emergency response.

**Outcome**

The workshop series led to a joint publication entitled “Sharing Space-based Information: Procedural Guidelines for Disaster Emergency Response in ASEAN Countries”. The publication provides guidelines for utilizing space-based information effectively during emergency response. The publication is available online on the following weblink: https://www.unescap.org/sites/default/files/7%20Step%20-%20Quick%20Guide.pdf.

**Emergency Response through Space-Based Technologies**

An increasing number of countries in the region are using international mechanisms like the International Charter “Space and Major Disasters” and Sentinel Asia.

The Charter is a worldwide collaboration, through which satellite data are made available for the benefit of disaster management. By combining Earth observation assets from different space agencies, the Charter allows resources and expertise to be coordinated for rapid response to major disaster situations, thereby helping civil protection authorities and the international humanitarian community.

Sentinel Asia is a voluntary and best-efforts-basis initiative led by the Asia-Pacific Regional Space Agency Forum (APRSAF) to share disaster information in near-real-time across the Asia-Pacific region, using primarily the Web-GIS technology. Its architecture is designed to operate initially as an internet-based, node-distributed information distribution backbone, eventually distributing relevant satellite and in situ spatial information on multiple hazards in the Asia-Pacific region. Whenever there is an additional need of satellite images, Sentinel Asia activates the Charter.

The UN-SPIDER conducted special efforts to enable countries to use international and regional emergency response mechanisms on their own so that they proactively access space-based information and use it effectively during emergencies. As a result, disaster management agencies of Myanmar and Sri Lanka have already become authorized users of the Charter and developing capacity to use the maps generated by the Charter.

UN-SPIDER also carried out specific outreach efforts with the national disaster management offices of the small island nations in the Pacific region, especially the countries supported by the Pacific Community. Of these, disaster management offices of Samoa and the Solomon Islands have already submitted the application to become Authorised User of the Charter.

**Way Forward**

Together with the growing network of regional support offices of UN-SPIDER and partnership with international and regional organisations in Asia and the Pacific, UNOOSA/UN-SPIDER will continue supporting countries in using space technologies to benefit DRR community in Asia and beyond. More resources are needed to support small island nations in the Pacific region considering its growing vulnerability to climate-related disasters. There is also need to attempt a survey of use of space-based information in all countries of Asia and the Pacific.
Regional Status of Urban Resilience and Climate Change

Joy Jacqueline Pereira¹, Tariqur Rahman Bhuiyan¹, Nurfashareena Muhamad¹ & Julian Hunt²

¹. Southeast Asia Disaster Prevention Research Initiative, Universiti Kebangsaan Malaysia
². Trinity College, University of Cambridge & University College London

Introduction

Urban resilience has evolved conceptually with multiple interpretations across policy, practice and research disciplines. The review of a decade of literature reveals that the central elements for urban resilience are resisting, recovering, adapting and transforming (Ribeiro and Goncalves 2019). In the context of climate change and disaster risk reduction (DRR), the traditional perspective of resilience as the simple ability to withstand and recover from a disruption has now widened, to include the capability to adapt and transform to shifting societal and environmental conditions. Some disruptions may be anticipated over time but others remain unknown. While urban resilience is a common goal in policy, its translation into practice through specific risk management strategies is challenging. Strategies that focus solely on infrastructure solutions are inflexible and preconfigure future conditions that may give rise to issues of inequity and justice, particularly where there is community displacement (Herbeck and Flitner 2019; Laeni et al. 2019). Research on the multiple dimensions of urban development, planning and management has to be enhanced to strengthen the systems and processes that constitute the urban metabolism, to meet the needs of a dynamic and uncertain future (Ribeiro and Goncalves 2019). Holistic and integrated approaches that take into account advances in science and technology, the role of multiple stakeholders as well as the socio-economic, institutional and political dimensions is critical to build urban resilience as the climate changes.

New research insights including tools and methods to measure resilience is required for policy and practice in cities. Progress in this aspect could be captured through a systematic and comprehensive assessment of scientific knowledge on urban resilience and climate change at the global level. This assessment is being led by the Intergovernmental Panel on
Climate Change (IPCC), which will support a Special Report on Climate Change and Cities in the Seventh Assessment (AR7) cycle (Decision IPCC/XLIII-6 # 6). The IPCC also supported a global conference on cities in 2018 as part of the Sixth Assessment (AR6) cycle to foster new scientific knowledge for cities based on science, practice and policy to marshal research that will lead to peer-reviewed publications (www.ipcc.ch). Initiatives that promote research and peer-reviewed publications are encouraged by the IPCC to support the proposed Special Report, particularly to highlight the regional dimension and poorly covered areas.

This was the context for the Workshop on Building Disaster and Climate Resilience in Cities in Kuala Lumpur on 15-16 October 2019, to capture current status of knowledge and link scientists from multiple disciplines, to promote research that is relevant to the region. The Workshop was convened by the Asian Network on Climate Science and Technology (ANCST), coordinated by Universiti Kebangsaan Malaysia’s Southeast Asia Disaster Prevention Research Initiative (SEAD-PRI-UKM), in conjunction with the Asia-Pacific Network for Global Change Research (APN) and International Science Council Regional Office for Asia and the Pacific (ISC-ROAP), with support from members of the UNDRR Asia-Pacific Science, Technology and Academia Advisory Group (AP-STAAG). National Partners included the National Disaster Management Agency (NADMA) Malaysia, Ministry of Energy, Science, Technology, Environment and Climate Change Malaysia (MESTECC), Academy of Sciences Malaysia and the City Hall of Kuala Lumpur (DBKL). A total of 141 participants of multidisciplinary background from academia, government, non-government organisations and the private sector, representing 14 countries from the Asia Pacific and international organisations attended the Workshop, to share progress in science and technology on climate change, DRR and their interactions in cities.

A cursory outlook of current status of knowledge on climate science and technology in cities is presented in this article, drawing on findings of the Workshop. The first part provides a snapshot of key findings presented at the Workshop, and knowledge gaps are highlighted in this context. This is followed by a discussion on selected enablers for building disaster resilience in the Asia Pacific. Such enablers include taking a systems approach, stimulating public-private participation, galvanizing knowledge-empowered youths and promoting open science communication and engagement.

**Highlights on Urban Hazards**

**Multi-hazard Platform:** The Kuala Lumpur Multi-hazard Platform (KL-MHP) is a visual decision-making theatre that displays the modelled products of geophysical and atmospheric hazards driven by meteorological forecasts, to graphically communicate risk (Hunt and Pereira 2019). Meteorological products such as the hourly rainfall, humidity, temperature and wind forecasts at the street level are displayed in the KL-MHP. In addition, the system also displays areas susceptible to geophysical hazards such as pluvial floods, landslides and sinkholes as well as forecasts of atmospheric hazards such as heat, strong winds and air pollution. The KL-MHP draws on daily information from the Meteorology Department of Malaysia to assist decision-making within the City Hall of Kuala Lumpur (Pereira et al. 2019). Such scientific information and early warning is strengthening urban resilience in Kuala Lumpur. This is particularly relevant in light of the expected intensity and frequency extremes events in tropical regions due to climate change (IPCC 2018). City scale meteorological modelling is increasingly
important for tropical Southeast Asia (Abdullah et al. 2019). The limitation for forecasting at the city scale relates to the distribution of deep mesoscale convective systems (monsoonal region), which may differ as it is strongly influenced by its unique topographic orientation. More work is required for determination of convection initiation at high resolution. Future work is also required for the application of low cost sensors as supporting methods for air quality or landslide monitoring, which could be linked to the KL-MHP.

Urban-Rural Linkage Approach: The urban-rural linkage approach encompasses complementary assets between urban and rural areas that are linked through various mechanisms as a useful means of enhancing collective resilience (Shaw 2019). The application of the concept was demonstrated through two cases; Kanagawa, Japan and Nagpur, India. In both these cities, there is a strong urban-rural linkage, where there is a common watershed providing the source of water. The Kanagawa Prefecture introduced a new taxation system that imposes USD 8 per year for each household, which is then used to improve the watershed environment. In the case of Nagpur, India, the rural-rural, rural-urban and collective linkages are being investigated at various levels, focusing on water supply. It is important for other cities in the region to learn from this approach to identify pathways for advancing urban resilience.

Smart Cities and Resilient Infrastructure: In India, institutional arrangements such as linkages with national disaster management agencies as well as city authorities and involvement of vulnerable groups are given priority (Mukherjee 2019). There are several initiatives in smart cities, which take into account geo-intelligence and cyber-physical systems as well as disaster risks. The economic factor has highlighted the interest of both the government and the community, which helped in building disaster resilience by using innovative approaches such as geo-intelligence and cyber-physical systems. The evidence indicates that there is significant positive relationship between the smartness of a city and its overall resilience (Zhu et al. 2019). The level
of resilience is dependent upon infrastructural, economic, social, institutional and environmental conditions. In China, risk and impact assessment of urban infrastructure is increasingly important for building resilience of critical infrastructure. Exposure analysis and modelled flood induced failure and system impact analysis is being conducted for road networks in China (Yang et al 2019). In addition to scientific and evidence-based disaster risk analysis and assessment, effective governance and place-based approaches including capacity building for emergencies are essential for resilient infrastructure (Inaoka et al 2019; Monstadt 2019). Further investigation is required on resilient infrastructure and smart cities in the Asia Pacific.

**Knowledge Gaps:** Urban Geoscience is increasingly important in terms of the construction environment, geological hazards as well as subsurface and resource management (Banks et al. 2019). Rapid urbanization, pressure on space, population growth, environmental change and climate change are important drivers. The urban environment is relatively rich in data. There are various types of technologies that can be deployed to acquire data including InSAR and other satellite data, drone, LiDAR, and sensor technologies, among others. Knowledge gaps in the region, particularly in the tropics, relate to surface and subsurface geological and hydrogeological uncertainty, weathering profile and erosion rates. Research on landslide susceptibility and determination of rainfall thresholds are challenging in the tropics (Arnhardt et al. 2019). Analysis using heuristical and statistical methods can effectively map out zones that have a high potential for slope failure, although both have limitations and uncertainties. The probabilistic approach that has been adopted using limit equilibrium-based analysis and the BGS water balance model, which integrates the correlation between the soil and hydrological properties to understand the evolving ground saturation condition are areas that need further work to identify rainfall thresholds for landslides. The development of a robust methodology for the determination of rainfall threshold levels for landslides will be very useful for the tropics. Cities offer the best opportunity for new holistic and integrated approaches in conjunction with social acceptance, which link disaster risks, climate change adaptation and climate change mitigation. The urban climate can be modified and optimized artificially by urban vegetation to reduce the urban heat effect and green buildings can promote emission reduction, for example solar panels on roof-tops of apartments as in Wuhan, China (Hunt and Pereira 2019). Integrated approaches could also be applied for modification of water systems to reduce pollution. Global warming of 1.5°C is expected to intensity and increase the frequency

![Figure 6: A basic definition of urban rural linkage is that they consist of flows of goods, people, finance, etc. over space and time (Shaw 2019).](image)
extremes events (IPCC 2018). New aspects of critical hazards can be expected i.e. extremes of temperatures associated with low wind speeds, oceanic stagnation, extremes and variability of local extreme events such as urban flash floods, storm surges as well as population migration, particularly in coastal regions; that implications tropical urban areas and have to further investigated (Hunt and Pereira 2019). In Kuala Lumpur, detailed pluvial flood modeling of 5 m resolution has been developed by simulating the condition of various return periods to develop a flood risk map, which is essential for the insurance sector (Smith 2019). This can be replicated for other cities in the region.

**Enablers for Building Urban Resilience Systems Approach:** It was emphasized that cities could benefit from a "system-of-systems" for assessing the resilience of infrastructure, which links physical and cyber systems through an integration of sensor data from networks, people, and artificial intelligence (Jonas 2019). The idea of "sensemaking" in conceptualizing resilience indicates how to increase the availability of information so that decision makers would know how to deal with the problem effectively. The discussion on the recovery strategy practised in other countries, such as giving priority to damaged and disrupted infrastructure in China, and attending to new infrastructure and upgrading in Japan, should both be learned from and emulated. The authorities should also concentrate on small-scale hazards that are more frequent to understand their accumulated impact. It was noted that changes are slowly taking place among politicians, policymakers and people as well. They are starting to think about forecasting, uncertainties, limitations of knowledge as well as a systems approach which is helpful for progress in building urban resilience.

**Public-Private Participation:** The role of public-private partnership in building resilience and how to move this from science to action was also emphasized (Loyzaga 2019). The National Resilience Council of the Philippines has evidence-based risk governance consisting of a comprehensive strategy, education and training on urban risk reduction and resilience. The components of the disaster resilience efforts include private, public and local government stakeholders as well as the community.

**Knowledge Empowered Youths:** The medium and long-term strategy of the UNESCO Regional Science Bureau for Asia and the Pacific gives emphasis to the four priority actions and seven goals of the Sendai Framework on DRR (Khan 2019). UNESCO established the U-INSPIRE Alliance in 2019 to mobilize youth and young professionals in science, engineering, technology and innovation for DRR and climate change. Since its establishment, members of the Alliance have also met to discuss career pathways in DRR and develop future plans to navigate the science-policy interface (Ismail 2019a). The workshops convened by science institutions in the Asia Pacific led by ANCST, APN and ISC-ROAP in conjunction with partners have provided better understanding of the DRR, climate change and its challenges; and connected senior researchers to youths from different backgrounds in the region (Pereira and Hunt 2019; Pereira and Nurfashareena 2019). This has also facilitated discussion with a high-level delegation from the IPCC on enhancing participation of youth and young professionals from the Asia Pacific in their report preparation process (Ismail 2019b). The U-Inspire Chapters of the Asia Pacific have also created links with the youth network in Africa to serve as a catalyst for future initiatives in both regions. A U-Inspire Stage will commence at the 2020 Asia Pacific S&T Conference on DRR in Kuala Lumpur, where the scientific findings presented will be channelled to peer-reviewed publications. The
U-Inspire initiative has generated a huge expectation; the involvement of youth and young professionals should be nurtured to fill knowledge gaps in the Asia Pacific.

