30 INNOVATIONS for DRR

Disaster
Risk
Reduction

30 innovations for Disaster Risk Reduction

About this publication :

This publication is developed by a group of individuals from the International Institute of Disaster Science (IRIDeS) at Tohoku University, Keio University, the University of Tokyo, the United Nations University Institute for the Advanced Study of Sustainability (UNU-IAS), and Church World Service (CWS) Japan in collaboration with the Association of Pacific Rim Universities (APRU) Multi-Hazards Program. The case studies of the 30 innovations were selected in a series of discussions with the group. The innovations are not limited to the 30 cases included in this publication.

This publication is not the official voice of any organizations and countries. The analysis presented in this publication is of the author of each innovation.

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Foreword

This publication is indeed a very valuable collection of thought provoking work which will contribute greatly to the world's understanding of disaster risk and how it can be managed through the practical application of science and technology. The volume is a wonderful response from the world of academia to the Sendai Framework's call for the promotion of scientific research and to support the "availability and application of science and technology to decision making."

It is particularly interesting to see this collection of 30 innovations divided into products on the one hand and approaches on the other.

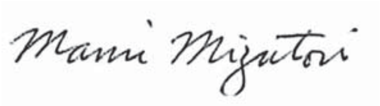
From the high tech innovations such as GIS and Doppler radar, to the introduction of seismic codes and earthquake early warning systems, it is clear that science and technology is making a profound difference in the world's ability to reduce death tolls in disasters and the damage to critical infrastructure.

These innovations can only make a difference if they are applied intelligently to improve the built environment around us so it is equally fascinating to review the list of 16 approaches included here which have been judged as sufficiently innovative to merit inclusion alongside the scientific breakthroughs.

It is encouraging to see the Sendai Framework's predecessor, the Hyogo Framework for Action being included for the significant role it played in engaging stakeholders in a common effort to build resilience to disasters, and to monitor and share progress reports. That experience has greatly informed the process now underway to monitor progress against delivery of the Sendai Framework targets and the Sustainable Development Goals.

This volume concludes with the results of a survey of 228 experts from academia, government, NGOs and the private sector which chose Community Based Disaster Risk Reduction as the most important innovation of the thirty listed.

The message here is that the approach matters just as much as technical innovation; our efforts must be people-centered and inclusive if we are to make progress on reducing disaster risk and disaster losses.



Mami Mizutori,
United Nations Special Representative
of the Secretary-General
for Disaster Risk Reduction

Preface

It has never been more important to connect sociological and scientific research and technological innovation to policy and practice. In 2018, the world faced a seemingly unending cycle of disasters: heatwaves, droughts, floods, typhoons, earthquakes, tsunami, volcanic eruptions. This increased frequency and intensity of extreme events requires us to accelerate our disaster risk reduction (DRR) efforts and create innovative solutions to minimize the damage and wide-ranging secondary impacts of future events. The Sendai Framework for Disaster Risk Reduction 2015-2030 (SFDRR) encouraged an increased focus on science and technology as a key tool to confront such global challenges. Innovative approaches and technological responses in DRR need to take account of underlying disaster risks such as inequality, climate change, urbanization, the increase in population density, and environmental degradation.

The Association of Pacific Rim Universities (APRU), is a network of 50 leading research universities from around the Pacific Rim – the North and South America, East and Southeast Asia, and Oceania. APRU established the Multi-Hazards (MH) program in 2013 with the major objectives of harnessing its members' collective capacities for cutting edge research on DRR and contributing to the discussions for science-based policy-making at international and regional levels. The APRU program hub has been hosted by Tohoku University at Sendai in Japan. The International Research Institute of Disaster Science (IRIDeS) established in 2012 after the 2011 Great East Japan Earthquake and Tsunami is honored to contribute to the program as the secretariat through various activities such as organizing the summer school and the academic conference and meetings. This publication is one of the collaborative efforts among the member universities under the APRU MH program and aims to share the most effective technological and other innovations for DRR.

