Exploring Transdisciplinary Approaches to Facilitate Disaster Risk Reduction at National and Local Levels Through Education, Training and Field Practice

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1. Introduction

Science and technology has been recognized as one of the driving forces in the development and implementation of major international disaster risk reduction (DRR) frameworks, from the International Decade for Natural Disaster Reduction (IDNDR) in the 1990s, the Hyogo Framework for Disaster Risk Reduction (HFA) 2005-2015 and the Sendai Framework for Disaster Risk Reduction (SFDRR) 2015-2030. However, to fully utilize the knowledge created with science and technology for DRR in real world situations, integration of different disciplines, collaborations among various DRR stakeholders and bridging the science with policy are critical. In concurrence, the Science and Technology Advisory Group (STAG) of UNISDR have proposed to strengthen the research-policy interface through better communication and engagements among DRR policy makers and stakeholders from all sectors including the science and technology group. Furthermore, innovation, customization, implementation and transparency are also important aspects to use science and technology to strengthen DRR policy and decision making process (Shaw, et al, 2016).

The importance to integrate science and technology that includes disciplines from natural science, engineering to social science for taking DRR measures and strengthening partnership with different stakeholders have been noted in the documents from IDNDR's Program Forum in 1999. During the implementation of HFA, UNISDR's STAG released several reports on the significance of science and technology for implementing the priority actions including, "Reducing Disaster Risks through Science: Issues and action" in 2009 and "Using Science for Disaster Risk Reduction" in 2013. The Bangkok Declaration from the Sixth Asian Ministerial Conference on Disaster Risk Reduction (AMCDRR) in 2014 had also emphasized the important roles of science, technology and academia stakeholders in research (advancing integrated disaster research), higher education (promoting multi-disciplinary DRR in university education) and integration (ensuring disaster research programs, policies and applications are integrated across disciplinaries and contributing to policy-making and capacity building) (Chatterjee, et al, 2015). In the SFDRR adopted in 2015, the expected roles of science and technology stakeholders, especially on their contributions with DRR research were highlighted and included in the priority actions – namely Priority 1 and 2 (see Table 1).

Table 1 Selected texts from Sendai Framework for Disaster Risk Reduction (2015-2030) on science and technology

- ...need for the public and private sectors and civil society organizations, as well as **academia and scientific and research institutions**, to work more closely together and to create opportunities for collaboration... (from I. Preamble, 7.)
- ...DRRM depends on coordination mechanisms ... with relevant stakeholders at all levels... including business and **academia**, to ensure... complementarity in roles and accountability and follow-up (from III. Guiding principles, 19., (e))
- ...promote and improve...cooperation among **scientific and technological communities**, other relevant stakeholders and policymakers...to facilitate a **science-policy interface** for effective decision-making in disaster risk management (from IV. Priorities for action (under Priority 1), 24., (h))
- ...enhance the development and dissemination of **science-based methodologies and tools** to record and share disaster losses and relevant disaggregated data and statistics, as well as to strengthen disaster risk modelling, assessment, mapping, monitoring and multihazard early warning systems... (from IV. Priorities for action (under Priority 1), 25., (a))
- Promote common efforts in partnership with **scientific and technological community, academia** and the private sector to... disseminate and share good practices (from IV. Priorities for action (under Priority 1), 25., (d))
- To **enhance the scientific and technical work** on DRR and its mobilization through the coordination of existing networks and scientific research...in order to strengthen the evidence base in support of the implementation of the present Framework; promote scientific research...and **application of science and technology to decision-making** (from IV. Priorities for action (under Priority 1), 25., (g))
- **Academia, scientific and research entities**...to focus on the disaster risk factors and scenarios...increase research for regional, national and local application...support the **interface between policy and science** for decision-making (from V. Role of stakeholders, 36., (B))

On the other hand, despite of the fact that science and technology has been increasingly featured in DRR, there are claims that DRR knowledge is still fragmented within and among different stakeholders and has not been adequately been incorporated into the decision making process (Abedin, et al, 2015). Gall et al (2015) also notes that there are still gaps remaining between research and practice as well as research and policy due to limited engagements between researchers and non-academicians. With the nature of DRR becoming increasingly complex and multifaceted, science and technology is expected to facilitate the integration of DRR actions with the "whole-of-society" (Shi, et al, 2018) and "whole-of-science" approaches that can be realized through a transdisciplinary approach (Ismail-Zedan, et al, 2016).