**Open Science Communication and Engagement:** The Australian perspective for building resilience in cities focuses on working across the value chain (Hazelwood 2019). It involves supporting community safety and national probabilistic hazard assessment. The probabilistic hazard assessment covers tropical cyclones, seismic hazards and tsunami hazard assessment; multiple maps are used for hazard prediction. The public has access to this hazard information to help them to understand better. The information and understanding is not only communicated to the community but necessary information is also collected from them. In Thailand, the Water Resource Management Operation Center is using information on demand, supply, logistic, management and money to increase the understanding of local communities regarding their water supply, water demand, waterway, use of the water table and costs of water resource management (Weesakul 2019). Simplified information and effective channels of communication are important for building resilience. Targeted communication strategies are also required to inform the various stakeholders regarding hazards and risks (Poole 2019). Many great ideas have been successfully implemented but the challenges lie in communication. It is vital that the public be informed of scientific findings and successful initiatives in DRR and climate change. The promotion of open data and access is vital to advance open communication and community engagement in the region.

**Conclusion**

A key achievement of the Workshop on Building Disaster and Climate Resilience in Cities in Kuala Lumpur on 15-16 October 2019, which was convened by the Asian Network on Climate...
Science and Technology (ANCST), Asia-Pacific Network for Global Change Research (APN) and International Science Council Regional Office for Asia and the Pacific (ISC-ROAP), with partners including the UNDRR Asia-Pacific Science, Technology and Academia Advisory Group (AP-STAAG), was to connect senior and young researchers working on urban resilience and climate change in the Asia Pacific. It also contributed a considerable step forward in connecting researchers, institutions, policymakers, and practitioners in sharing research advances. The initiative to bring young scientists into the research domain and to connect them with experienced researchers can yield a prolific output if data and information sharing is properly executed.

A highlight of the Workshop was the launch of the Kuala Lumpur Multi-hazard Platform, a visual decision-making theatre to graphically communicate risk for decision making. The MHP could serve as a useful tool to address the challenges of downscaling climate information and upscaling local information, to bridge the gap between climate change and resilient cities. Another highlight was the urban-rural linkages approach applied in Kanagawa, Japan and Nagpur, India, which could be emulated elsewhere in the region, to promote innovative approaches to generate financial resources. Further investigation is required on smart cities and resilient infrastructure as well as urban geoscience in the region, to provide insights for building resilience. Urban resilience in the Asia Pacific could benefit from a systems approach, public-private participation, knowledge-empowered youths and promotion of open data and access, to advance community engagement. Youth and young professionals offer the best potential to fill knowledge gaps in the Asia Pacific.

Acknowledgment

The authors would like to thank the Asia-Pacific Network for Global Change Research (APN) and International Science Council Regional Office for Asia and the Pacific (ISC-ROAP) for sponsoring young scientists to attend the Workshop. Acknowledgment also goes to the Newton-Ungku Omar Fund, administered by the Malaysian Industry-Government Group for High Technology (MIGHT) and Innovate UK; as well as all workshop partners, speakers, moderators and participants for their support.
PART 3: CASE STUDIES
3.1 Thematic Cases

3.1.1 Disaster Risk Reduction Knowledge Service of International Knowledge Centre for Engineering Sciences and Technology under the Auspices of UNESCO (Action-1.1.3)

Juanle Wang

1. Institute of Geographic Sciences and Natural Resources Research, Chinese Academy of Sciences, Beijing, China

Introduction

In response to the world demand for disaster prevention and mitigation, driven by UNESCO’s mission of disaster risk reduction, the International Knowledge Centre for Engineering Sciences and Technology (IKCEST), one of UNESCO’s Category 2 data centres, established the Disaster Risk Reduction Knowledge Service System (DRRKS) in 2016. The tasks of DRRKS are to formulate global metadata standards and establish a global meta-database for disasters by consolidating the data from different kinds of disasters; integrate cross-disciplinary, cross-field, and cross-region data resources for earthquake, draught, and flood disasters; promote the database development method and the knowledge information service model for disaster risk reduction; establish DRRKS with the support of big data mining and analysis techniques; and carry out education, training, and technology exchange on disaster risk reduction. DRRKS website: http://drr.ikcest.org

Measures for Improving Infrastructure Resilience

DRRKS provides knowledge services, such as platform, technology, data, and education services, for global disaster prevention and mitigation. The knowledge service system focuses on the needs of the target users and the special resources of the DRRKS, and produces those special services as a linkage between online and offline information. Users can get all sorts of disaster knowledge resources through querying,
browsing, downloading, analysing, and visualizing. DRRKS services offer resource sharing services, including a data service, a map service, an organization service, an expert database service, a disaster event service, etc.; resource communication services, including a video training service, a popular science service, etc.; and knowledge application services, including the Global Earthquake Daily Distribution Map Service, etc.

1. **Construction of Shared Resources:** By the end of December 2019, DRRKS has provided 173 disaster datasets, 235,814 disaster information network mining metadata, 201 disaster expert datasets, 200 disaster organization datasets, 1,191 disaster event metadata, 223,395 disaster literature records, 100 disaster open classification directories, 1,050 disaster maps, 50 disaster video records, and 12 disaster popular science documents.

2. **Knowledge Service Application:** DRRKS provides a total of 15 knowledge applications, including a knowledge service for global earthquake daily distribution mapping; major organization mapping for disaster risk reduction; an online China historical disaster atlas; the Chinese and international experience in Natural Disaster Relief; the spatio-temporal distribution of arable land drought in the Belt and Road areas; forest freezing, rain, and snow disaster prevention and reduction in southern China; a flood control knowledge service in Songliao Basin; an annual spatial distribution data service for drought monitoring on the Mongolian Plateau; the application of grassland yield in the China–Mongolia–Russia economic corridor, etc.

3. **Case Sharing of Disaster Prevention and Mitigation:** To understand and promote the Chinese and international experience of typical disaster prevention and mitigation cases, DRRKS established the Chinese and International Experience in Natural Disaster Relief knowledge application. Disasters such as the Wenchuan earthquake, the Zhouqu debris flow, the Jiuzhaigou earthquake, the Kubuqi desertification, the Daxinganling fire, the Indonesia tsunami, the Bangladesh heatwave, etc., were collected, and the application demonstrated their pre-disaster prevention, disaster rescue procedures, and post-disaster reconstruction.

4. **International Training Courses:** Since 2015, DRRKS has organized five international training workshops in China, with 93 participants from more than 21 countries participating in these trainings. Furthermore, DRRKS improved the training as a combination of domestic and foreign case studies, beginning with the International Training Workshop on Resource and Environment Scientific Data-Sharing and Disaster Risk Reduction Knowledge Service at Quaid-i-Azam University, Pakistan, in September 2019. Thanks to the training of young people in developing countries and the sharing of regional scientific disaster data, the capacity of disaster prevention and mitigation in developing countries has been improved.

5. **International Workshop for Disaster Risk Reduction Knowledge Service:** Since 2017, DRRKS has organized three international disaster prevention and mitigation workshops, with more than 300 participants from 20 countries participating in these workshops. The Third International Workshop for Disaster Risk Reduction Knowledge Service 2019 was broadcast live on the global network for the first time, with more than 13,000 global online visits.

**Impact**

1. **Impact on Human Life:** After the occurrence of the Nepal earthquake in 2015 and the Jiuzhaigou earthquake in China in 2017, the knowledge service system focuses on the needs of the target users and the special resources of the DRRKS, and produces those special services as a linkage between online and offline information.
the DRRKS team quickly integrated relevant resources and released a thematic knowledge service application to provide support for earthquake rescue and post-quake recovery.

2. **Economic Impact:** DRRKS shared cases of post-disaster reconstruction such as the 2008 Wenchuan earthquake in China to provide support for the economic development of earthquake-stricken areas.

3. **Environmental Impact:** DRRKS shared the long-time series monitoring of aridity and desertification in arid and semi-arid regions such as the Mongolian Plateau and the China–Mongolia–Russia economic corridor, to provide data and methodological support to prevent land degradation. Sharing environmental change information on typical lake and wetlands such as Poyang Lake, Dongting Lake, and the Sanjiangyuan wetlands in China, to provide support for ecological environmental protection and disaster prevention and mitigation in typical areas.

4. **Health impact:** DRRKS shared the temporal and spatial distribution of the heatwave disaster in South Asia to provide data support to reduce disease deaths.

5. **Other impacts:** Since launched in June 2017, the number of visits to the DRRKS website has reached an average of 14,000 per month; the proportion of international visits has maintained a steady growth, with average proportion of approximately 50%.

**Experience/ Lessons Learned/ Recommendations**

1. With disaster threats and challenges faced by the world, DRRKS is the common foundation of UNESCO’s international cooperation in disaster prevention and mitigation.

2. With the support of science and engineering technology, DRRKS is an international platform that integrates data, information, and the knowledge of disaster prevention and mitigation, and provides services for users.

3. All kinds of disaster prevention and mitigation databases, basic databases, product databases, knowledge databases, and multimedia information databases are knowledge resources for disaster prevention and relief operations, and DRRKS is an important carrier of disaster data resource accumulation.

4. Serving the world, DRRKS is a typical demonstration of cooperation between IKCEST and UNESCO in the field of disaster prevention and mitigation.
3.1.2 A Resilient Road Network Planning in Sichuan Province (Action- 3.4.1)

Yaqiao Wu¹ and Saini Yang¹
1. Beijing Normal University, Sichuan, China

Introduction

On May 12, 2008, the magnitude of 8.0 Wenchuan earthquake caused great loss of life and property. Infrastructure and public service facilities were seriously damaged, with a total loss of 61.2 billion yuan in highway infrastructure. The external transportation to the county towns of Qingchuan, Pingwu, Beichuan, Maoxian, Wenchuan and Heishui were disrupted. Widely distributed major roads and rural roads accounted for about 94% of the total loss.

A recovery plan for resilient transportation was carried out with an investment of around 120 billion yuan (including railways), and the transportation restoration project involving about 4,800 kilometers of major roads and 2,900 kilometers of rural roads. The restoration and reconstruction of transportation infrastructure achieved great success within 3 years’ time. The production, livelihood and infrastructure quality in the disaster-hit area were not only restored but also greatly improved with the goal of “Build Back Better”.

Measures

1. Sufficient transportation recovery investment: The total investment in transportation is 122 billion yuan, about 14% of the total investment in recovery and reconstruction. A lifeline road network with total mileage of 4,900KM was constructed in the disaster area.

2. Improved the seismic fortification standards of the lifeline road network: Based on the post-disaster assessment of the earthquake intensity, the seismic fortification standards of the disaster-hit area were specified according to the national and industrial classification standards. For the lifeline road network, the seismic fortification level was set to be one level higher than the others to ensure the transportation capacity in emergency.

3. Flexible technical standards and indicators: In accordance with the concept of flexible design promoted by the Ministry of Transport of the People’s Republic of China in recent years, the technical standards and indicators set in the plan are flexible to the complex terrain. For instance, the specification for road with better construction conditions could be appropriately increased.

4. Science-based construction plans and protection plans: Unfavorable geologic conditions were avoided in the construction projects with detailed geological investigation. Draining engineering, bridges, tunnels, shed tunnels and security protection facilities were built to increase the resilience of roads. The highway administration authorities in the disaster areas strengthened the monitoring of multiple natural hazards and their secondary hazards and have better emergency response plan both in human resource and facilities to ensure smooth transportation.

Impact

1. Boosted regional economic development: The main economic indicators such as the growth rate of GDP and fiscal revenue, and per capita income of urban residents and farmers in the 39 extremely heavy and severe affected counties (cities, districts) are higher than the provincial average.

2. Enhanced resilience of major roads in the disaster-prone area: The lifeline road network played survived the 8.13 flash flood and mudslide disaster in 2010 and the heavy rainfall in early July 2011, and played an important role in emergency response and disaster relief. This concept has been widely recognized and applied.
3. **Better transportation accessibility:** The technical level of major roads has been further improved. More than 2,100 kilometers of level 2 and higher level roads were built, with an increase of around 50%. The percentage of towns linked up by asphalt roads and highway accessible villages have been increased significantly. Almost all the towns and villages in Sichuan, Gansu and Shaanxi are covered by the newly built road network.

4. **A more robust and efficient road network:** In Qingchuan, Pingwu, Beichuan, Maoxian, Wenchuan, Songpan, Jiuzhaigou and other mountainous region, at least 3 alternative routes were built to ensure network robustness. Driving conditions have been significantly improved. According to the statistics of Department of Transportation of Sichuan Province, the travel time of highway has been shortened by 30%, and the capacity increased by 50%.

**Lessons Learnt and Recommendations**

1. Develop an efficient transportation emergency response mechanism. The transportation emergency response mechanisms have been optimized after the Wenchuan earthquake. With the guide of this mechanism, the emergency rescue and recovery of transportation sector were carried out efficiently after natural hazard-induced disasters occurred in Yushu, Zhouqu, Lusha, and Ludian.

2. The concept of people-oriented and safety first is applied in road construction. For instance, the design of tunnels shall ensure the slope stability instead of shortening the tunnel length to save cost. In order to prevent falling rocks from the mountain, protective facilities were constructed in front of the tunnel entrance with an additional investment.