This publication features 30 innovations across its member network for DRR including products and approaches. As a group of academic researchers and experts, we strive continuously to share data, information, and research findings, aiming to translate these into practice. We believe such collaborative efforts across academia, the private sector, governments and other stakeholders will contribute to the implementation of the SFDRR. The innovations introduced in this report are not only high-tech products but also provide contextual approaches, traditional ideas and social science insights, offering solutions that do not require large budgets or the use of advanced technology. Economies and regions can identify the most suitable solutions for their own geographical conditions, financial and human resources and availability of technology. In this way, we intend this publication will support the development of localized innovations for reducing future disaster risks, providing increasingly effective and prompt responses, promoting "build back better" in the recovery stage, and building disaster-resilient communities.

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Introduction

The need for increased application of innovation and technology for disaster risk reduction (DRR) has never been greater in order to foster new development and implementation of more effective evidence-based approaches. Tremendous DRR efforts have been ongoing for many years; however, further improvements and new methods of DRR beyond the conventional and traditional initiatives are urgently required, especially those related to serious underlying causes such as climate change, poverty, urbanization, population density, and environmental degradation. Further, the Sendai Framework for Disaster Risk Reduction encourages better access and support for innovation and technology as well as increased investment in DRR to develop new innovations that are both cost-effective and beneficial when applied in all disaster management phases: response, recovery, mitigation, and preparedness. In addition, strong collaboration between various stakeholders such as government, academia, NGOs, and the private sector is crucial to the application of technology and innovations. A series of discussions about many forms of potential collaboration continue to take place.

The Association of Pacific Rim Universities (APRU) Multi-Hazards Program organized a strategic meeting to discuss their influence on disaster risk reduction policy at Tohoku University in February 2018 with APRU member universities and partner organizations. At the meeting, all agreed that a viable link between researchers and practitioners is currently absent. Academia conducts research based on science and technology, but many of these research results and findings are either not shared, inaccessible, or barely recognized by actual users and practitioners. To improve this situation and create a mutually cooperative environment, it was suggested that material be developed to be used at training sessions, seminars, and classes to introduce the DRR products and approaches considered to be the most innovative and effective based on science and technology, especially those that target practitioners. Named 30 Innovations for DRR, the collection aims to share information about the most effective technology and innovations for DRR. It also provides guidelines to identify the most important, most suitable, and innovative DRR tools that can contribute to reducing disaster risks and preparing for future disasters in the readers' own countries or regions.

30 Innovations for DRR includes the innovative products and approaches considered to be extremely effective and those that have already contributed to reducing disaster risks. They were identified in discussions between experts primarily from Keio University, University of Tokyo, United Nations University, CWS Japan, and IRIDeS of Tohoku University. This does not imply that only thirty innovations exist to date, rather that many others also exist. They were identified as the very best of many innovations in discussions between experts. The DRR innovations listed in this publication are divided into products (14) and approaches (16). The innovations listed first in each section are those applied for 1) multi-hazards. The list continues with specific hazard types: 2) Earthquake, 3) Flood,

and 4) Others. In this format, readers can easily identify the DRR innovations suitable for tackling the hazards that affect them most.

Parallel to the publication, a survey was conducted to determine the innovations for DRR considered to be the most effective among academia, NGOs, international organizations, governments, and the private sector. The question asked participants to select three innovations considered or proven to be most effective out of thirty innovations. The survey received 228 responses. A summary of the survey results is included after the list of innovations. Of special interest to many, of the ten innovations selected most frequently, five are products and six are approaches (two received the same score). These results show that products and approaches are equally recognized as innovations, and that they both contribute to improving existing and traditional DRR efforts for tackling new challenges. We must not forget that technology and innovations are not only high-tech products but also soft-measures such as approaches and frameworks that can lead to changes as well as influence people's thinking and behavior.