2. Transdisciplinary Approach (TDA) in DRR

2.1 Defining Transdisciplinary Approach (TDA)

Transdisciplinary approach (TDA) can be defined as an approach in which all players and stakeholders in various disciplines (natural, social and humanity sciences) and sectors (public, private, academia and civil society) work together to achieve a common goal. Cronin (2008) and Ismail-Zadeh et al (2017) have illustrated the

transformation of single-, multi-, inter- to trans-disciplinary approaches and the differences in the outputs of each as below.

The traditionally common disciplinary studies (or single discipline approach) are conducted purely within the bounds of a single discipline that work with discipline-specific questions, hypotheses, theories, models and methods. As so, there is no significant linkage with other disciplines. With multi-disciplinary approach, scientists and experts in different disciplines may work together on a same issue, but each will work with their own methodologies that will result in individual outputs. The interdisciplinary approach may involve disciplines that are unrelated, but may share the same methodologies and each other's findings, thus the disciplines become more integrated. This may result in creating new knowledge and theories that could help to solve a common goal. The transdisciplinary approach (TDA) additionally requires different stakeholders (including non-academic) of various disciplines to collaboratively find solutions beyond the limit of single disciplinary knowledge and often times to work outside of own disciplinary. Moreover, TDA aims not only to create desktop knowledge, but also implementable, solution-oriented knowledge for complex problems that cannot be solved by a single discipline (Gall, et al, 2014). Figure 1 illustrates transformation of single discipline approach to multi-, inter- and trans-disciplinary approaches.

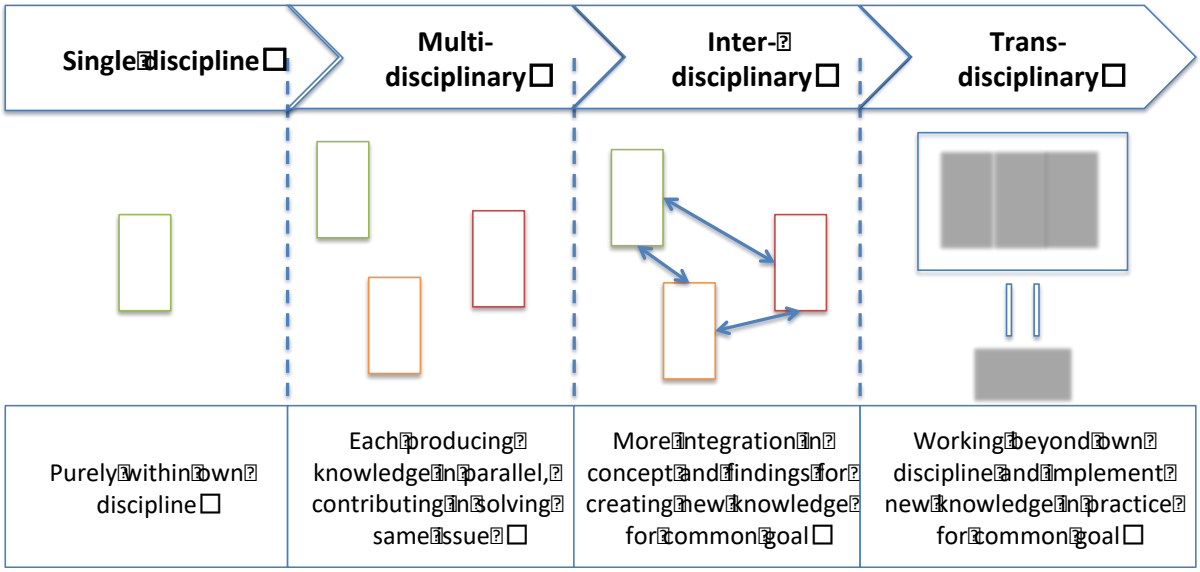

Figure 1: Transformation of single, multi-, inter- to trans-disciplinary approaches (adopted from Ismail-Zadeh et al, 2017)