3. Advanced engineering experience and research results were widely applied in restoration and reconstruction, such as highway damage analysis, highway rapid recovery technology, seismic design of highways, bridge reinforcement and restoration technology, tunnel reinforcement technology, etc. These applications also accumulated valuable experience for disaster prevention in the future.
3.1.3 Rapid Recovery Technology of Highway Infrastructure: Case Study of Sanyuan Bridge (Action- 4.4.1)

GUO Chaohui
1. Beijing Municipal Commission of Transport, Beijing, China

Introduction

Rapid recovery of facilities or restoration of function is an important component of infrastructure resilience. Sanyuan Bridge is located at the junction of the two busy major urban roads of Beijing: Third Ring Road and Jingshun Road. Built in 1984, the bridge is 54.9 meters long and 44.8 meters wide. It has three spans and the upper structure is concrete steel frame π-shaped beam; the lower structure is strip-type enlarged foundation, with V-shaped pier.

Due to long time operation and structural deterioration, the bearing capacity is reduced, and the bridge is rated as D-class (failed). If the conventional construction method is adopted, the impact on traffic will last for several months, which will bring great inconvenience to the public. The Beijing Municipal Commission of Transport finalized a rapid overhaul plan for the replacement of the superstructure of the bridge using an innovative technology.

The replacement started at 11 pm on November 13, 2015, and resumed traffic at 6 pm on November 15th. It took only 43 hours to complete the overall replacement of a large bridge deck structure in a mega city, which is a new record of urban transport infrastructure recovery. A time-lapse video of the Sanyuanqiao “Old Bridge and New Bridge” filmed by Beijing TV Station was heated up on YouTube, and viewed for more than 10 million times. This triggered a sensation and heated discussion domestically and internationally.

Measures

The core technology of the project is to adopt the “thousand-ton-class truck-loading machine” developed by Chinese enterprises. The new bridge superstructure with a weight of 1,350 tons was installed at one time and the new beam was prefabricated at the site. To minimize the impact on traffic time, the overall replacement work was arranged on the weekend. The commuters went to work on Monday did not even notice that the old bridge had been changed. With this technology, bridge replacement can be completed in one weekend, which minimize the interruption of urban traffic in the congested area of big cities. It is a new way to improve the resilience of urban transportation infrastructure and ensure the safety and effectiveness of urban operation.

Impacts

1. The safety of the bridge structure has been greatly improved, and the service life of the bridge design has been extended to 100 years, effectively ensuring the safety of urban operation.
2. Minimize the impact of bridge renovation on urban traffic and effectively reduce function disruption.
3. Using GPS and Beidou dual positioning system for cross verification. The laser tracking technology is innovatively used to realize the automatic correction of the truss car, so that the final overall beam changing accuracy reaches millimeter level.
4. A duplicable approach balancing the contradiction between project implementation and traffic control, to achieve the goal of the shortest construction period, as well as the least impact on traffic and the lowest social cost.
Lessons Learnt and Recommendations

1. The command system has clear responsibilities, clear assignment, and high efficiency from top to bottom. The departments of engineering construction, traffic management, public security, and comprehensive coordination played their roles, which ensured the smooth progress of the project.

2. Technical innovation scientific argumentation support is strong. In the early stage, a large number of meticulous construction plans, the bold innovation of the overall replacement method and the successful application of advanced equipment laid a solid foundation for the smooth implementation of the project. A team of 9 senior experts conducted multiple rounds of auditing and demonstration of 12 key process plans, implementation plans and material application. 48 rationalization proposals were proposed and tested one by one.

3. Fine crisis handling mechanism. With narrow working space, huge number of tasks, complicate task types, and various large equipment, nearly 500 on-site operators coordinated this project. When the old bridge was transported, there was an unexpected situation. The old concrete structure of the beam was damaged seriously, and the integrity was insufficient. It was difficult to judge the safety after the top of the beam was tested. After comprehensive analysis and judgment, the plan was changed to local dismantling and transportation. The situation was successfully handled through a series of prescribed procedures.

4. Timely notifications for the public. During the project implementation, telecoms sent SMSs to the public in advance to inform the traffic control scheme. Baidu, Gaode and other navigation companies increased the release of construction information of the Sanyuan Bridge and realized the detour to the construction area. Coordinated 6 sub-district offices and distributed more than 10,000 flyers to nearly 50,000 residents and more than 5,000 companies in 27 surrounding communities, public notification service reached individuals. Information release played an irreplaceable role in the relief of traffic pressure.
3.2 Action Specific Cases

3.2.1 Enhancing Drought Resilience and Rice Yield Security in Vietnam (Action 1.1.1)

**Peeranan Towashiraporn**, Susantha Jayasinghe, Aslam Perwaiz

1. Asian Disaster Preparedness Center (ADPC), Thailand

**Process:** To address this challenge ADPC, through its SERVIR-Mekong project, worked with Vietnam’s Ministry of Agriculture and Rural Development (MARD) and the Vietnam Academy for Water Resources to develop a geospatial tool that integrates hydro-meteorology and agricultural knowledge. The tool allows users to receive information on drought indicators on a daily basis as well as 3-month forecast. Moreover, currently the tool is being expanded to integrate rice production estimation into it. Once completed, this tool, which are publicly available, will allow a diverse group of users from hydro-meteorological officers to agricultural planners to gain access to useful information they could use for their own work.

**Context:** During 2015-2016, Vietnam experienced its worst drought in 90 years due to the El Niño, where 52 out of the 63 provinces were affected (Source: FAO, 23 August 2016). A total of 2 million people was affected and the total cost for recovery needs from October 2016 until 2020 is estimated at US$1,221 million (Source: UNICEF, 15 August 2016; Government of Vietnam/UNCT/OCHA, 21 Oct 2016). Since Vietnam is heavily reliant on rice crops for its economy and people’s livelihoods, lack of adequate planning and preparation for droughts can cause a significant drop in rice production, resulting in less income for farmers and less food for the people.

**Key Stakeholders:** Vietnam’s Ministry of Agriculture and Rural Development and its Vietnam Academy for Water Resources.

The tool allows users to receive information on drought indicators on a daily basis as well as 3-month forecast.
Role of Science and Technology: This work in Vietnam utilizes Earth observing satellites and the data derived from them, combined with hydrological and crop modeling techniques to calculate a number of drought indicators, both near-real-time and 3-month forecast. The results are presented as a web application accessible by the general public.

Possible Replication and Challenges: The work was piloted in Ninh Thuan province of Vietnam, but it is totally scalable and replicable in other areas. The only challenge is that the drought and crop yield models require a significant amount of ground-observed data to help calibrate and validate the satellite and model estimation.

3.2.2 Rainfall and Earthquake Induced Landslide Susceptibility Zonation Mapping: A Case Study from Chamoli District, Uttarakhand, India (Action 1.1.4)

Sangeeta¹

1. Centre of Excellence in Disaster Mitigation and Management, IIT Roorkee, India

Context: Landslides account for considerable loss of life and damage to communication routes, human settlements, agricultural fields and forest lands in Himalayan region. In India, about 0.42 Million km² areas of the landmass (12.6%) is landslide-prone.

Landslides are typically induced by rainfall or earthquake, sometimes a rainfall event followed by an earthquake or vice versa. In the landslide literature, these two kinds of landslides are different in terms of mechanics...
and dynamics (Chang et al. 2007). Rainfall and earthquakes do not present the same spatial incidence, nor are they similarly conditioned by the same predisposing factors. Thus, several researchers have highlighted the significance of an individualized assessment of landslides according to their triggering factor (Yamagishi and Iwahashi 2007; Zhang et al. 2014).

Most of the researchers have been largely focused at the single event-susceptibility model; this type of modeling is found inadequate in places where the triggering mechanism involves both factors such as Indian Himalayan. Generally, a single event based model provides only limited information of landslide spatial distribution and thus minimize the potential combination-effect of earthquakes- and rainfall-induced landslides combination of multiple hazard is required.

With this background, the major objective of this case study is to assess the composite effect of rainfall and earthquake on landslide susceptibility zonation (LSZ) and consequently prepare a rainfall and earthquake induced landslide susceptibility map for the Chamoli district, Uttarakhand, India.

Key Stakeholders: Various stakeholders including government officials, local communities living in landslide-prone hilly regions, non-governmental organizations and planners/engineers need such susceptibility maps, illustrating the areas that may be affected by future landslides so that these maps would be considered in development plans and appropriate risk mitigation measures.

Process: For this case study, a part of Chamoli district, Uttarakhand, India has been...
selected which was affected by 1999 Chamoli earthquake (Figure 20). The topography of the area is highly rugged and dissected with altitudes ranging from 787 to 5717 m above the mean sea level. Alaknanda River, along with its tributaries, constitutes the drainage network of the area. The study area is dominated with landslide-prone factors like steep slopes, barren land, highly dissected hill slopes, heavy rainfall, severe earthquake intensity zone and highly elevated hills.

For landslide susceptibility mapping, it is important to assume that the landslide causative factors influence the spatial distribution of landslides, and that future landslides will occur under the same conditions as the past landslides (Lee and Talib, 2005). In this study, Relative Frequency Ratio (RFR) method applied for the LSZ mapping. The RFR is widely used in landslide susceptibility mapping highly compatible with GIS technology.

Landslide Inventory: The landslide inventory map provides information to assess the influence of different causative factors on landslide occurrence. For this case study, landslide inventory (Figure 21) is derived from Bernard (2000).

According to the landslide inventory, 220 landslides that occurred before the Chamoli earthquake were rainfall induced landslides. Besides, 56 landslides were earthquake induced.

Landslide Controlling Factors: Spatial distribution and intensity of the landslides are significantly controlled by the topography, geology, hydrology, vegetation cover, rainfall, and earthquake. In order to apply relative frequency ratio method, a spatial database that considers 8 factors, including slope angle, slope aspect, slope curvature, geology, NDVI, distance to drainage, seismicity and rainfall was designed and constructed. All of these data were produced in raster format with a pixel size of 30 x 30 m² to be compatible with the spatial resolution.

Rainfall and Earthquake Induced Landslide Susceptibility Index Analysis: In the present study, the RFR method was adopted for the purpose...
Figure 22 Controlling parameters maps and relationship of training dataset for rainfall induced landslide (RIL) & earthquake induced landslide (EIL) with class area of controlling factors

Landslide Controlling Factors: Spatial distribution and intensity of the landslides are significantly controlled by the topography, geology, hydrology, vegetation cover, rainfall and earthquake. In order to apply relative frequency ratio method, a spatial database that considers 8 factors, including slope angle, slope aspect, slope curvature, geology, NDVI, distance to drainage, seismicity and rainfall was designed and constructed. All of these data were produced in raster format with a pixel size of 30 × 30 m² to be compatible with the spatial resolution.
of the calculation of a landslide susceptibility index (LSI) from which the landslide susceptibility maps were prepared. Landslide inventory was divided in two parts, 70% for training the model and 30% for testing the model. Distribution of training dataset in all controlling factors is shown in Fig. 3. Based on the training dataset, RFR values calculated. Geospatial datasets of controlling factors were converted to a raster format with a 30 x 30 grid size. The landslide susceptibility index (LSI) was calculated by the summation of RFR of controlling parameter. If the LSI value is high, it indicates a higher susceptibility to landslide, while a lower LSI values indicates a lower susceptibility to landslides for the particular area.

For visual interpretation of LSI maps, the data need to be classified into categorical susceptibility classes. In this study, the landslide susceptibility map generated with the RFR method was reclassified into five classes: very low, low, moderate, high, and very high.

LSZ map (Figure 23) shows that, the very low, low, moderate, high, and very high susceptibility classes constitute 10.13%, 30.05%, 29.49%, 18.81% and 11.51% of the total area, respectively. Meanwhile, the results show that the percentages of the total landslides in very low, low, moderate, high, and very high susceptibility classes are 0.64%, 9.62%, 17.31%, 26.28%, and 46.15%, respectively (Table 7).

Most LSZ models have been targeted at single-type-induced landslides Nevertheless, in areas such as the Chamoli area, Garhwal Himalaya, where landslides can be mainly activated by both earthquakes and heavy rainfall, it is essential to combine both types into the susceptibility modeling. Therefore, including both rainfall and earthquake, should be give more accurate prediction of landslide prone areas. This study will help to predict and prevent landslides, and to reduce losses of capital and human life as much as possible. The presented case study has much practical significance. This is because of high possibility of devastating earthquake and heavy rainfall exists in Uttarakhand. LSZ maps which include earthquake and rainfall parameter are helpful for the state government and disaster mitigation and management agencies and to take necessary action against any up-coming disaster scenario.

Figure 23: Rainfall and Earthquake Induced LSZ Map
### Table 7: Classification of Different Susceptibility Class for Rainfall and Earthquake Induced LSZ Map

<table>
<thead>
<tr>
<th>Hazard Class</th>
<th>LHI Range</th>
<th>Area (km²)</th>
<th>Area (%)</th>
<th>Landslide incidence Training (No.)</th>
<th>Landslide incidence Training (%)</th>
<th>Landslide incidence Testing (No.)</th>
<th>Landslide incidence Testing (%)</th>
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### 3.2.3 Improving Understanding of Flood Risk through Satellite Data in Myanmar (Action 1.1.4)

*Peeranan Towashiraporn¹, Kittiphong Phongsapan¹, Aslam Perwaiz¹*

1. Asian Disaster Preparedness Center (ADPC), Thailand

**Context:** Myanmar suffers from devastating monsoonal flooding on a frequent basis. The fast and effective management of floods relies on pre-planning to ensure the availability of supplies, shelters and emergency response personnel by the Department of Disaster Management (DDM), under the Ministry of Social Welfare Relief & Resettlement (MSWRR), international actors and local response NGOs.

Currently, the lack of systematic flood risk analysis means the DDM collects local knowledge to inform their preparedness planning, which although critical, takes significant resources and allows bias and human error to effect plans. Flood risk assessment requires several complex layers of information, including exposure of hazard to the population and likelihood of the physical event. The process is time-consuming and requires much financial resources and technical expertise.