30 innovations for DRR :
PRODUCTS

01. GIS and remote sensing
02. Drones
03. Social networking service / system (SNS)
04. Concrete and steel: Building material and infrastructure
05. Disaster risk insurance
06. Disaster prevention radio (Bosai musen) and the telemetry system
07. School cum cyclone shelter
08. Seismic code
09. Seismic micro-zonation
10. Earthquake early warning for high speed train
11. Doppler radar
12. Disaster resilient materials
13. Rain water harvesting
14. Electricity resistant survey

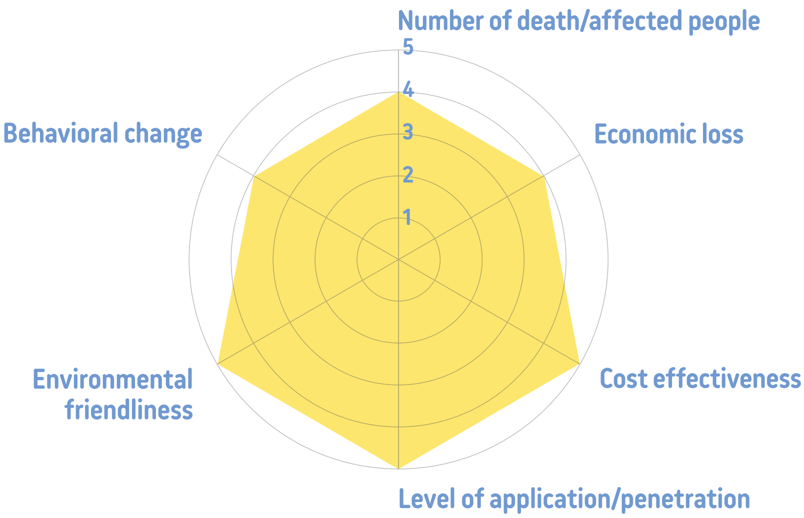
01 GIS and remote sensing

A Geographic Information System (GIS) is a computer-based tool for mapping and analyzing feature events on earth. GIS technology integrates common database operations, such as query and statistical analysis, with maps. GIS manages location-based information and provides tools for display and analysis of various statistics, including population characteristics, economic development opportunities, and vegetation types. GIS allows you to link databases and maps to create dynamic displays. Additionally, it provides tools to visualize, query, and overlay those databases in ways not possible with traditional spreadsheets. These abilities distinguish GIS from other information systems, and make it valuable to a wide range of public and private enterprises for explaining events, predicting outcomes, and planning strategies[1].

Remote sensing is the art and science of making measurements of the earth using sensors on airplanes or satellites. These sensors collect data in the form of images and provide specialized capabilities for manipulating, analyzing, and visualizing those images. Remote sensed imagery is integrated within a GIS.

[1] https://kb.iu.edu/d/anhs

Assessment



Number of death / affected people	4	With proper use of the combination, it can reduce death and affected people significantly.
Economic loss	4	Similar to death / affected people, it helps only it is planned and used.
Cost effectiveness	5	Extremely cost effective
Level of application / penetration	5	Very high level of penetration, and widely used
Environmental friendliness	5	No negative impact on the environment
Behavioral change	4	Spatial mapping has helped significantly to understand the risk and enhance behavior change.

Era	Type	Stage
◯ Before 1960s	✓ Earthquake	✓ Response
◯ 1960s	✓ Flood	✓ Recovery
✓ 1970s	✓ Typhoon/ Cyclone	✓ Mitigation
◯ 1980s	✓ Tsunami	✓ Preparedness
◯ 1990s	✓ Volcano	
◯ 2000s	✓ Landslides	
◯ 2010s	✓ Others	

How did it drastically change the existing DRR status and strategies? How is it innovative?