2.2 Challenges of Transdisciplinary Approach (TDA)

TDA is not necessarily a new concept, and is said to have originated from sustainability science that involves diverse areas of expertise and wide stakeholder interests (Cronin, 2008). Nonetheless, TDA practices have not been widely exercised both in discipline and in actions (Takeuchi, et al, 2016). This may be because hazard science is still predominantly conducted in a traditional framework of basic geosciences in which scientists do not feel the responsibility to translate knowledge into actions. Moreover, it is difficult for various DRR stakeholders, such as disaster managers, community leaders, scientists, NGOs and experts that have different roles and responsibilities in DRR, to collaborate and coordinate on disaster-related issues that are uncertain and infrequent (Ismail-Zedan, et al, 2016). Various actors also tend to prioritize different aspects of disasters (e.g. geoscientists will focus on hazard data, while disaster managers are interested in political and economical situations) that may create new problems for tackling the same DRR issue. Cronin (2008) identifies limited knowledge, skills and financial resources, and especially the lack of institutional commitment and leadership as some of the bottlenecks for realizing TDA.

2.3 Towards implementation of Transdisciplinary Approach (TDA)

As noted, TDA is not simply about creating new scientific knowledge, but developing practical solutions that can be implemented to solve problems on the actual field. In implementation, TDA requires all relevant stakeholders of various disciplines to co-design, co-produce, co-deliver and co-implement with aim to solve a common issue through scientific knowledge-based decision making.

Figure 2 summarizes some of the key elements of TDA that may be referred to as a checklist for implementing or analyzing case studies that adopts TDA for DRR. It has been already noted that TDA requires DRR to be seen as a holistic and cross-cutting issue that need various stakeholders of different disciplines to collaborate and coordinate. It has been also mentioned that TDA should make scientific knowledge to be practical and be able to influence important decisions and policies. The remaining elements, like institutionalization of TDA as a national policy, capacity building and budget provision for implementation could be more challenging, but essential to maintain the effectiveness and sustainably of TDA.

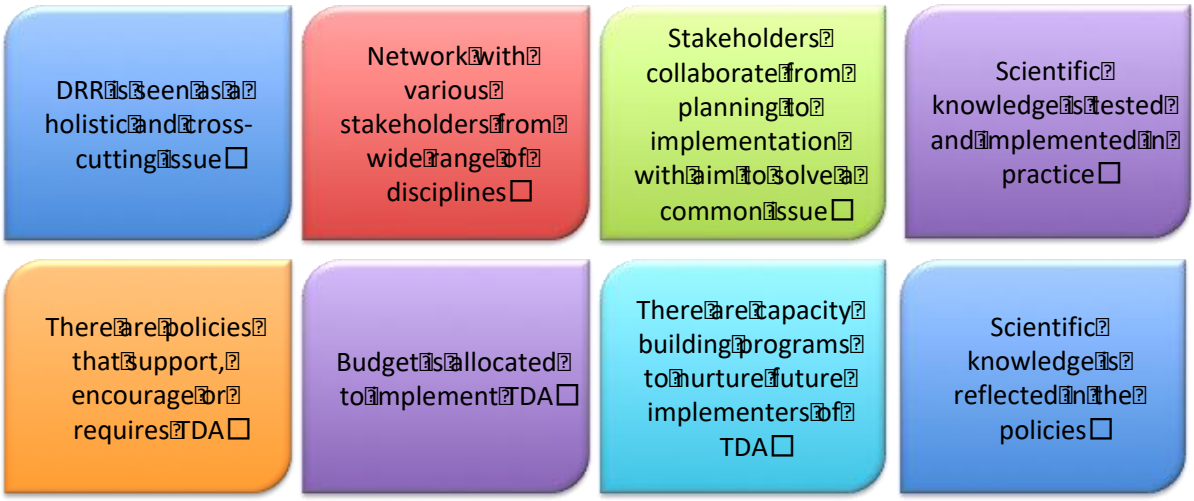

Figure 2 Key elements for TDA implementation

During times of increasing climatic, environmental, socio-economical and political dynamism, society is commonly inclined to seek for unbiased and objective explanations that could clarify some of the uncertainties. The key elements of TDA listed above may ensure that knowledge created by science and technology can be relevant and useful to various stakeholders and implementable to solve real world problems. Specifically in the DRR context, it may be only then that science and technology can truly provide a holistic and transformative solution and bring a paradigm shift for DRR decision making possible (Takeuchi, et al, 2016).

2.4 Role of universities for Transdisciplinary Approach (TDA)

The challenges of implementing TDA provide opportunities for science and technology stakeholders, particularly for universities, to take on the important role to mainstream TDA for DRR strengthening. On this point, universities are able to (1) provide **education and training** to build capacities of DRR stakeholders, (2) provide evidence-based information through scientific **research** and (3) test and verify the practicality of education and research through implementation of **field practice** that may significantly help facilitate the TDA process.