**Key Stakeholders:** Myanmar’s Department of Disaster Management

**Process:** ADPC brings satellite data for estimat-
ADPC co-developed with DDM a systematic decision-support tool of flood hazard and exposure indices which will allow the identification of areas of high risk in terms of historical flood frequency combine with the integration of socio-economic and population data. The tool enables more informed decisions on the exposure of people to floods to support preparedness planning.

**Role of Science and Technology:** The Joint Research Center (JRC) data set was used for historical flood frequency mapping for Myanmar. The data set was developed by more than 30 years of Landsat satellite imagery. ADPC recently integrated more recent imagery from the European Space Agency’s Sentinel-1 data to complete the data set. The end results of the tool are flood hazard and exposure indices within a user-defined time period and presented in a map format. DDM has indicated use of the tool to improve services around pre-allocation of flood relief supplies to the townships that have high flood risk and identifying possible sites for shelters. In addition, the historical flood map and flood indices will also be used to advocate to the government for effective agricultural, urban and city planning.

**Possible Replication and Challenges:** The methodology is totally replicable in other countries that need better understanding of flood risk but lack resources to conduct detailed flood risk assessment.

**Figure 24: Systematic Decision Support Tool**
3.2.4 Thaiwater.net: Thailand’s Hydroinformatic Platform - the Information Based Solution for DRR (Action 1.2.2)

Pintip Vajarothai

1. Hydro-Informatics Institute (HII), Thailand

Context: Thaiwater.net was originally initiated by the initiative of King Bhumibol Adulyadej in 1988 as part of the Thailand Water Resources Management Network. The network was supported from the Massachusetts Institute of Technology (MIT) and working closely with the Office of the Royal Development Projects Board (RDPB) and Thailand Research Fund (TRF), to set up the process of data gathering and forming research and development networks among various organizations to collectively contribute in all aspects of water resource management. Currently the Thaiwater.net data center is one of services provided by the National Hydroinformatics and Climate Data Center (NHC) which collects and integrates information from more than 38 water resources and weather-related agencies. All collective data such as rainfall, water level, dam level, storm tracking, forecasting, and, country situation, are stored in the same database and available for exchange between agencies in order to maximize mutual benefits in managing water resources, monitoring all situations, disaster warning, and minimizing life and property loss in a timely manner.

Key Stakeholders

- National Water Resources Committee
- Government agencies related to water resources, weather and disaster management
- General public

Figure 25: System Architecture of the National Hydroinformatics and Climate Data Center
**Process:** The development of Thaiwater.net involves 4 stages of NHC system architecture as shown in figure 25. The architecture is described from the bottom to top of the process in the following:

- Collecting data from various agencies: There are more than 400 data items from 38 agencies in the data base. The data are grouped into six main categories relevant to water and weather management.
- Connecting data via the Government Information Network (GIN): GIN is used for securely sharing and exchanging data among member agencies in the system.
- Developing data integration tools and techniques: These include the computer infrastructure in the data center, the support system, and the data standardization.
- Providing services: The services are provided through various applications for different uses which include the website (Thaiwater.net), mobile application, data exchange service, model processing, and media box for local people accessing information in their own areas.

**Role of Science and Technology:** Promote access to data, information and technology

**Possible Replication and Challenges**

- Extending the services to provincial water resources management center: Currently there are more than 5 pilot provinces on process to set up and practice the use of information for analyzing water situation.
- Magnify the outcome to regional level: The NHC and Thaiwater.net can be counted as a best practice in data integration and exchange. The professional experiences and knowledge will be sharing to all ASEAN countries.
- Future challenges: the NHC and Thaiwater.net must need to be prepared for rapid technological changes and how to secure the system and services stability in a long run.

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### 3.2.5 Bridging Science and Public Divide (Action 1.2.2)

*Pradip Khatiwada*

1. Youth Innovation Lab (Yi-Lab), Nepal

**Context:** Disaster related data and information is one of the most crucial components for policy making, planning, and implementing Disaster Risk Reduction and Management (DRRM) activities. In the past, several disasters related portals have been developed by the Government of Nepal (GoN), development agencies, and non-governmental organizations. However, the data was scattered, insufficient, and not fully harmonized data thus creating barriers in its accessibility.

With the aim of creating a one-stop platform for disaster related data and information management, an integrated and comprehensive Disaster Information Management System locally named as Building Information Platform Against Disaster (BIPAD) has been built. BIPAD serves as a repository for disaster data and information and fosters data partnership at all three tiers of government and relevant stakeholders. BIPAD is now hosted in the government’s domain and has been developed by pooling all credible digital and spatial data available within different government bodies, non-governmental organizations, and research/academic institutions on a single integrated platform.

**Key Stakeholders:** The key stakeholders include

- Three spheres of Government: Federal, 7 Provincial and 753 Local Governments
- District Administrative Offices (DAO)
• United Nation Organizations (UNO)
• International/ National Non-Governmental Organizations (I/NGOs)
• Nepal Police (as first responders)

**Process:** With the vision of building a one-stop platform that covers all aspects of DRRM, six specific modules were developed within the system. Each module has unique features and host different data and information. The data of each module are interlinked that allows for comprehensive analysis. These modules serve to enhance early warning, and preparedness, strengthen disaster communication and emergency response, and improve evidence-based planning and decision-making. Adopting a user-centric approach, the development has been an iterative process with close consultation with the users as well as experts.

**Role of Science and Technology:** Acknowledging the importance of science and technology, BIPAD has been developed using the state-of-the-art technology; robust and flexible for upgrading is also adaptable. Being DIMS, the system has integrated digital and spatial datasets on alert, incident, hazard, exposure, vulnerability, risk and capacity and resources. These data sets are collected or obtained from government institutions, I/NGOs, national and international research institutions and academia. The data and information in the system are backed by science and is verified by the Government of Nepal (GoN). With the visualization of geo-spatial data backed by credible research, the decision makers and DRR practitioners can effectively prepare, plan and respond to disasters.

**Possible Replication and Challenges:** BIPAD is the blend of indigenous knowledge of Nepal and use of cutting-edge technological tools, which make this unique and innovative. This system is open in terms of data as well as its codebase. All data in BIPAD are accessible and are easily downloadable. Most of the datasets are integrated using API of which user too has an access to. Because of the open codebase, local government also have the flexibility to customize and build the new disaster portal if needed at the local level. Furthermore, the system has read and write usability providing the authorized users the facility to create, add, edit and manage database through Frontend. Since the system is open, with appropriate credits BIPAD can be replicated in anywhere in the world.
In the course of the development of BIPAD, some of the major challenges are as follows:

- **Technical Capacity**: Though the technical capacity of the government officials has improved, the data management and handling is still a challenge, especially in local governments. Continuous monitoring and technical assistance is needed in the future to enhance their technical capacity to institutionalize the system.

- **Data aggregation and standardization**: There has been an enormous challenge on the part of data aggregation and standardization. Integration is challenging on account of:
  - Data compatibility and format of data
  - Multiple sources of similar data
  - Different organizations have different purposes of creating data. Aggregating data into a single platform without misleading is a challenge.

### 3.2.6 Integrated CWRM Work for DRR to SDGs (Action: 1.2.3)

**Sutat Weesakul**, Royboon Rassameethes

1. Hydro Informatics Institute (HII), Thailand

**Context**: Today, people realize that water is a key element to reduce poverty and alleviate disaster risk, since water can help increase agricultural production, improve environmental conditions and enhance the community’s livelihood. The results of good water management would then contribute to the achievement of several Sustainable Development Goals (SDGs). Then, the Community Water Resource Man-

**Figure 26 : Khlong Yan Community Network**
agement (CWRM) has adopted new technologies combining with indigenous and local knowledge to enhance the capacity of communities to better adapt with climate change impacts, reduce disaster risk, and eventually alleviate the poverty of the local community. The best practice in Khlong Yan Community Network, Surat Thani province, has shown that key elements of S&T, local knowledge, and practices could understand the Disaster Risk prevention and reduction.

**Key Stakeholders:** The key stakeholders are local, private and public organizations. Each organization has its function but integrate work for mutual benefits to Khlong Yan Community Network. The core stakeholder is the network who operates with the indigenous knowledge, and coordinates with others for efficiency outcomes. The private sector provides the budget whereas the public provide the S&T knowledge.

**Process:** HII convey the knowledge of S&T as the instrument for the network in order to understand themselves for CWRM. Then, the network integrates the S&T, community innovation, and their indigenous knowledge including the local knowledge to develop and manage their water resources. The output is to solve the water problems for the consumption and agricultural propose, and the outcomes are the climate changed resilience, DRR, especially, SDGs.

**Role of Science and Technology:** The role of S&T are divided into 2 factors, first is the technology that the network use as the tools, i.e., GPS, land used map, telemetering station, etc. which result to the data which is the second factor. The data are used to analyze and manage the water resources, monitor the water and weather situation, and prevent the disaster. The network has over 38 sub-network disaster warning stations. They prevent the disaster along the canal, over 70 kms.

**Possible Replication and Challenges:** Currently, Khlong Yan Community Network has practiced their DRR and SDGs. The network, totally 2 sub-district, has secured in water and food, including no disaster since 2016. In 2019, the network has replicated their practices to the 17 communities’ warning network all over Thailand.

### 3.2.7 Transdisciplinary Citizen Science Project on Mangrove Monitoring and Rehabilitation (Action 1.2.4)

**Glenn Fernandez¹, Maria Cecilia Ferolin², and Charell Romano³**

1. Institute for Disaster Management and Reconstruction, Sichuan University, China
2. Department of Extension, Mindanao State University – Iligan Institute of Technology, Philippines
3. U-INSPIRE Mindanao, Philippines

**Context:** Tsunami-prone archipelagic developing countries, like the Philippines, don’t have coastal protection infrastructure such as concrete seawalls. Residents along the coasts therefore rely on natural barriers like mangrove forests for protection against giant waves. Unfortunately, mangroves are being threatened with destruction caused by the commercial and residential development of coastal land. The decline of Philippine mangroves has been due to the exploitation of mangroves for fuel wood and the conversion of coastal areas to agriculture, industry, and settlements. Mangrove degradation in the Philippines is anticipated to continue. With the treat of a tsunami looming and mangroves being further degraded, mangrove conservation and rehabilitation is imperative for residents of coastal cities like Pagadian in Mindanao, Philippines. This can be an excellent opportunity especially for the youth to make significant contributions. Not known to many, the 1976 Moro Gulf Earthquake and Tsunami was actually the biggest disaster in the history of the Philippines in terms of the number of casualties. Over 8,000 people were killed or missing, 10,000 were injured, and 90,000 were left homeless, mostly due to the tsunami that devastated
700 kilometers of coastline. The worst hit city was Pagadian.

**Key Stakeholders:**

- Youth councils of coastal villages of Pagadian City
- Village councils
- City government
  - Office of the Mayor
  - Youth Council Federation Office
  - City Disaster Risk Reduction and Management Office
  - City Environment and Natural Resources Office
- Local higher education institution
  - Saint Columban College
- External higher education institutions
  - Institute for Disaster Management and Reconstruction, Sichuan University
  - Department of Extension, Mindanao State University – Iligan Institute of Technology
  - University of the Philippines – National Institute of Geological Sciences (UP-NIGS)
- Funding agency
  - Takagi Fund for Citizen Science, Japan

**Process:** In the Philippine local governance system, there is one youth council in each of its 42,000 villages (barangays). In Pagadian, 12 out of its 54 villages are along the coast. This means that there are 12 youth councils that can contribute in saving and propagating the mangroves in their villages. To help protect the remaining mangroves of the city and to help in reforestation efforts, the youth councils can do the following: assist in the initial assessment of the current condition of mangroves in their village; help in selecting appropriate mangrove species and reforestation sites based on advice from experts and available references and guidebooks; and share the importance of mangroves to residents of their village in order to convince them to join mangrove conservation and rehabilitation efforts. This ongoing project will strive to create opportunities and spaces for youth councils to be actively involved in the monitoring and rehabilitation of the mangroves of their village with financial help from the Takagi Fund for Citizen Science and from the experts among the project team members who will contribute their knowledge, time, and effort pro bono in order to mentor the youth council members and other young people in the coastal villages to be citizen scientists.

**Role of Science and Technology:** There are several numerical and physical model studies that support the mitigating capabilities of mangroves for tsunamis. Mangroves can provide...
additional drag against wave energy through their trunks, leaves, root systems, and pneumatophores. Mangroves can also promote the stabilization and establishment of coastal soil with their complex root systems, which can reduce wave impacts further inland. Science can be used to explain to the coastal village residents the importance of mangroves as tsunami bio-shields.

**Possible Replication and Challenges:** This project can easily be replicated by other coastal villages in and outside the Philippines. Project documentation is through a dedicated website: https://savemangroves.org/ (under construction). We intend to share our project results with the local government and with the local and national offices of the Department of Environment and Natural Resources (DENR) and of the National Disaster Risk Reduction and Management Council (NDRRMC). We also aim to publish journal articles with some of the stakeholders in order to share the lessons learned from our project to a wider audience.

### 3.2.8 Mobilising Malaysian Youth and Young Professionals in Disaster Risk Reduction and Climate Change through Science-Policy Interface (Action 1.3.3)

*Mohd Khairul Zain¹, Joy Jacqueline Pereira¹, Sarah Aziz Abdul Ghani Aziz¹ and Nurfashareena Muhamad¹*

¹Universiti Kebangsaan Malaysia’s Southeast Asia Disaster Prevention Research Initiative (SEADPRI-UKM), Malaysia

**Context:** The role of the IPCC is to access on a comprehensive, objective, open and transparent basis the scientific, technical and socio-economic information relevant to understanding the scientific basis of risk of human-induced climate change, its potential impacts and options for adaptation and mitigation. The involvement of the Asia researchers especially the youth and young professionals in the IPCC Sixth Assessment Report (AR6) are limited. To date, only 19% of authors in the Asia region are involved in preparing the AR6, compared to 34% of authors in Europe.

