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Cover photo: An Early Miocene carbonate banked block, a wackestone sample in strongly cemented tallus facies (reef debris). Photo courtesy of John Jong and Franz Kessler taken in the Shen Yang quarry in Batu Niah, Northern Sarawak.

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Advancing science, technology and innovation for disaster risk reduction: The Kuala Lumpur Consensus on Disaster Risk Reduction

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Abstract: The Kuala Lumpur Consensus on Disaster Risk Reduction was the outcome of the 2020 Asia Pacific Science and Technology Conference for Disaster Risk Reduction (APSTCDRR), documenting renewed commitment to accelerate the implementation of the Sendai Framework for Disaster Risk Reduction in four priority areas, drawing on multi-disciplinary knowledge including geoscience. The 2020 APSTCDRR offered an opportunity for science-policy interfacing to enhance the appropriate role of science, technology and innovation, facilitate the inclusion of empowered young scientists, and accentuate the integration of risk from all perspectives into planning and development at all levels. Highlights of the 2020 APSTCDRR include the status of disaster risk reduction (DRR) in the Asia Pacific, and means of addressing systemic risk including Natural Hazards Triggering Technological Disasters (NATECH) and its associated shortcomings in the region. There was also focus on climate risk and local action spotlighting the Kuala Lumpur Multi-hazard Platform, as well as youth engagement in science and technology through U-INSPIRE Alliance, an alliance of young professionals in DRR. Many of the initiatives showcased in the 2020 APSTCDRR are of relevance to the geoscience community, to strengthen their role in DRR in Malaysia and the region.

Keywords: Disaster risk, Science and Technology, Sendai Framework, science-policy dialogue, Kuala Lumpur, Malaysia

INTRODUCTION

The Sendai Framework for Disaster Risk Reduction, 2015-2030 shifts the focus from responding and managing disaster events to managing the risk of disasters (UNISDR, 2015). The shift is reflected in its four priorities, which covers understanding disaster risk; strengthening disaster risk governance to manage disaster risk; investing in disaster risk reduction for resilience; and enhancing disaster preparedness for effective response, and building back better. It also requires reliable science and technology-based disaster risk reduction (DRR) measures with innovations for a better understanding of risk from all perspectives. Evidence-based disaster risk governance is also required to ensure that risk is integrated into planning and development at all levels. Connecting science to policy is a major challenge in efforts to achieve sustainable development (McConney *et al*., 2016). Notwithstanding, there is progress in the DRR arena particularly in the Asia Pacific, where science-policy interfaces allow for periodic linkages between scientists and policy-makers.

The Science and Technology Roadmap to Support the Implementation of the Sendai Framework for Disaster Risk Reduction was agreed upon in 2016. The global roadmap emphasizes the four priorities of the Sendai Framework and includes expected outcomes, actions and deliverables for each. Focusing on this, the inaugural 2016 Asia Pacific Science and Technology Conference for Disaster Risk Reduction (APSTCDRR) was held in Thailand, where 12 actions and cooperative mechanisms were identified for implementing the Science and Technology Roadmap 2015-2030 (APSTCDRR, 2016). The actions and mechanisms were further expanded in the Second

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APSTCDRR in 2018 to 14 actions and six cooperative mechanisms in the "Beijing Consensus" (APSTCDRR, 2018). As a continuation, the third APSTCDRR in 2020 focused on how to strengthen science-based DRR policy development for building the resilience of communities and infrastructure. The 2020 APSTCDRR was hosted virtually on 15 October 2020 by the United Nations Office for Disaster Risk Reduction (UNDRR) and the National Disaster Management Agency (NADMA) of Malaysia. Key partners included the UNDRR Asia Pacific Science, Technology and Academia Advisory Group (APSTAAG), International Science Council Regional Office for Asia and the Pacific (ISC-ROAP), Integrated Research on Disaster Risk (IRDR), Asian Network on Climate Science and Technology (ANCST), Academy of Sciences Malaysia (ASM) and Universiti Kebangsaan Malaysia's Southeast Asia Disaster Prevention Research Initiative (SEADPRI-UKM).