As an educational institution, universities are hubs that offer professional development in numerous cross-cutting issues in DRR. UNISDR's STAG also notes that as a science and technology stakeholder, universities play an essential role in such capacity building and knowledge sharing. Furthermore, as a research entity, universities function as vehicles of knowledge accumulation and creation (Shaw et al, 2011) and have been sharing knowledge with research outputs to wide range of audiences beyond the academic world through various channels including research papers, textbooks, websites, conferences, TV programs and social networks. Providing scientific

information to the society can boost transparency that encourages institutions and individuals to act with honesty, integrity and fairness when making important decisions. Finally, while scientific knowledge is only good when implemented and used by practitioners, field practice in collaboration with DRR agencies and departments can ensure that university education and research activities are in demand and valid for solving issues on the field. Additionally, universities can contribute to TDA by offering a platform for different stakeholders in government, NGOs, other universities and communities to build network (Abedin, et al, 2015) that can further strengthen the coordination mechanisms among DRR stakeholders.

The following sections introduce five case studies by universities and research institutes in Malaysia and other countries in the Asia-Pacific region that have been endeavoring to take their roles to facilitate implementation of SFDRR through education, research and field actions by incorporating TDA.

3. Malaysia-Japan International Institute of Technology (MJIIT) Disaster Risk Management Program (Case Study 1)

Disaster managers today are demanded to plan and implement evidence-based disaster risk reduction and management measures for building resilience of their communities and countries for sustainable development. Professionals with adequate knowledge and skills are invaluable if these challenges are to be met. In response to this demand, the Malaysia-Japan International Institute of Technology (MJIIT) of Universiti Teknologi Malaysia (UTM) Kuala Lumpur has been offering the Master of Disaster Risk Management (MDRM), the first ever post-graduate taught course program in Malaysia that targets mid-career professionals in DRR since 2016.

3.1 Concept of MDRM Program: 3 pillars for professional development

The program's fundamental concept lies in the balance and links among *Education/Training, Research and Field Practice* (see Figure 3). The curriculum and learning activities of this MDRM program were developed and designed based on these three pillars, which consist of knowledge enhancement through *Education/Training* (e.g. in-class lectures, learning case studies and student-centered learning), *Research* (e.g. research thesis, group project assignments) and *Field Practice* (e.g. technical visits to DRR agencies, field survey in Malaysia and Japan and community engagement programs). In such ways, knowledge is acquired through *Education/Training* and *Research* builds the analytical capacities and *Field Practice* develops the skills to make evidence-based decisions and actions

in actual situations. In this context, the MDRM program aims to develop DRR professionals who will be equipped with holistic knowledge and skills to plan and implement DRR measures.