**Key Stakeholders:** An outreach event on IPCC role, activities and findings was organised on 26 October 2019, at Academy of Sciences Malaysia (ASM). The event was organised by Ministry of Energy, Science, Technology, Environment and Climate Change (MESTECC), Academy of Sciences Malaysia, UKM’s Southeast Asia Disaster Prevention Research Initiative (SEADPRI-UKM), and Asian Network on Climate Science and Technology (ANCST), in collaboration with U-INSPIRE Malaysia and Malaysian Youth Delegation.

**Process:** The event aims to present the work and findings of the IPCC in a simple language. It also provides an opportunity for local youth and young professionals to discuss, understand and share the idea on issues pertaining to climate change and disaster risks that can be implemented at the national level through a science-policy interface. The event was organised with the local youth and young professionals, with a specific objective; to encourage youth and young professional’s contribution towards the IPCC reporting processes in the region, especially in reviewing the IPCC reports. The review is an essential part of preparing IPCC reports. It ensures that IPCC reports cover the most up to date scientific, technical and socio-economic findings, and are representative of a broad range of independent experts from developed and developing countries.

IPCC has three working groups, namely Working Group I (WGI), dealing with the physical sci-
ence basis of climate change; Working Group II (WGII), dealing with impacts, adaptation, and vulnerability; and Working Group III (WGIII), dealing with the mitigation of climate change. It also has a Task Force on National Greenhouse Gas Inventories that develops methodologies for measuring emissions and removals. The event was coordinated by Prof. Dr. Joy Jacqueline Pereira of SEADPRI-UKM, who is ANCST Director and IPCC WGII Vice-Chair. The three most recent IPCC special reports were presented during the event, namely on IPCC Special Report on the Ocean and Cryosphere in a Changing Climate (SROCC), IPCC Special Report on Climate Change and Land (SRCCL), and IPCC Special Report on Global Warming of 1.5°C (SR15). Speakers include IPCC Chair, WGI Co-Chair, WGIII Co-Chair, WGIII Vice-Chair and IPCC Author.

Role of Science and Technology: All IPCC reports provide a scientific basis for governments at all levels to develop climate change-related policies. These reports are policy-relevant but are not policy-prescriptive; this means that reports present projections of future climate change based on different scenarios, the risks that climate change pose, and discuss the implications of response options, but they do not tell policymakers what actions to take.

Possible Replication and Challenges: This type of event could be replicated in other countries, to ensure the involvement of local youth and young professionals in the IPCC reporting processes, particularly in Asia and the Pacific region. The main challenge for local youth and young professionals is to publish their current scientific works related to disaster risk reduction and climate change in Asia and the Pacific, so that their work is acknowledged and cited by the IPCC reports in the future.
3.2.9 Hackathon: Youth Hacks for DRR (Action 1.4.2)

Suman Chapagain¹, Suraj Gautam² & Kaushal Raj Gnyawali³

1. Himalayan Risk Research Institute, Nepal
2. Institute of Himalayan Risk Reduction, Nepal

Context: There are tens of thousands of youths and young professionals working in hundreds of organizations in Nepal. In the meanwhile, thousands of young researchers graduate from the university every year. Still, there is a big gap between young researchers and professionals in terms of knowledge and resource sharing. During the talk program conducted on the occasion of International Day for Disaster Risk Reduction in October 2019, it was realized that there is a need for a program that can create a bridge between youths, young researchers, young professionals and experienced professionals. Thus, the hackathon was organized on November 29 of 2019, at Pulchowk Lalitpur. The program was conducted in the auditorium provided by the Center for Disaster Studies (CDS) in Pulchowk Campus, which is the biggest technical knowledge hub in Nepal. The program was organized by U-Inspire Nepal, Co-organized by Center for Disaster Studies (CDS), Himalayan Risk Research Institute (HRI) and Institute of Himalayan Risk Reduction (IHRR), Supported by National Technical Committee of Asian Civil Engineering Coordination Committee (ACE-CC), Nepal Engineers’ Association (NEA) and Free Students’ Union (FSU) of Pulchowk Campus, and media support from Engineer Khabar (www.engineerkhabar.com)

Key Stakeholders: Institutional participants from U-Inspire Nepal Chapter, HRI, IHRR, CDS, ACE-CC, NEA Province 3, Pulchowk Campus, Institute of Engineering, and other humanitarian organizations. Inclusive participation of:

Figure 33: Participants at Youth Hackathon for DRR
• Youth volunteers,
• Students,
• Young researchers,
• Young professionals, and
• Professors/academicians

Process:

• Inauguration: Program inauguration through the remarks from the president of Nepal Engineers’ Association followed by the best wishes from UINSPIRE colleagues in China, India and Indonesia through Skype.


• Presentation (Uttam Pudasaini, NAXA & Nepal Flying Lab): Use of drone technology in Disaster Risk Reduction, Management and Recovery.

• Use of Technology for Sharing and Learning: Experience sharing and problems identification was conducted among the participants. Participants explored resources available throughout the internet. The relevant findings from the internet were validated through the experience and knowledge of professionals. Similarly, the professionals shared their findings on issues and challenges for emerging youths.

• Spider-web game (Facilitated by Navin Dahal, Rabin Sharma and Suman Chapagain): The spider-web game was played involving all participants. The game is capable of making participants realize the responsibilities of different stakeholders. At the end of the game, the self-assessment was conducted which further make realize the importance of coordination during emergency situations.

• Group Discussion (Within six different groups): Group members discussed on their learning and findings, and choose one theme among the five assigned themes to develop project ideas.

• Development of project ideas (Facilitated by Suraj Gautam, Suman Chapagain, Rabin Sharma and Navin Dahal): Each group developed one project ideas on one of theme selected by them. The ideas and innovation of young researchers were structured by the professionals and facilitators. The project ideas were discussed and presented in a chart paper in prescribed format and design.

• Sharing and award: Each group shared their ideas through the presentation in front of jury from CDS and ACECC. The best group was selected based on project ideas, group coordination, presentation, and structure developed in a paper and awarded with a cash prize.

Role of Science and Technology

• Participants agreed on the scientific phenomenon of disasters and the need of scientific learning and sharing related to disasters.

• Youths learned to use the existing technologies and exploring online resources with the help of young professionals.

• The program focused on the use of modern technology like internet platform and projected presentations for learning and sharing.

• Youth and professionals used the internet technology to explore the secondary resources.

• They used the systematic framework for developing project ideas.

Possible Replication and Challenges: The program concept is replicable to any parts of the country or the world with locally developed themes and identified stakeholders.

Major challenges:

• Inclusion of youths and young professionals working in the rural parts,
• Availability of relevant young professionals or experienced professionals for the program,
• Transformation of ideas into reality due to lack of organizational support.


3.2.10 Introduction to Technology & Humanitarian Aid in Afghanistan (Action 1.4.3)

Afghanistan Research and Evaluation Unit (AREU), Zabiuallah Siawash and Afghanistan State Ministry for Disaster Management and Humanitarian Affairs (SMDM) Officials

Context: The provision of humanitarian aid and in response to conflict and disasters require an appropriate amount of information for the assessment of the situation, planning and implementation of actions, and the evaluation of them. Collecting this information can be difficult in places affected by high intensity levels of conflict (HIC). The insecurity and the volubility of the situation prevent the collection of data, at the same time that relevant information has been missed, destroyed or not correctly and systematically collected.

The humanitarian aid sector (including disaster management, disaster risk reduction, and resilience and development actors) have seen a steady growth of the use of technology for data collection and communication during the last decade (Barnett, 2013; Fast, 2017; IFRC, 2013; Jacobsen, 2017; Stephenson and Anderson, 1997). As presented in the World Disasters Report, developed by the International Federation of Red Cross and Red Crescent Societies (IFRC): “The development of a more technology-oriented approach to humanitarian action is essential – and inescapable – to take advantage of the opportunities to improve, for example, information gathering, analysis, coordination, action or fund-raising” (IFRC, 2013: 9)

Key Stakeholders: One FGD was conducted and co-organized with officials from the Afghanistan National Disaster Management Authority (ANDMA) in their facilities. The second one was co-organized with the Agency Coordinating Body for Afghan Relief and Development (ACBAR) and the focus was to hear the voice of non-governmental humanitarian aid actors. It included the presence of three United Nations representatives, one participant from ACBAR, two participants form INGOs, and two participants from national and local NGOs. The third focus group discussion focused on governmental actors related to the provision of humanitarian aid and disaster management. Included the presence of a representative from different ministries, such as Ministry of Interior (MoI), Ministry of Communication and Information Technology (MCIT), and Ministry of Defence (MoD).

Process: Multiple qualitative research methods were used in the development of this report, including literature review, a survey, in-depth interviews, and focus-group. The literature review of academic work, policy and regulation documents in the country informed the survey questionnaire, interviews, and focus group, and supported the reading of the results.

The survey and interviews sought to identify the technologies being used, and explore the challenges associated with the use and management of them. The impact the conflict and how the conflict in the country affects the use of technology was also part of the survey, interviews and focus groups.

The survey considered a broad range of actors. Table 1 present details of the total numbers of participants of the survey (n=60), including representatives from National and local Government of Afghanistan, United Nations, International non-governmental organizations (NGOs), and National and Local NGOs. The survey was delivered in English and Dari to facilitate the participation of all actors and was delivered during June and July of 2018.

Five in-depth key-informant’s interviews were also conducted with people in managerial positions, including one Ministry, one UN Director, one INGO Country Director, one National NGO Country Director, and one manager of a private organization providing satellite and communication solutions. As requested by the participants, the specifics in terms of names and organizations need to be maintained confidential. Following up on the results from the sur-
3.2.11 Virtual Reality (VR) Application for Flash Flood Education (Action 1.4.5)

Nattapon Trumikaborworn\textsuperscript{1,2} and Porntida Poontirakul\textsuperscript{1,2}

1. Asian Institute of Technology (AIT), Thailand
2. U-Inspire Thailand

Context: Utilizing VR application for flash flood education

Key Stakeholders: Department of Disaster Prevention and Management (DDPM), the Thai Red Cross Society, and the public.

Process: Set up a computer simulation of flash flood and present the situation through VR tool for the users to gain virtual experience.

Role of Science and Technology: Utilizing VR application allows the users to immerse in a disaster situation. Users can have a virtual experience compared to other media, such as TV.

Possible Replication and Challenges:

- Having a number of full-headset VR could be expensive.
- Preparing a computer simulation for various types of hazard requires experts.
- Wearing VR for a long period could cause motion sickness.

Figure 34: VR Simulation
3.2.12 National and Regional Platform of Youth and Young Professionals in Science, Engineering, Technology and Innovation for Disaster Risk Reduction (Action 2.2.1)

N. Rahma Hanifa1,2, Risye Dwiyani1, Mizan B. Bisri1,3

1. U-INSPIRE Indonesia
2. Research Center for Disaster Mitigation, Institut Teknologi Bandung, Indonesia
3. United Nation University, Japan

Context: Connecting Youth and Young Professionals in co-creation on Science, Engineering, Technology, Art and Innovation for Disaster Risk Reduction.

Bridging the gaps between scientist, government, practitioners and community at risk.

Key Stakeholders: Youth and Young Professionals from universities, government, NGOs, private sector, media, independent.

Process: On the 29th of March 2019, 31 young leaders in SETI for DRR across Indonesia were invited to UNESCO Office Jakarta. During the meeting, they discussed cases of youth role in SETI for DRR, identified challenges and gaps, and agreed to build a platform to connect and support youth and young professionals who are willing to actively contribute to DRR through SETI. The platform was named U-INSPIRE (Youth & Young Professionals on INnovation, Science and Technology Platform for Resilien-
ty) and was launched on 3 November 2018 in Indonesia, during regional workshop of UNES-
CO – ICIAR LIPI and U-INSPIRE, titled “The Asia and the Pacific Regional Workshop on Strengthening, Empowering, and Mobilizing Youth and Young Professionals in Science, Engineering, Technology, and Innovation (SETI) for Disaster Risk Reduction (DRR)”.

The agreed vision of U-INSPIRE is: Indonesian youth and young professionals as the genera-
tor of innovation in science, engineering, and technology for disaster resilience at national and global level. The platform aims to bridge the gaps between the world of researchers with government, practitioners, and the public/communities as well as across different disciplines, institutions, and scale (local, national, global), by creating spaces for youth and young professionals to empower their role in SETI for disaster risk reduction. It is expected to contribute to the achievements of the Sendai Framework and Sustainable Development Goals, particularly Goal 4, Goal 8, Goal 9, Goal 11, and Goal 17.

As of December 7, 2019, the members have grown from 31 to 216, spread in 21 provinces of Indonesia and abroad, from different types of occupations and diverse fields of expertise. The member consists of students (29%), researchers/lecturers (19%), entrepreneur/artist/media professionals (17%), NGO/INGO workers (13%), local/national government officers or consultants (11%), and private sector officer (10%). The field of expertise vary from natural sciences, social sciences, to urban planning, public policy, arts, journalism, engineers, etc. Currently the platform is run by 30 core members.

The core activities of the platform have been around knowledge management, science communication, generating innovations, networking and advocacy at sub-national, national and global level. Partners have grown from three in March 2018, to 8 international agencies, 16 government/national institutions, 35 NGOs/CBOs/universities/research institutes, 7 private sectors and 4 media partners after 1.5 years.

In October 2019, a survey to U-INSPIRE members (n=48) was conducted to obtain their feedbacks on how U-INSPIRE has served its purpose. The results: 68% have started collaboration with other U-INSPIRE members on
SETI for DRR; the average score of perceived achievement of "U-INSPIRE moving in the correct direction towards its vision" was 7.5 (out of 10 as highest score); U-INSPIRE has changed the member's life positively with the median score of 8 out of 10, mainly because it has provided most recent knowledge and expands their horizon, access to wide DRR networks and has increased their motivation.