The 2020 APSTCDRR provided an opportunity to the science, technology, and academia community in Asia and the Pacific to continue the much-needed science-policy dialogue to ensure that implementation of DRR measures is based on reliable science, technology and innovation. A total of 175 participants, comprising academics, policymakers and young professionals from 19 countries in the Asia Pacific were involved. The event also showcased successful applications of science and technology in preventing and mitigating risks for different types of hazards. The highlights of this important science-policy interface are briefly mentioned in the following sections. These include the status of DRR in the region, addressing systemic risk, climate risk and local action, and youth engagement in science and technology. Many are relevant to the geoscience community, and some feature entry points for geoscience information to strengthen DRR in Malaysia and the region.

STATUS OF DRR AND SCIENCE AND TECHNOLOGY IN THE ASIA PACIFIC

Generally, implementation of the Science and Technology Roadmap in the region is good with respect to the four priority areas (Shaw, 2020; UNDRR-APSTAAG, 2020a). The progress under priority area 2 (strengthening disaster risk governance to manage disaster risk) was relatively the best among the four priorities. For this priority area, maximum progress was made in promoting disaster risk assessment in planning and development, while the least progress was made for considering root causes of risk and input from traditional knowledge for decision making. Relatively, priority area 4 (enhancing disaster preparedness for effective response, and building back better) showed the least progress and needs improvement (UNDRR-APSTAAG, 2020a). There are many issues related to integrating science and technology into DRR, particularly in the Pacific Islands of the region. Lack of integration of climate change adaptation and disaster risk management in national policies and development plans is a major challenge. In addition, limited capacity for integration of technologies and lack of appropriate technology amongst practitioners is a barrier. This calls for increased capacity-building and training for integrating science and technology into DRR to build resilience.

The top ten innovations for linking DRR to Sustainable Development Goals (SDGs) in the region have been identified (Izumi, 2020). These include ecosystem-based DRR in the livelihood sector; integrated water resources management in the water sector; earthquake guard - an early warning system; a nexus approach toward climate change, food security, and livelihoods; and a Nationalized Cluster Coordination Mechanism in the emergency response sector. Several recommendations were made to increase the applicability of innovative DRR measures. Among these were the need to reduce the huge gap between the interface of science, technology, innovation, and policymaking. In order to do this, the co-production and collaboration between researchers and practitioners have to be enhanced. Furthermore, the sharing case studies of innovations have to be intensified. It is also suggested that academia takes an additional step to improve their skills in communicating their research and its results to the public (Izumi *et al.*, 2019).

The cumulative effect of COVID-19 has strongly impacted national and local development planning with respect to DRR and the science and technology agenda. As biological hazards have different impacts on the SDGs, it was recommended that multi-sectoral impacts be analysed to understand how sectors exacerbate the transmission of infectious diseases, and identify the health mitigation measures. For example, the information and telecommunication sector can support multiple sectors from different aspects in responding to biological hazards.

ADDRESSING SYSTEMIC RISK

The Asia Pacific Framework for NATECH (Natural Hazards Triggering Technological Disasters) Risk Management is now available to address systemic risk in the region (Chatterjee, 2020). Risks associated with NATECH have not been well documented in the region. There is no baseline available to compare risk trends. This is in part due to its low impacts prior to the large-scale 2011 East Japan Earthquake and Tsunami that triggered the Fukushima nuclear disaster. Despite increasing coverage in academia, government reports and policy documents are relatively sparse in covering NATECH risk (UNDRR-APSTAAG, 2020b). Inclusion of NATECH risks is recommended for policies, transboundary response mechanisms and agreements at the regional level. Similarly, the coverage of this aspect should be enhanced in the implementation of policy, regulation, and

combination of risk assessment tools at the national level. In addition, risk assessment, awareness generation, and specialized response teams at the local level should include the risk of NATECH. The conversion of knowledge to local actions should be strengthened for NATECH risks, and this context, geoscientists have a major role to play.