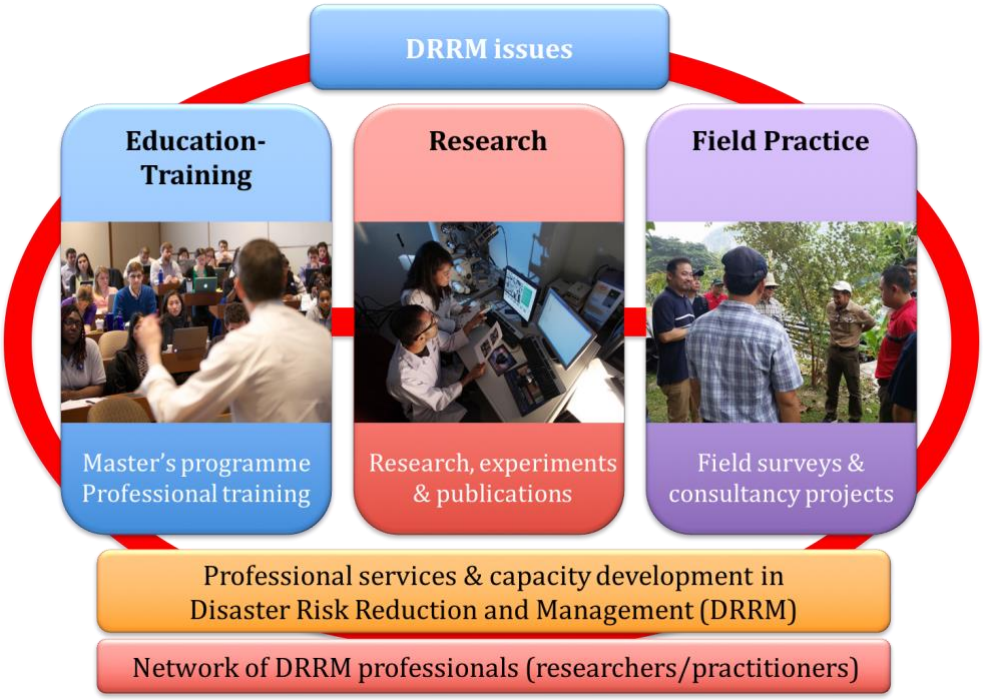

Figure 3: Concept of MDRM program at MJIIT, UTM Kuala Lumpur

3.2 Structure of the MDRM program

MDRM is a one-year (12 months) post-graduate program (2 semesters and 1 short semester) consisting of 42 credit learning hours covering five core courses (Integrated Disaster Management, Disaster Data Management and Forecasting, Control Measures and Mitigation Planning, Emergency Response Planning and Communication, Recovery and Reconstruction Management) and 5 elective courses (Healthcare in Emergencies and Rehabilitation, Flood Forecasting and Hazard Mapping, Disaster Education and Preparedness for Social Resilience, Geoinformation for Disaster Risk Assessment). Each course is implemented in a 2-week module. In addition, students must complete the master's project/thesis and 2-week Japan Attachment Program that are included in the program.

Working DRR professionals also have an opportunity to take the short-term Certified Professional Training (CPT) that is offered concurrently with the MDRM courses. CPT students are able to choose and attend any of the 2-week modules based on their interests and needs. If a student completes all of the modules within a period of 3 years, he or she may pursue a master's degree by completing the master's project. Students who have specific

interests, but have very limited time away from their work may attend any of the lecture sessions (usually in a span of 2-3 days) from any of the modules and be awarded with Continuing Professional Development (CPD) credits.

All MDRM courses are implemented by a lecture team consisting of prominent Malaysian and Japanese DRR experts who are selected from the Disaster Risk Management (DRM) Sub-Committee members of the Japan University Consortium (JUC) that consists of 29 top Japanese universities and research institutes. These members include Tsukuba University (Chair), Kyoto University (Co-chair), Kyushu University (Co-chair), Yamaguchi University, Shibaura Institute of Technology, Kanazawa University, National Research Institute for Earth Science and Disaster Resilience (NIED), International Centre for Water Hazard and Risk Management (ICHARM) and Japan International Cooperation Agency (JICA) that provides operational and technical support. The DRM Sub-Committee members also provide technical support to conduct DRR projects and attachment programs in Japan. In addition, MDRM owns a technical advisory group comprised of local and international DRR researchers, practitioners and industry players that oversees the program's quality, implementation and deliverables.

3.3 Research and field practice components of the MDRM Program

For integrating education/training with research and field practice activities, MDRM program offers opportunities for both faculty members and students to collaborate with any of the partner universities, research institutes, government department/agencies, NGOs/CBOs, international organizations and private companies in Malaysia, Japan and other countries throughout the Asia-Pacific region. beyond educational activities.

One example to illustrate the integrated activities of the MDRM program is a case study from the national project, the Slope Hazard and Risk Mapping (*Penghasilan Peta Bahaya dan Risiko Cerun*, PBRC). PBRC is a national initiative that tackles the issue of landslide hazards and risks with the use of advanced and modern geospatial technologies, specifically topographic laser scanning or known as LIDAR. Multi-sensor LIDAR technology is capable of providing crucial spatial data for solving previous geological problems and producing hazard and risk maps that are effective to plan and implement preventive measures. In the project, hazard and risk maps based on LiDAR were developed and applied to future development plans at the district level (e.g. Local Plan 2030 in Cameron Highlands, Pahang, Malaysia). The project also conducted quantitative analysis of landslide hazard and integrated risk assessments to promote pre-disaster actions rather than reactive post-disaster actions of local stakeholders..