**Role of Science and Technology:** The core of U-INSPIRE activities using science and technology that tie the members and its partners have mostly been science communication, emergency spatial data acquisition, and hackathons. Science communication has been exercised in the development of infographics on 10 FAQ factsheets on recent significant disaster in Indonesia to counter hoax news. Two factsheets have been published, i.e. on Lombok 2018 Earthquake and Tsunami-Volcanic 2018 Eruption of Anak Krakatau, Flash Flood of 2019 (under review) and the Central Sulawesi 2018 Earthquake (under review). The other form of science communication was development of video series focusing on youth and young professional potentials in DRR.

Whatsapp Lecture (kulwap) using social media technology as a platform in disaster knowledge

**Figure 35:** Left. U-Inspire Indonesia Launching, 3 November 2018. Right Geospatial Hackathon during DRR Month 2019

**Figure 36:** Left. Covers of Infographic FAQ of Recent Disaster in Indonesia, Right Map of Damage Assessment after Halmahera 2019 Earthquake using UAV Technology
sharing, to date it has been conducted 8 times, with average participants of 250 members, collaboration with Indonesia Youth in Disaster Risk Reduction. UAV/drone Technology is used together with Sky Volunteer and NDMA for emergency spatial data acquisition after Lombok 2018 earthquake, Halmahera 2019 earthquake and Ambon 2019 earthquake.

Two hackathons have been conducted: a mini-hackathon to reengineer disaster data in Indonesia, and a geo-spatial hackathon: Shape for Better Community (SBC) funded by Unicef. SBC aim to generate innovative geospatial solutions to enhance earthquake preparedness in a populated area prone to flood risk, that fully take into consideration the needs of local beneficiaries. Five teams were shortlisted, and five low-cost technology prototypes were developed. The 1st winner developed GIFA (Geo-Intelligence System for Flood Prone Area) Apps – a gamification system to attract public to report by using the apps, and the 2nd winner developed HEPI App and Concept, a low-cost near-real-time and prediction of inundation, using crowd-sourcing data reported by public through cell-phone. Mentoring is continued and these application is currently being tested together with the local community.

Possible Replication and Challenges: U-INSPIRE has been replicated in 7 countries/sub-regions, namely Pakistan, Central Asia (DACRYN), Nepal, Malaysia, Philippines, India (CRRP), and Afghanistan. With the support and facilitation of advisors, members, UNESCO, UN-DRR, and other partners, this initiative has been brought up to the regional level, marked by the declaration of U-INSPIRE Alliance. Challenges: resources management with the voluntary nature of works.
3.2.13 Hypothetical Damage Scenarios for Earthquake Using Geographical Information System (Action 2.2.3)

Jeevan Madapala

1. Centre of Excellence in Disaster Mitigation and Management, IIT Roorkee, India

Context: Understanding of disaster risks to physical assets (physical infrastructure) and thus their assessment and quantification, aids in developing evidence-based disaster risk management strategies. The process undertaken in this study develops a model (methodology) which can be used henceforth, in different contexts, underlining the notion that disaster risk assessments should be mainstreamed in all sort of development and planning agenda, whether it be a large-scale mitigation program or a preparedness activity.

Key Stakeholders: The key stakeholders in this study where the academia (Centre of Excellence in Disaster Mitigation and Management, Indianan Institute of Technology Roorkee) and the disaster management authority of the state of Bihar in India.

Process: This study estimates the probable damages, loss of lives that may occur in various districts of Bihar, if 1934 earthquake is to return with the same intensity. This study also identified the vulnerable areas in Bihar by studying the demographic profile, housing profile and last but not the least the seismic profile of various districts of Bihar using the national census data of 2001. Based upon the publication 'Vulnerability Atlas' by the BMTPC (Building Material & Technology Promotion Council) the building types stipulated in 2001 census has been correlated to the building types defined under MSK intensities so as to achieve of Census houses having various Damage Grades in different Seismic Zones. The human loss calculation due to the collapse of buildings is attributed to the G5 and G4 damage grade (i.e., collapse and destruction). Human lives are lost only severe damage grades i.e., G5 and G4 and it was assumed that the loss of lives may be 6% in a house under damage grade G5 and 2% in a house under damage grade G4. It is also assumed that the life loss reduction factor is based on light roof R1, R2, R3 housing types. It was also assumed that the life loss reduction factor for an area during clear weather and daytime is 0.31 and is taken as F.

\[ R = \frac{\text{Total population of the country}}{\text{Total houses of the country}} \]

\[ L = \frac{0.1 \times \text{Number of R1 Housing} + 0.3 (\text{Number of R2 and R3 Housing})}{\text{Total Housing}} \]

\[ F = \frac{0.3 \times \text{Number of Rural Houses} + 0.5 \times \text{Number of Urban Houses}}{\text{Total Housing}} \]

The above mathematical equations developed and the demographic data prepared by BMTPC and published in "Vulnerability Atlas" were used with GIS to calculate the damage. The timing of the earthquake is major factor in deciding the number of deaths which has also been taken into consideration. Uniform distribution of buildings throughout the district was considered and the calculation of each building types into the respective damage grades have been done in GIS using the field calculator.

Role of Science and Technology: As it is obvious, without the equations developed by BMTPC based on statistical regression and its incorporation into GIS, re-creation of the hypothetical scenario would have been impossible. Such studies open up scope for assessments of disaster risks, pertaining to physical assets, and provides scientific basis of preparation of disaster risk management strategies. Moreover, it also opens up avenues of extrapolating such studies for other hazards too.

Possible Replication and Challenges: As the
methodology of this study is scientifically robust, it could be replicated in different contexts, provided data / information is available. Even more, a sound preliminary scientific study demarcating the grades of damage and the probabilistic estimate of life loss associated with such grades of damage would be useful to make this tool effective, if it is to be replicated.

The precision of the calculations used in GIS toolbox can be further improved by reducing the individual unit from a district to either a block or a village, however, that would require additional resources in terms of human resources as well as financial provisions. The use of satellite images can further enhance the ground truthing of this tool.

3.2.14 Provincial Water Resource Management Center (PWRM): Collaboration between National Hydroinformatics and Climate Data Center and Local Operation Centre (Action: 2.3.1)

Sutat Weesakul 1, Jittiporn Chantarojsiri 1, Pensiri Saranrat 1

1. Hydro-Informatics Institute (HII), Thailand

Context: Hydroinformatics and Climate Data are a significant fundamental for an effective and efficient situation analytics, water resources management planning, and decision support system during a crisis. Hydro-informatics Institute (Public Organization) or HII has modernized and developed National Hydroinformatics and Climate Data Center (NHC) by integrating hydroinformatics and climate data from 44 government agencies. The integrated data could be identified as follows; statistical data, area-based data, observed data, real-time information for
monitoring current water situation data, water situation forecasting, flood- and storm surge-risk, and real-time situation monitoring at the provincial level. NHC is the complete data center to support the government sector, public sector, local government sector, and people in planning for efficient water management.

### Key Stakeholders
- National Hydroinformatics and Climate Data Center
- Provincial Water Resource Management Center
- Local government
- People

### Process:
From the successful operation of NHC, HII cooperates with Provincial Water Resource Management Center (PWRM) with intention to collaborate and support information for Provincial Administration Organization when crisis situation arise. For example, when storm is approaching Thailand, HII will collaborate with PWRM for storm tracking regarding direction and severity of the storm. The monitoring system will project 7-day forecasting which enable HII to identify the affected area beforehand.

Therefore, HII can early notify local provincial center and provide information to the provincial governor for official decision accordingly.

### Role of Science and Technology:
S&T as a tool to provide precise information for disaster risk reduction and preparation.

### Possible Replication and Challenges:
The implementation of the provincial water resources management center is an important mechanism to help local people on monitoring water situation, including planning for normal and crisis situation.

1. Phrae Provincial Water Resources Management Center - Phrae Provincial Administration Organization has collaborated with HII to deal with Doksuri storm on September 2017 since its formation. The rainfall forecasting model is the tool that can identify the areas with heavy rain and floods in Phrae province. Then, Phrae Provincial Water Resources Management Center has used this information to discuss with other related local organizations. As a result, all related organizations agreed to drain out the water in the reservoir and brought in the machine to clear the waterway for fast drainage.

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**Figure 28: Collaboration between NHC and Provincial Water Resource Management Centre**
drain out in order to receive incoming water from Doksuri storm. These preparations can reduce losses of properties and lives of local villagers. Phrae Provincial Water Resources Management Center is the first PWRM that has established in 2013 and becomes the prototype of the collaboration between the central organization (HII) and local (provincial).

2. Surat Thani Provincial Water Resources Management Center – Surat Thani Provincial Administration Organization has collaborated with HII to deal with Tropical Storm Pabuk on January 2019 by preparing manpower, tools, equipment, communication tools, and machinery to the surveillance area to help tourists and local people. The preparation also included the allocation of manpower and machinery for effective operation. During the landing of Pabuk storm through the south of Thailand, Surat Thani PWRM monitored the 24-hour situation and continuously communicate with HII.

3. Trang River Basin Management Center – On 4 January 2019 while the tropical storm Pabuk landed at Nakhon Si Thammarat province and caused heavy rain at Yong Waterfall National Park, the flashflood from this area causing serious flooded in Thung Song Municipality. However, with the continuous monitoring of the situation with HII, Thung Song Municipality had successfully alerted local people via social media to evacuate and transfer valuable items 6 hours before the flood arrived.

3.2.15 CARI! (Cerdas Antisipasi Risiko Bencana di Indonesia) / SEARCH! (Search Engine for Research on Risk and Resilience) (Action 3.1.5)

Mizan B. F. Bisri1,2,3, Retno Rifa Atsari2, Ridwan Firdaus2, Dewa Putu AM2, Riyanti Djalante1 and Alexandros Gasparatos3

1. UNU-IAS. Tokyo, Japan
2. (CARI!)
3. The University of Tokyo, Japan

Context: Indonesia has witnessed a continuous trend in the proliferation of research in disaster-related sciences, especially after the 2004 Indian Ocean Tsunami (Djalante, 2018). More so if we considered research and knowledge products published in Bahasa Indonesia, as well as those stored in repositories of national universities and research institutes. However, the series of catastrophic disasters in 2018 show how the link between science, policy, and action is not fully utilized for creating a resilient nation. After the 2018 triple disasters in Central Sulawesi Province, people are scrambling to fully grasp the event, particularly on the earthquake-tsunami occurrence scenario and due to the devastation caused by the liquefaction in Palu City. It was not rare to find claims that liquefaction risk was unknown to Palu city, despite the fact that prior research has shown the opposite. A few months after, the 2018 Sunda Strait Tsunami impetus public confusion as to why the tsunami occurred without any earthquake preceding the event and was in fact caused by a collapse-flank of Mount Anak Krakatau. The latter scenario was documented in research published six years before the event (Giachetti et al., 2012) and once the public exposure to this research product occurred, the typical blame gaming and claims that the government’s spatial and development policy did not consider scientific evidence were floating around.

The two events above show that despite progress in the number of disaster-related research, a variety of topics and a variety of knowledge products (Djalante, 2018); policy-makers still face difficulties to find and internalize the relevant key-research into the spatial & non-spatial policy documents. Our citation network and discourse network analysis to research papers vis-à-vis national government policy shows that par-
tially some policy documents have either directly or indirectly citing key research on earthquake and tsunami in Indonesia and we argued that Giachetti and colleagues work was considered an outlier to the policymakers (Bisri & Djalan-te, forthcoming). Accordingly, we are designing CARI/SEARCH as a next generation and user-friendly tool for knitting networks of science, policy, and actions for resilience building.

Key Stakeholders: National Disaster Management Authority (BNPB); Ministry of science and technology (formerly Ministry of science, technology, and higher education); Indonesian Association of Disaster Management Expert (IABI); U-Inspire Indonesia; academic publishers; research repositories of universities; National Library of Indonesia

Process and the Role of Science and Technology: CARI/SEARCH designing process starts with an exploration of citation network analysis on disaster-related research in Indonesia and discourse network analysis between those research with national and selected local policy documents. However, upon reflection on the feedback gathered from key policy-makers, we realized that network modeling itself is not enough, and key development actors from public and private sectors need a more user-friendly platform for accessing and harvesting knowledge already available. They need more than risk information, which already available in the context of Indonesia through various platforms (e.g. the BNPB’s InaRisk), and they want to access knowledge useful for reducing the risk in their area of interest.

In the current state, CARI/SEARCH employs the following science and technological capabilities: 1) automated search engine and spatial visualization of disaster-related journal articles as well as knowledge products stored in university library repositories across Indonesia; 2) machine-assisted process for geotagging the location of a research object and automated filtering to classify research products based on hazard-type and phase in disaster risk management; 3) machine-assisted area brief based on available research products tailored to a particular area of interest and its risk profile on InaRisk (down to sub-district level). For future de-

![Figure 29: Features of CARI/SEARCH](image-url)
velopment, CARI/SEARCH will also add a layer on local assets and capabilities, and their available supply-chain, useful for disaster risk reduction in a specific area of interest.

Possible Replication and Challenges: With the current system-design of CARI/SEARCH, it is possible to upscale and replicate its implementation for other countries context and at the regional levels. There are two key challenges that need to be resolved for future replication: 1) tailoring the algorithm to learn and digest the content from knowledge products published in native-languages and with different characters (e.g. Japanese, Khmer, Chinese, Thai, Burmese), and 2) availability, access, and volume of research papers of other country (other than publication about that country published in English).

Acknowledgement: CARI/SEARCH is an innovation inspired by the ongoing research "Networked-politics of science and policy on disasters and climate change in Southeast Asia / 東南アジアにおける災害管理および気候変動に関する科学-政策の相互作用" (JSPS KAKENHI Grant Number JP18F118810).