The implementation of the Sendai Framework could be strengthened using a "system of systems approach" drawing on digital solutions for managing systemic risk, using wide-ranging risk analytics. The fundamental aspects of high complexity with the interaction of multiple systems need to be considered in this approach, where stochastic relationships between triggers and effects are involved. In addition, the risk is transboundary and global in nature where the systemic developments are non-linear and include tipping points. There is a need to carefully consider the complexity involved. As a solution, science could offer modelling for scenario analysis and sketching out the stochastic nature of the system. Eight steps for building a scenario of systemic risk were presented. These were (a) Scope the risk, (b) Conduct background research, (c) Frame the scenario, (d) Develop a candidate scenario, (e) Develop a narrative, (f) Assess impacts and materiality, (g) Communicate and alert, and (h) Evaluate and update. Additionally, Big Earth Data platforms for DRR and SDGs can help to fill gaps in scientific knowledge to support the achievement of SDGs. It has great potential as a digital solution for managing systemic risk.

CLIMATE RISK AND LOCAL ACTION

The readiness of ASEAN countries for a 1.5°C world is generally at a low to medium level for many aspects covering extreme events, food security and water availability, among others (Pereira & Shaw, 2022). Disaster prevention, mitigation and preparedness provide opportunities for climate change adaptation with the co-benefits of emission reduction. The integration of climate change adaptation and DRR, specifically in cities is facilitated by a system of systems approach, public-private participation with the involvement of local government stakeholders, participation of knowledge-empowered youth who offer the best potential to fill the knowledge gap, authentic community engagement, and open science communication and engagement, where community members are involved in systematic data collection and storage. The Kuala Lumpur Multi-hazard Platform was presented as a case study, to illustrate the potential for communicating local level risk through forecasting and disaster alerts in the city (Pereira *et al*., 2021). For climate risk-related local action, it was suggested that the challenge is to determine how many local level DRR strategies exist (Perweiz, 2020). In terms of reaching to local level, it was emphasized that "Local-action" should take place instead of localization. This means much must be done at the local level in translating such technologies into decision-making for risk-sensitive investment planning.

The Japanese experience reveals that DRR and environment and development consist of a set of issues that can be explored as scientific questions, but cannot be resolved using scientific actions alone (Koike, 2020). Therefore, the approach of "Science for Humans and Society" should be given priority. The addition of "science for discovery of social wish" was also suggested to discover and resolve social issues. This includes promoting different types of sciences as "consilience", so that science could contribute to resolve social problems as well as develop sustainably for developing "consilience knowledge base". However, there is a critical gap between scientific knowledge and social actions. To minimize that gap, an Online Synthesis System (OSS) was introduced. The functions of OSS are exploration, collection, archival, and search of scientific information in mother tongues; data integration, information fusion, prediction, simulation, and visualization; coordination of various disciplines towards consilience; mutual risk communication between society and the science community. It was recommended that the scientific community should develop the Online Synthesis System (OSS) to promote DRR and sustainable development.

YOUTH ENGAGEMENT IN SCIENCE AND TECHNOLOGY

Countries in the Asia Pacific have prioritized building skilled human capital in the field of disaster risk, as reflected by long-standing investments in national higher education and research institutions (Holloway, 2020). Higher education and research are at the forefront of grounded disaster risk knowledge, policy, and innovation, for fast tracking skilled capacity development and human resource. However, many countries in the region are still lacking in embedded institutional capability to grow their own 'scientific and educational timber'. This calls for a dual-track for strengthening skilled capacities. The first track is advocacy to bridge higher education institutions and disaster risk policy. The second track is technical integration and embedding in higher education by integrating disaster risk across a wider disciplinary and professional range, and promoting such scholarship in vulnerable countries.