This knowledge-creating project involved various academicians, experts and professionals from different

fields and backgrounds (e.g. geoscientists, geologists, geomorphologists, civil engineers, geotechnical engineers, geomatics engineers, urban planners, social scientists, disaster managers) and promoted TDA to better understand the root causes, analyze local risk profiles and assess spatial and temporal probability of future landslide risks in a complex and changing environment. This project was assigned to several institutes including UTM by the Prime Minister's Department to the Minerals and Geoscience Department, Ministry of Natural Resources and Environment, Malaysia for the period of September 2014 to March 2016. Later on, the project period was extended (and still on-going) and implementation expanded to the other regions.

The methodologies, approaches and case studies developed for landslide hazard and risk mapping and assessment carried out in the PBRC project are embedded in the MDRM course module, "Geohazard Information for Disaster Risk Management.". Because of its good mix of theoretical and practical contents, the course attracted many senior and junior geologists, geomorphologists and young government officers to join and enhance their professional knowledge and skills.

Photo 1: Education/Training, Research and Field Practice Activities of MDRM Program of MJIIT/UTM

Such collaborative examples can be also seen at international levels, including the Japan ASEAN Science, Technology and Innovation Platform (JASTIP) and ASEAN University Network/Southeast Asia Engineering Education Development Network (AUN/SEED-Net) that have been promoting science and technology collaboration among ASEAN stakeholders. . Another example is a project under the JICA Partnership Program (JPP), "Strengthening the Disaster Risk Reduction Capacity to Improve the Safety and Security of Communities by

Understanding Disaster Risks" that is jointly implemented by Selangor State Government, Malaysia, Sendai City, Japan, Tohoku University, Japan and MJIIT/UTM, Malaysia. The project analyzes flood and landslide risks with scientific data that is checked against community disaster risk maps that will be made by the target communities. Then, based on the consolidated disaster risk map, project partners will identify a set of prioritized DRR actions that will be implemented by the communities and facilitated by local authorities and community leaders. The project attempts to close the gap among science, field practice and policy making for reducing current risk and preventing future disaster risks.

3.4 Partnership with the National Disaster Management Agency, Malaysia

The science and technology sector in Malaysia is said to have had a national prominence in DRR since the implementation of HFA along with countries like China and Japan (Shaw, et al, 2016). In 2013, Malaysia had already established the National Platform for DRR (also called as "myDRR") in which academia has been one of the most active groups among other members including line agencies/departments, NGOs and private sector representatives. With the establishment of the National Disaster Management Agency (NaDMA) under the Prime Minister's Department in 2015, the Scientific Expert Panel (SEP) with members from key sectors were formulated and mandated with the following tasks:

(a) Provide scientific advice to MyDRR;

(b) Facilitate strategic networks among various ministries, agencies and entities involved in Disaster Risk Reduction (DRR);

(c) Take note on the various science-based DRR programs in the country by holding regular meetings to avoid duplication;

(d) Identify science-based DRR initiatives that can obtain positive results for the wellbeing of Malaysia;

(e) Consolidate research conducted at universities and research institutions with the private sector; and

(f) Encourage local Research & Development (R&D) in DRR through public-private partnership.

Under the new government and leadership after the general election in May 2018, NaDMA plans to upgrade and transform the SET to the Science and Technology Expert Panel (STEP) by expanding its membership to include more academic institutes, private sector and technical agencies/departments to further formalize the advisory mechanisms of the science and technology stakeholders to support NaDMA. As so, STEP's function is merely not

just providing scientific information to NaDMA like previously, but also to assist in the coordination of for different stakeholders of various sectors and implementation and monitoring of national DRR strategy and SFDRR.

Established around the same time with NaDMA, MJIIT's Disaster Program has established a close relationship with NaDMA, in support to build their in-house capacity through technical visits and training programs as well as technical support to implement DRR drills. MJIIT has been also accompanying NaDMA as a member of the Malaysian Government delegation to regional and international DRR conferences, including UNISDR's Asian Ministerial Conference for DRR in providing logistical and technical support (see Photo 2).

Photo 2: Dato' Seri Dr. Wan Azizah binti Wan Ismail, Deputy Prime Minister and Chairwoman of the Central Committee on Disaster Management of Malaysia in discussion with DRR experts from Universiti Teknologi Malaysia (UTM) at AMCDRR 2018 in Mongolia

5. Case studies from other countries: Indonesia, Thailand, Pakistan and Fiji

In addition to the example from Malaysia, four additional case studies from universities and research institutes in the Asia Pacific Region were selected on basis that each of their activities are based on the key elements of TDA. Also, each case study showcase some, if not all, of the abovementioned elements of TDA and the co-designing, co-producing, co-delivering and co-implementing factors that make scientific knowledge practical in solving DRR issues on the actual field.