3.2.16 Flash Flood Forecasting and Warning System (Action 4.1.1)

Sutat Weesakul¹, Piyamarn Sisomphon¹, Apimook Mooktaree¹, Ticha Lolupiman¹

¹.Hydro-Informatics Institute (HII), Thailand

Context: A flash flood is a rapid flooding caused by heavy rainfall in a short period of time. It can be associated with steep slope terrain and saturated soil so that the rainwater cannot be absorbed anymore. A large volume of runoff or flood water is swept down to the low lying area below. Flash flood is considered to be among the most dangerous kind of floods that affect to loss of life and properties. However, this event is difficult to forecast due to its sudden occurrence. The risk area is mostly located on the remote or watershed area on the mountain where ground observations is rare or not available.

Flash Flood Forecasting and Warning System provides hourly and daily forecasting of flash flood areas which are calculated using rainfall forecasting and soil moisture data. To increase the accuracy of the Forecasting and Warning, the physical index was calculated.

Figure 38: The characteristic (left) and the factor (right) of flash flood

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>High speed</td>
<td>High intensity rainfall</td>
</tr>
<tr>
<td>Rapidly evolving!</td>
<td>Rain magnitude and duration</td>
</tr>
<tr>
<td>Short duration!</td>
<td>Time to occur</td>
</tr>
<tr>
<td>High peak!</td>
<td>High saturation</td>
</tr>
<tr>
<td>Hard to predict!</td>
<td>Soil type</td>
</tr>
<tr>
<td></td>
<td>Duration</td>
</tr>
<tr>
<td></td>
<td>Severity</td>
</tr>
<tr>
<td></td>
<td>Physical property</td>
</tr>
<tr>
<td></td>
<td>Topography and Land use</td>
</tr>
</tbody>
</table>
Key Stakeholders

- Water-related agencies
- Educational institution
- General Public

Process

1. Select the high potential area using the Flash Flood Potential Index, which depends on physical properties.

2. Update state from AMC class calculate by 5-day accumulated rainfall using satellites and radar.

3. Forecast 24-hour risk area with precipitation forecast from WRF-ROMs model.

4. Flash flood Warning of risk areas by sub-district.

Role of Science and Technology: Promote warning systems with emergency response services and communication to local agencies to Preparedness for Effective Response

Tropical Depression “Wipha”: From 31 July to 4 August 2019, several provinces in northern and western Thailand were been hit by heavy rain brought by tropical depression “Wipha” and a strong southwest monsoon. Flash floods, flood-
ing and landslides occurred in many provinces.

**Tropical Storm “Pabuk”:** From 3 to 5 January 2019, several provinces in southern Thailand were hit by heavy rain brought by tropical storm “Pabuk”. Flash floods, flooding and landslides occurred in many provinces.

**Possible Replication and Challenges:**

- The flash flood early warning system could provide accurate and timely (three hours before flash flood occurs) outputs for related agencies to issue public warnings.
- Standard procedures to react after receiving the warnings is needed. Therefore, the crisis response plan must be jointly developed by a collaboration between public authorities and local community people to increase disaster management effectiveness and efficiency.
- An appropriate and accurate geographical data and precipitation data from radar at high spatial and temporal resolutions are required to scale up the system to national level.

### 3.2.17 HII’s Automatic-telemetry System (Action: 4.1.1)

**Vorawit Meesuk¹, Surajate Boonya-aroonnet¹**

¹.Hydro-Informatics Institute (HII), Thailand

**Context:** Since 2004, HII successfully developed the first generation of telemetry system. Our system adopted “The Field Server” from the National Agriculture and Food Research Organization (NARO), Ministry of Agriculture, Forestry and Fisheries, Japan. HII’s telemetry system was distinctly designed along with three major ideas, i.e., affordable, simple installation and maintenance, and suitable for Thailand and ASEAN.

In mid-2017, the 4.0 version with compact design of HII’s automatic-telemetry system was upgraded and currently the 4.1 version with low-power consumption is ready. The latest version is more accurate, more reliable, and low cost (30% cheaper), supports various sensors, quick installation (4 man-hours to complete installation), easy maintenance and safety in operations (the height of overall structures is lower than 1.7 metres which can be easily accessed for average height for ASEAN people).

HII’s telemetry system automatically records hydro-met data, e.g., temperature, air pressure, relative humidity, solar intensity, rainfall, water level, salinity, etc. Our system can transmit the data every 10 minutes through cellular or satellite networks. All collected data are processed at HII’s data centre and publicly available at “www.thaiwater.net”, and “ThaiWater” mobile application. The system can also send SMS alerts government agencies and stakeholders when critical water situations are detected and potentially lead to disasters.

**Key Stakeholders**

- Water and weather-related agencies
- Educational institution
- General Public

**Installation Process**

1. Select high potential site concerning, e.g., landlord agreement, space availability, WMO standards, etc., to install HII’s automatic telemetry station.

2. Install HII’s automatic telemetry station in the selected site. Relocation the site may be needed from time to time by demanding of landlord.

3. Regularly and remotely check the monitored hydro-met data for the latest status of HII’s automatic telemetry station, data reliability, and logged error messages.

4. Regularly maintain HII’s automatic telemetry station, on-site, in order to upgrade the newer versions of hardware and software, and replace decadent parts.
Role of Science and Technology: Promote all hydro-met data monitored through the website "www.thaiwater.net", and "ThaiWater" mobile applications at Google Play and App Store. The make use of tailor-made informative data monitored from HII’s automatic telemetry system is ready for all key stakeholders at different levels.

- Community Water Resource Management (CWRM) is provided for stakeholders at community levels.
- Provincial Water Resource Informatics Operation Center is provided for stakeholders at provincial level.
- National Hydroinformatics and Climate Data Center (NHC) is provided for stakeholders at Thai’s nation level.
- ASEAN Hydroinformatics Data Center (AHC) is provided for stakeholders at ASEAN level.
Possible Replication and Challenges:

- All hydro-met data monitored from HII’s automatic telemetry system could provide informative, accurate, and timely data (every 10 minutes) for weather forecasting and flash flood early warning system.
- These vital hydro-met data should support disaster risk reduction, strengthen preparedness and response capacities in collaboration with public authorities, local community, and other stakeholders.
- Our ambition is not only made use of hydro-met data when disaster strikes, but also use this vital data for agricultural and water resources management throughout the year.

3.2.18 Coupled Model for Weather Prediction (Action 4.1.1)

Kanoksri Sarinnapakorn¹, Kritanai Torsri¹, Rati Sawangwattanaphaibun¹, Surajate Boonya-aroonnet¹, Sutat Weesakul¹

¹.Hydro-Informatics Institute (HII), Thailand

Context: The Coupled model is a system that combines the Weather Research and Forecasting (WRF) and Regional Ocean Model System (ROMS) models; it is developed from the Coupled Ocean Atmosphere Wave Sediment Transport Modeling System (COAWST) of the U.S. Geological Survey (USGS) (Warner et al. 2010). The COAWST is an integration of earth modeling systems (i.e., atmosphere, ocean, wave and sediment transport) to represent a more realistic of natural phenomena and their interaction (figure 43). Sea surface temperature (SST) is a major driver of climate and, somehow, it also plays an important role on variation of weather. Because Thailand is located in a tropical region.

Figure 43: COAWST Modeling System (Warner et al. 2010)
and surrounded by oceans, SST should be taken into account for weather prediction. Thus, HII developed a coupled modeling system based on the COAWST for operational 7-day forecast (Torsri et al., 2014). In this system, we focus on synoptic processes of the atmosphere and its interaction with the ocean, thus only WRF and ROMS models are coupled.

**Key Stakeholders**

- Water-related disaster management agencies
- Educational institution
- General public

**Process:** The coupled WRF-ROMS modeling system is routinely operated at the HII for 7-day weather forecast. The WRF and ROMS are calculated concurrently with 3-nested domains for the atmospheric model and single domain for oceanic model (figure 44). Only the WRF’s mother domain is allowed to exchange information with the ROMS. Boundary conditions of the WRF model are initiated and updated using meteorological fields from 3-hr Global Forecast system (GFS). For ROMS, it is initialized by global HYCOM ocean prediction system output.

The modeling system is processed twice a day at 00UTC and 12UTC to update and disseminate forecasted information to end-user for their further applications through both web-service and mobile application.

**Figure 44: Operational WRF-ROMS System for 7-day Weather Forecast at the HII**

**Role of Science and Technology:** Prediction of extreme weather poses challenges for scientific communities in Thailand. The more accurate the prediction, the more efficient disaster risk reduction and management. Since its first official operation in the HII in 2016, the coupled WRF-ROMS has been used routinely to provide and support information for normal and crisis situations, especially when severe floods or tropical storms occur. The model can forecast the rain intensity and storm directions well. For example, during June 24-28, 2017, flooding occurred in the northern part of Thailand due to tropical storm Sonca and during January 1-6, 2019 when storm Pabuk hit the South. Based on statistical reports, death-toll, economic losses and damages were smaller than in the past when storms attacked the area.

**Possible Replication and Challenges:** Improving accuracy of weather forecasting to monitor crisis situations due to extreme events for loss prevention or risk reduction.
**3.2.19 Shapefor Better Community (SBC): A Geospatial Hackathon (Action: 4.1.1)**

*Hilman Arioaji*¹, *Risye Dwiyani*¹, *N. Rahma Hanifa*¹²

1. **U-Inspire Indonesia, Indonesia**
2. **Research Center for Disaster Mitigation, Institut Teknologi Bandung, Indonesia**

**Context:** Shapefor Better Community (SBC) is a Geospatial-themed Hackathon contributing to Disaster Risk Reduction month in October 2019 that brought together a group of the most active individuals and communities who have been developing or using geospatial data in various forms. SBC gathered a diverse group of over 56 scientists, engineers, entrepreneurs, artists, educators and not-for-profit organisations from various cities in Indonesia. The objectives of SBC were generating innovative geospatial solutions for flood and earthquake risks, that fully take into consideration the needs of local beneficiaries.

**Key Stakeholders:** U-Inspire Indonesia, funded by UNICEF, partnered with: UNITAR, UNESCO Office Jakarta, the National Disaster Management Agency (BNPB), Local Disaster Management Agency (BPBD) of West Java Province, BPBD of Bandung Regency, Center for Earthquake Science and Technology - Research Center for Disaster Mitigation Institut Teknologi Bandung, ESRI Indonesia and local partners: Jaga Balai, Sky Volunteer, Geocreate and Barudak Baraya Cisangkuy Citarum (B2C2).

**Process:** Shape for Better Community was divided into two stages, Pre-event and Main Event. A call for participants was announced two weeks prior to the Pre-event, inviting those who were interested in geospatial approach as alternative solutions for disaster risk reduction. Interested audience were requested to form a team of four persons with multidisciplinary background and develop a proposal based on provided challenges, i.e. based on the case of a densely populated area having earthquake and flood risks, build a geospatial product prototype that could (1) enhance city, school and community resilience towards the risks; (2) reduce disruptions to public facility and critical infrastructure; (3) improve information management and build unique way to disseminate it. Study case was in Baleendah District - Bandung Regency in West Java. The output could be in the form of data visual solutions, software or application solutions, or integrating platforms. There were 5 short-listed multidisciplinary teams from different cities among 14 applicant teams, selected with the following criteria as considerations: innovation, creativity, social impact, and project feasibility. The selected teams were invited to the Pre-event of SBC.

**Stage 1 - Pre-event (Bandung, 4 - 6 October 2019).** The pre-event's objective was to provide insights to the participants on disaster risks, particularly earthquake and flood, design thinking, and understanding the local context. Participants were expected to gain insights through Deep Talk Sessions on earthquake risks in Bandung and local flood risks, on the function of InaRisk Personal, an application that provides information on disaster risk in a particular area, on GIS technology and remote sensing data in case of disaster early response, on the usage of UAV in the context of disaster, product development and design thinking, as well as on location-based analysis for actionable intelligence. A field trip was conducted on the second day, where participants were expected to gain insights on the complexity of the problems through direct interaction with the local communities. After the field trip, the participants shared the key learning points from the field trip, and received feedback from the resource persons on how the project prototype should be further developed. The teams were given two weeks to build the prototype before they finalize it during the Main Event.

**Stage 2 - Main Event (Jakarta, 19 - 20 October 2019).** The main event, was officially opened by the NDMA, followed by a Flash Talk by UNITAR Office Bangkok on “The Use of Geospatial Information Technology for Understanding Disaster
Risk”. In the remaining 24 hours, the five teams continued to finalize their prototype. Further, within two hours’ duration, they prepared for the pitch and demonstration to be presented before the judges and observers. During the scoring time by the judges, 19 institution representatives were invited as observers, such as BMKG, Save the Children, Baznas, and Grab Indonesia provided feedback to each team’s presentation.

Prototypes developed by the five finalists and more detail process of SBC are presented completely in the following page: http://uinspire.id/sbc2019

Role of Science and Technology: Understanding risk was the first step given to the participants by providing basic science of local context, then GIS technology, drone technology and related technology was taught and explored. Nowadays by using open source technology, translating science into useful data driven information is not a big deal.

Possible Replication and Challenges: For future replication, the key lessons learned from the whole process of SBC are that:

1. It is possible for a two-week duration of Call for Proposals to attract quite a number of enthusiastic applicants in Indonesia. However, since the number of qualified applicants having interest in geospatial-based solution for DRR was rather limited, only enough for small-scale hackathons, better strategy to attract more relevant applicants need to be explored for a larger scale hackathon.

2. The field trip during the Pre-Event was essential for the participants to grasp the real and complex situation of the area, and to understand the need of the local community.

3. For a geospatial hackathon, a two-week time might be feasible to build the first prototype if the participants know how to find a baseline dataset. However, learning from all the finalists’ solutions which were crowdsourced base, where the gathered data are relied upon the willingness and capacity of local communities, a genuine understanding on the community, as well as community’s connection with the apps and the maker, should be first built. And this process could not be “hacked” as quick as just hacking software. A prototype test and further exploration with local community should be conducted in order to build an impact-based solution.