The U-INSPIRE Alliance is a platform for youth engagement that was inaugurated in Indonesia in 2018 (Kathiwada, 2020). It is an alliance of young professionals, working to support DRR with the vision of developing a powerful collaboration platform for empowering youth and young professionals in DRR focusing on linking to policy at the local, national, and global levels. The Alliance has chapters in 12 countries with close to 1000 members. The major initiatives of U-INSPIRE include contributing to the status report of the Science and Technology Roadmap,

Framework for NATECH Risk Management, conducting surveys on youth participation in managing COVID-19, and developing the COVID-19 Monitor. In Malaysia, U-INSPIRE is coordinated by the Special Topic Group on Young Professionals in DRR & Climate Change of the Asian Network on Climate Science and Technology (ANCST). The group has convened numerous capacity building and outreach programs, including workshops and associated events in partnership with key national and regional partners including the Geological Society of Malaysia (Muhamad, 2020). Student exchanges and information dissemination are also conducted with the support of ANCST.

Members of U-INSPIRE Alliance have developed innovative technologies. In Indonesia, a coping practice for flood disaster called "Kentongan" was introduced, which is fast and usable without electricity to send information by monitoring river water level, and can serve as a traditional early-warning tool in the face of disaster (Findayani, 2020). In Nepal, the conventional paper-based vulnerability and capacity assessment process was digitized while keeping the participatory approach intact at the community level (Gautam, 2020). Geoscience information provided in this process include hazard ranking and its historical timeline. In Sri Lanka, the community relies on kinship, relatives, and religious community to mitigate flood damages (Tsuchida, 2020). A disaster ethnographic study was conducted to identify the missing links where young practitioners and researchers play an important role in interacting with the community. This is important to prepare for future disaster events. U-INSPIRE Malaysia play an important role in providing exposure to young professional geoscientists in multidisciplinary settings (Muhamad, 2020).

CONCLUDING REMARKS

The Kuala Lumpur Consensus on DRR was the outcome of the 2020 APSTCDRR. The Kuala Lumpur Consensus renewed the commitment to accelerate the implementation of the Sendai Framework for Disaster Risk Reduction to achieve the goals of sustainable development and resilience. The Consensus recommends 14 actions and six cooperative mechanisms to the global "Science and Technology Roadmap", and sets the pathway for strengthening the four priority areas of the Sendai Framework drawing on multi-disciplinary inputs including geoscience. A multi-hazard approach is key for improving understanding of disaster risks, specifically emerging climate risks, exposure, vulnerability, and public health threats. This also includes risks of transboundary, cascading, biological, technological, environmental, and NATECH disasters. Enhanced disaster risk governance requires improvement in transdisciplinary engagement between scientists, policymakers, civil society, and businesses at all levels. Other important elements include strengthening science-based decision making, considering future risk, and promoting local and traditional knowledge, including land-based solutions.

Priority actions to increase investment DRR for Resilience covers knowledge, education, research, innovation, technology transfers, and the empowerment of youths and young professionals, to advance multi-disciplinary disaster risk reduction and build resilience. In order to enhance disaster preparedness for effective response and to build back better, the priority is to develop and disseminate information on multi-disciplinary science, technology, and innovations for effective pre-disaster planning, preparedness, response. The element of regular outreach programmes to connect with the most vulnerable groups in exposed areas is critical in this context. Implementation of the Kuala Lumpur Consensus requires cooperation on strengthening transdisciplinary action-oriented research and education, and engagement in disaster risk science, technology, and policy. Non-government organisations also have a role in advancing science and technology drawing on Local and Indigenous knowledge to support decision-making. Enhancing the inclusion of science and technology groups, including youths and young professionals, and stakeholder groups in DRR activities and policy platforms is also important. Efforts are required for increasing investment from governments, societies, businesses and other stakeholders in research, capacity building and development of DRR science and technology. In Malaysia, the Geological Society of Malaysia (GSM) can play a leading role in garnering support from universities, government, businesses and other stakeholders, around innovation, partnership development, international cooperation and exchanges on science and technology-based DRR. There is also much to be done in translating into actions the "whole of Government" and "whole of Society" approaches in DRR, and the GSM is well positioned to support this endeavour.

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AUTHORS CONTRIBUTION

JJP – conceptualisation, writing and editing; TRB – writing and editing; NM – information curation, review and editing; SY – review and editing; and SY and RS – review and editing.

CONFLICT OF INTEREST

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the effort reported in this paper.

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