5.1 Case study from Indonesia (Case Study 2)

The Indonesian case study is from the Center of Excellence for Disaster Mitigation and Technological Innovation (GAMA-InaTEK) of Universitas Gadjah Mada in Yogyakarta, Indonesia. Originating as the Disaster Mitigation Team of Faculty of Engineering that was established in demand after such major disasters as 2006 Yogyakarta Earthquake and eruption of Mount Merapi in 2010, the Center together with the National Authority for Disaster Management (BNPB) and Regional Authority for Disaster Management (BPBD) has installed early warning systems (EWS) for landslide disasters in 98 districts/cities in 28 provinces in Indonesia. EWS was developed based on a hybrid sociotechnical approach in DRR for local-scale landslide and received an ISO 22327 for publishing Indonesia's Landslide Early Warning System. In addition, as preparedness measures, the center had conducted risk assessments in high-risk areas throughout the country and implemented community awareness programs that emphasized on the participatory approach and sustainability. As a result, the center significantly contributed in saving lives from series of landslide-related disasters including those in Banjarnegara (2007), Aceh Besar (2015), Donggala (2016), Lombok Barat (2016), Kerinci (2017), Gunungkidul (2017). In Banjarnegara, the EWS issued a warning to the community to evacuate about four hours before the landslide, which later destroyed 10 houses and severely damaged the district road (Fathani, et al 2008). Investment in this EWS can be referred to as a good practice; as an effective collaboration with the science and technology group that is contributing to the third and fourth priorities of SFDRR.

Photo 3: Installation of Early Warning System for Landslide in Kabupaten Banjarnegara, Central Java, Indonesia

5.2 Case study from Thailand (Case Study 3)

The Disaster Preparedness, Mitigation and Management (DPMM) program, established at the Asian Institute of Technology (AIT) in Bangkok in 2008, has been offering interdisciplinary academic program that aims to produce highly qualified DRR professionals. DPMM has been contributing to disaster preparedness, mitigation and management by playing leading roles to develop appropriate disaster management policies, strategies and techniques to help build resilient communities across Asia-Pacific region and beyond. DPMM does not only offer traditional postgraduate programs, but also provide various options including internship program and certification for working professionals to continue their studies in DRR. This integrated program covers from community based, geospatial technology to planning and humanitarian issues. Another unique feature of DPMM is the balanced partnership among academic (e.g. Integrated Research on Disaster Risk: IRDR), government (e.g. Department of Disaster Prevention and Mitigation (DDPM), Thailand), international organization (e.g. International Federation of Red Cross and Red Crescent Societies: IFRC) and private sector (e.g. Télécoms Sans Frontières: TSF) to maintain their program to be practical and continuously addressing real world DRR issues. This program also demonstrates a good TDA example for partnership between universities, government agencies, civil societies, and private sector. The decision makers, experts, professionals and practitioners have been working together by contributing their knowledge, expertise and network towards achieving the same goals.

5.3 Case study from Pakistan (Case Study 4)

Another case study is from Pakistan in which the Network of Disaster Management Practitioners (NDMP), a registered entity under the Company Ordinance 1984 and supported by network of experienced and highly skilled disaster management practitioners. NDMP has been putting its efforts in empowering and building disaster resilient communities through trainings, organizational cooperation, field visits, conferences, seminars and symposium. Since 2011, NDMP has trained over 2,520 participants (1,728 male/792 female) and developed a database of potential trainers (PT) for sustainable knowledge and skill management and dissemination. In addition to supporting disaster management agencies and field practitioners for developing disaster management/contingency plans, public awareness programs and project management, the NDMP collaborates with academic experts and groups to conduct scientific research work such as damage and loss assessments, multi-hazard vulnerability risk assessments at national and sub-national levels and utilization of geographical

information system (GIS) and remote sensing (RS) technologies for DRR interventions. To support the aforementioned activities, NDMP also collaborates with international partners such as Asian Disaster Preparedness Center (ADPC), Thailand, National Society of Earthquake Engineering (NSET) Kathmandu, Nepal and Center for Disaster Preparedness (CDP), Philippines.