4. Fresh innovative ideas could be generated within a limited time by youth and young professionals – more opportunities for them to innovate and collaborate need to be provided in order to accelerate disaster risk reduction.

Figure 45: Shape for Better Community: A Geospatial Hackathon
Context: More than half of the world’s population today live in urban areas and are particularly at risk from the combined effects of the urban heat island phenomenon and heat increases due to climate change. Here, by applying the risk framework of the Intergovernmental Panel on Climate Change, we assess the heat risk in Philippine cities, whose population accounts for over 40% of the country’s total population. The cities that are at high and very high risk are found in Metro Manila where levels of exposure and heat hazard are higher. The most vulnerable cities are, however, found mainly outside of the national capital region where sensitivity is higher and capacity to cope and adapt is lower. The cities with high levels of vulnerability and exposure to heat need to be prioritized for adaptation. The results contribute to the understanding of city-level heat risks in the developing region of the Asia-Pacific.

Key Stakeholders: Local government units, health centers

Process: The study employed a mixed-methods analysis. Utilizing both expert opinion in ranking the risks and vulnerability, which was then complemented by the health-related risks. Both results were combined to create the urban heat-health island index.

Role of Science and Technology: Both spatial information as well as population vulnerability were complemented by the health risks, which would later be incorporated in urban planning systems.

Possible Replication and Challenges: The techniques can be replicated in areas where secondary data is available. However, not all areas will have the said data (spatial information/weather variables), hence there is a need to further explore possible alternatives or proxies.

Figure 46: Heat Health Risk Index Map

Source: Estoque et al (Under Review)
3.2.21 Dengue-Related Warning System: Health Risk Estimation (Action 4.1.2)

Jesavel A. Iguchi¹, Xerxes T. Seposo² and Yasushi Honda³

1. Department of Health Care Policy and Health Economics, Graduate School of Comprehensive Human Sciences, Japan
2. Department of Environmental Engineering, Graduate School of Engineering, Kyoto University, Japan
3. Faculty of Health and Sports Sciences, University of Tsukuba, Japan

Context: Dengue fever is a major public health concern in the Philippines, and has been a significant cause of hospitalizations and deaths among young children. Previous literature links climate change to dengue, and with increasingly unpredictable changing climate patterns, there is a need to understand how these meteorological variables affect dengue incidence in a highly endemic area. The results would be utilized for an early warning system to prepare the health systems, through the hospitals and the health units/clinics for impending risks due to weather change.

Key Stakeholders: Health centers, Provincial health office

Process: Readily available secondary data for both dengue cases and weather variables were obtained from the respective agencies. After thorough data management, health risk estimation was done using state of the art climate change and health modeling techniques.

Role of Science and Technology: Health-related statistical models were utilized to estimate the health risks, which would later be incorporated to health system-related early warning component.

Possible Replication and Challenges: The techniques can be replicated in areas where secondary data is available. However, not all areas will have the said data (dengue/weather variables), hence there is a need to further explore possible alternatives or proxies.
3.2.22 Collection of Case Studies on Youth Participation in Disaster Recovery (Action 4.1.3)

Glenn Fernandez\(^1\) and Rajib Shaw\(^2\)

1. Institute for Disaster Management and Reconstruction, Sichuan University, China
2. Graduate School of Media and Governance, Keio University, Japan

**Context:** The Sendai Framework for Disaster Risk Reduction (DRR) 2015-2030 states that DRR requires an all-of-society engagement. Everyone, regardless of their age, gender, ethnicity, religion, or socio-economic position, should be involved in thinking, planning, and deciding about DRR. One of the stakeholder groups specifically exhorted in the Sendai Framework to have increased engagement in DRR is the youth. The youth make up around one-fifth of the population of Asian countries and show great potential in helping build the disaster resilience of their communities. Whereas there have been numerous studies on the involvement of young people in disaster preparedness and in emergency response, research on youth participation in disaster recovery is largely missing (Cox et al., 2017; Fletcher et al., 2016; Fernandez & Shaw, 2013). Reliable data on the actual number of young people participating in post-disaster rebuilding and rehabilitation is very limited. Scientific journal articles rarely provide information on the magnitude of youth involvement in disaster recovery projects and programs. There is little information on what young people are actually contributing to help their communities rise up after they are hit by disasters.

**Key Stakeholders**

- Youth organizations in Asia engaged in disaster risk reduction
- Himalayan University Consortium (HUC)
- U-INSPIRE network
- Higher education institutions
  - Institute for Disaster Management and Reconstruction, Sichuan University, China
  - Graduate School of Media and Governance, Keio University, Japan

**Process:** In one of the group discussions at the meeting of the Himalayan University Consortium (HUC) Thematic Working Group on Disasters hosted at the Institute for Disaster Management and Reconstruction (IDMR) of Sichuan University in May 2018, the collection of case studies on youth participation in disaster recovery was suggested. To follow through on this suggestion, we launched an initiative to collect at least 20 case studies on youth participation in disaster recovery from different Asian countries. For this purpose, a two-page case study template and a case study example have been prepared and shared in various DRR networks, such as HUC and U-INSPIRE members. In the end, we were able to collect 30 case studies from 12 countries.

**Role of Science and Technology:** It will be easier to promote youth participation if it can be shown through various case studies that indeed young people can provide significant inputs and can assist in the post-disaster rebuilding and rehabilitation processes. Science can be used to explain how the participatory approach engaging the youth, who comprise 20 percent of the population of most Asian countries, is a sound strategy moving forward.

**Possible Replication and Challenges:** The collected 30 case studies each show the context (the disaster that happened), the specific disaster recovery action of the youth organization being featured, and lessons learned from the involvement of the youth. The contact details of the person who submitted the case study is shown so that those who are interested to replicate the action can get more information. The case studies are currently being edited for publication in 2020. The publication will be posted on PreventionWeb and other websites for wide dissemination.
Possible Replication and Challenges: The collected 30 case studies each show the context of the population of most Asian countries, is a sound strategy moving forward.

Science can be shown through various case studies that indeed young people can provide significant inputs and can assist in the post-disaster rebuilding and rehabilitation processes. Science can be used to explain how the participatory approach engaging the youth, who comprise 20 percent of the disaster-affected populations, can assist in the recovery process.

Role of Science and Technology: It will be easier to promote youth participation if it can be shown through case studies how science and technology can be used in the recovery process. This can be done through various case studies that show the context of the population of most Asian countries and how young people can provide significant inputs and assistance in the post-disaster rebuilding and rehabilitation processes.
3.2.23 Disaster Waste Management Contingency Planning in Coastal Cities in Fiji and the Philippines (Action 4.2.1)

Glenn Fernandez¹, Noralene Uy², and Liza Velle Ramos³,
1. Institute for Disaster Management and Reconstruction, Sichuan University, China
2. Department of Environmental Science, Ateneo de Manila University, Philippines
3. Makati City Disaster Risk Reduction and Management Office, Philippines

Context: The management of disaster waste is a necessary task in the early phase of disaster recovery (Asari et al., 2013). In catastrophic disasters, such as 2013 Typhoon Haiyan in the Philippines, the amount of waste generated can overwhelm local capacity to handle the waste, affecting other tasks such as rescue operations and delivery of humanitarian aid. It can take weeks or months to dispose of disaster waste, possibly due to underestimation or lack of estimation of the amount of waste that particular natural hazards such as earthquakes, flooding, and typhoons, can generate. As a consequence, disaster waste management can consume a significant portion of the disaster recovery cost. However, pre-disaster planning and capacity-building can result in cost-effectiveness. Funding mechanisms, institutional arrangements, and assignment of roles to various stakeholders must be in place in advance to enable sound disaster waste management that can result to cost and time savings and recovery of resources for recycling.

Key Stakeholders:
- Lautoka City, Fiji
- Makati City, Philippines
- External higher education institutions
  - Institute for Disaster Management and Reconstruction, Sichuan University
  - Department of Environmental Science, Ateneo de Manila University, Philippines
  - Graduate School of Global Environmental Studies, Kyoto University, Japan
  - UNEP-Tongji Institute of Environment for Sustainable Development (IESD), Tongji University, China

Funding agency
- Asia-Pacific Network for Global Change Research, Japan

Process: Wastes can pose a serious threat to human health and safety. It is, therefore, necessary for coastal cities frequently affected by typhoons to have adequate capacity for post-disaster waste management. This ongoing project will contribute to this end via the provision of appropriate knowledge and training to government and non-government stakeholders. This ongoing one-year project will be implemented in Lautoka City, Fiji and Makati City, Philippines with the support of five prominent universities (Sichuan University, Hong Kong Polytechnic University, Kyoto University, Ateneo de Manila University, and Tongji University). In our capacity development intervention, we will utilize a blended learning approach, combining online distance education (i.e., requiring the participants to complete an introductory Disaster Waste Management course with the use of the Internet) and traditional face-to-face training facilitated by university professors, subject matter experts, and city officials. At the end of the project, we target to produce at least 100 individuals (50 in each participating city) trained in post-typhoon disaster waste management. The two cities are also expected to produce a typhoon-specific disaster waste management contingency plan.

Role of Science and Technology: Evidence suggests that communities with pre-disaster waste management arrangements tend to have more effective waste management processes than communities without such arrangements. Science can be used to justify
The Elderly in Disaster Situation; Key stakeholders: Ministry of Social Affairs

Process:
The number of elderly population in Indonesia in 2018 was 24.49 million or around 9.27% of the total national population (BPS: 2018). In 2020 it is estimated that around 10% of Indonesia's population will be 60 years old up and up to around 20% in 2040 (BPS: 2018).

The elderly in Indonesia who live in the area prone to natural hazard-induced disasters, requires the efforts of all parties to provide protection and handling from the impact of the disaster.

Law no.24 of 2007 concerning Disaster Management, especially Article 48 and 55 mentioned that in the organization disaster management is needed protection towards vulnerable groups such as children, people with disabilities, and elderly. Protection of elderly in situations disaster relief includes: 1) rescue and evacuation to temporary shelters, 2) recovery of physical

Possible Replication and Challenges: Training materials and other knowledge products of this ongoing project will be shared freely on the dedicated project website to benefit more cities: http://disaster-waste.org/ (under construction).
conditions in the form of providing food and side dishes, and clothing, 3) recovery of psychological conditions.

The author’s experience while serving as a psychosocial support team for the elderly who were victims of earthquake in Pidie Jaya-Aceh, 2017, and the earthquake and tsunami disaster in Palu, Central Sulawesi in 2018, the elderly who live in refugee sites seem to lack serious handling. Basic needs such as food and clothing are fulfilled, but after that the elderly almost no one handles further. Officers and volunteers are more focused on handling for children, people with disabilities, and pregnant women, even though the elderly are also vulnerable groups.

Role of Science and Technology: Social care for the elderly in disaster situations is an activity carried out by a caregiver to ensure elderly people who are not fully capable of caring for themselves, can maintain the highest quality of life in a disaster situation, according to their choices, participation, fulfillment of personal needs, and fulfillment of human rights as a human being. Thus, social care for the elderly in disaster situations carried out by the officers and caregiver is focused on helping the elderly to carry out activity daily living and fulfill their basic needs, maintaining independence and reducing dependency, and increasing the capacity of families to care for the elderly in emergency situations. The author as an elderly companion, with a background in social work science education.

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<tr>
<th>Approach</th>
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<td>Method/Technology</td>
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<td>Technique</td>
<td>micro social work: small talk catharsis support though therapy live review therapy emotion freedom techniq relaxation mezzo social work: support group social conversation family therapy self help group capacity building for local community about social care for elderly</td>
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Social work is a profession that focuses its attention on the social functioning of people (Skidmore: 1981), while The National Association of Social Workers/NASW (2004) define social work as a professional activity that aims to help individuals, groups or communities to strengthen their own abilities in social functioning and create social conditions that support these goals.

Social work is a profession that focuses its attention on the social functioning of people. The technology used in assisting for elderly in disaster situations is micro and mezzo social work practice, while macro practice was not able to be implemented, due to lack of time in the field, but it has been recommended to local stakeholders, namely how to capacity building of local community to provide social care for the elderly. Micro social work technology is developed through providing direct services to the elderly in IDPs camps through psychosocial support, in stages; psychosocial assessment, plan of intervention, implementation of the intervention, evaluation and termination. In implementing, the author as a companion uses techniques such as; invites talk and dialogue that leads to therapeutic communication, touch therapy, reminiscence therapy, emotion freedom technique, and relaxation. The application of mezzo social work technology is done by providing indirect services, namely by capacity building of families and local community to carry out social care for the elderly.

Possible Replication and Challenges: Social care for the elderly applies universally, what is different is the approach based on scientific discipline, but actually social care should be integrative with health services and other services, which allows elderly people in disaster situations to get protection and guaranteed safety and happiness. The author’s experience in assisting elderly people who are victims of earthquake disasters in Pidie Jaya, Aceh, and Palu, Central Sulawesi with a focus on social care, can certainly be replicated elsewhere, especially in areas prone to natural hazard-induced disasters. As a challenges, social care is a new term that is not yet understood or practiced by humanitarian workers, especially for elderly people in disaster situations. Therefore, we need support from stakeholders to strengthen humanitarian workers who care about the elderly with a focus on social care.
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Facebook: dacryn, Instagram: @dacryn_ca, Email: dacryn.ca@gmail.com


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90. U-Inspire Nepal: www.uinspire-nepal.org, Facebook: uinspire.nepal, Email: Uinspire.nepal@gmail.com

91. U-Inspire Pakistan: https://uinspire.neduet.edu.pk/

92. U-Inspire Phillipine: Email: u.inspire.ph@gmail.com