Photo 4: School DRR Programs at 34 Government Schools in Chitral District, Khyber-Pakhtunkhwa Province, Pakistan

5.4 Case study from Fiji (Case Study 5)

The Pacific Centre for Environment and Sustainable Development (PaCE-SD) of the University of the South Pacific (USP) that was established in 1999 with mandate to empower the people of the Pacific with knowledge that enables them to adapt to the impacts of climate change and disasters for sustainable development. PaCE-SD offers post graduate education programs for DRR practitioners (e.g. government officials, NGO staffs, officers in international organizations, etc.) on climate change that include DRR issues and regionally accredited professional qualifications through technical and vocational programs that include training on climate change, hazards and disasters, vulnerability assessment and participatory process to develop and implement resilience building actions. Specific topics and skills covered in the programs are determined by the needs and demands from DRR practitioners. For implementation, climate change adaptation activities were jointly implemented in 40 communities in 15 countries under the USP EU-GCCA project (EU funded) with government agencies, NGOs and CSOs. These activities by project partners continued in another follow up project that conducted risk mapping and vulnerability assessment that developed awareness of climate change adaptation issues and approaches that allowed acquirement of fundamental decision-making skills for building climate resilient societies.

This case study illustrates how USP's PaCE-SD, one of the leading science and technology actor in the Pacific Region, has been supporting the DRR agencies, including National Disaster Management Offices (NDMOs) through TDA. PaCE-SD not only conducts capacity development programs for these offices, but also collaborates in field projects that have been helping communities build resilience to disasters based on scientific evidence. One example is the development of a tool called Participatory Assessment of Vulnerability and Adaptation (V&A) that has been widely used by government agencies, NGOs and experts in the region to plan DRR activities.

Photo 5: Professional Development Program and Community Engagement Project of PaCE-SD, USP

6. Summary and Way Forward

Four years have passed since major global frameworks, namely SDGs, SFDRR and Paris Agreement, were adopted in 2015. By this time, it would be fair to say that there is a wider consensus on the importance of science and technology that may enable risk informed, evidence-based decision making and policy strengthening for a common goal: building disaster resilient societies in a fast changing environment. Yet in reality, there are still gaps among different disciplines and among scientific and non-scientific stakeholders, which call for a stronger science-policy interface to be in place.

In this light, the transdisciplinary approach (TDA) has been suggested with a set of key elements that is an implementation methodology to make better use of science and technology in a collaborative process that involves active and direct engagement of stakeholders of multiple disciplines to jointly tackle DRR problems (Stokols, 2006; Hadorn, et al, 2008). It is also important to emphasize that TDA focuses on societal relevant problems, enables mutual learning from various disciplines and actors; and tries to create solution-oriented knowledge that is equally socially responsive (Lang et al., 2012). The case studies from the Asia-Pacific Region

that integrate cross cutting DRR issues and involve various stakeholders showcase actual TDA experiences that can be referred by other disaster-prone regions and countries. These case studies put the spotlight on science and technology stakeholders, particularly universities and research institutes, that have been active in capacity building and knowledge creation through education/training, research and field programs. These efforts have also either directly or indirectly supported resilience building of disaster-prone communities and regions. Some of the major findings from the case studies can be summarized as below:

1. Science and technology stakeholders (academia, research institutes) can provide education and training to build capacities of DRR practitioners to effectively plan and implement disaster preparedness measures.
2. Science and technology stakeholders can also support evidence-based decision making through locally specific scientific assessments and analysis.
3. Science and technology stakeholders can test and validate scientific information on the actual field for DRR practitioners and agencies.

On the other hand, a stronger science-policy interface may be still pursued if policies that support TDA itself can be institutionalized. Such policies may not only oblige multi-stakeholders of different disciplines to practice TDA and work together, but also justify governments to allocate budget to support such activities. These may be the two of the remaining key elements of TDA that need to be strengthened and looked into as next steps to fully utilize science and technology to facilitate the implementation of SFDRR.

This paper has identified the key knowledge gaps and opportunities to strengthen the contribution of science by promoting TDA towards operationalizing the Science and Technology Roadmap for DRR. Enhanced linkage between science and policy is necessary to support the implementation of science-based policy making at global, regional and local levels for risk-informed decision making across the post-2015 Agenda. DRR stakeholders must collectively enhance collaboration with an integrated approach, using science and technology and incorporating the key TDA elements for strengthening measures for DRR, climate change and sustainable development.

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