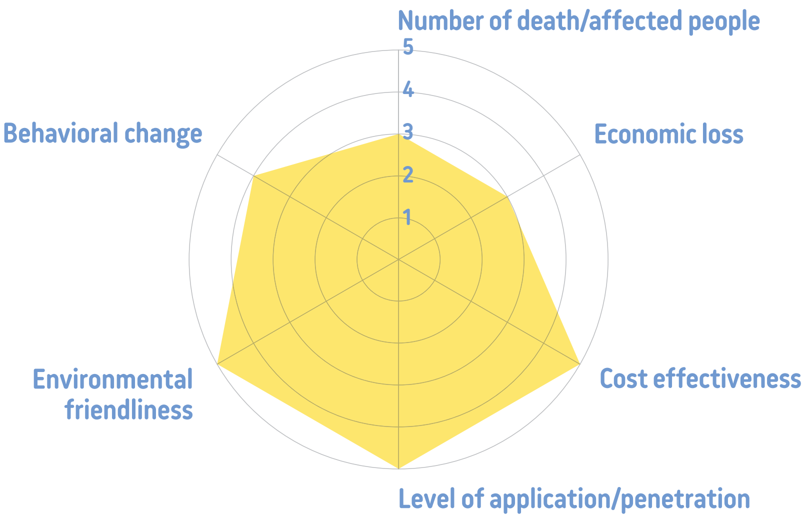
GIS is now the very basic information system for any disaster related data base at the local, national and regional level. This has tremendously changed the concept of mapping with different overlying layers, which can be used on a customized way. Thus, GIS is considered as the basic mapping tool for many purposes, and disaster risk reduction is no exception to that. Remote sensing images are used for interpretation of resources as well as risks and can be used for effective pre-disaster mitigation measures. With current high precision remote sensing data, especially using high precision satellite images, the urban diagnosis has become easier as well as effective. Before after remote sensing images help to understand the extent of damages immediately after a disaster. Thus, the combination of GIS and remote sensing has drastically changed the concept of mapping and spatial interpretation of risk and resources.

02 Drones

Many technological breakthroughs in recent years have emerged in places areas where it was least expected. Unmanned Aerial Systems (UAS), for example, have transitioned from highly defense-focused applications to a multitude of commercial use cases that transcend industries[1]. But what makes UAS, more commonly referred to as drones, fit for emergency response? Aerial views are critically helpful in large-scale disaster zones. Drones, designed to be agile, fast and robust, empower response teams with a substantial upper hand without costing as much as manned flight operations. Because many are autonomously flown, drones can access hard-to-reach areas and perform data-gathering tasks that are otherwise unsafe or impossible for humans.

[1] http://geoawesomeness.com/drones-fly-rescue/

Assessment



Number of death / affected people	3	Drones have not been able to save people's lives that much, but possibility transportation of emergency medicine, blood etc. to the affected areas would help in reducing death and affected people.
Economic loss	3	It has somehow been able to reduce the agriculture loss in some way, but needs improvements.
Cost effectiveness	5	Extremely good for cost effectiveness.
Level of application / penetration	5	Penetration is extremely good.
Environmental friendliness	5	No negative impact on the environment
Behavioral change	4	When combined with entertainment, drone can help in changing mindset of people.

Era	Type	Stage
◯ Before 1960s	✓ Earthquake	✓ Response
◯ 1960s	✓ Flood	✓ Recovery
◯ 1970s	✓ Typhoon/ Cyclone	✓ Mitigation
◯ 1980s	✓ Tsunami	✓ Preparedness
◯ 1990s	✓ Volcano	
◯ 2000s	✓ Landslides	
✓ 2010s	✓ Others	

How did it drastically change the existing DRR status and strategies? How is it innovative?

Many disaster management protocols have been tested over the years. While many of these strategies have been successful, they also come with major hurdles. Time is the most important issue in disaster response. This becomes more crucial when the terrains hit by disaster become inaccessible, especially in the mountain regions. Drones can play an important role in getting first hand image of the terrains hit by the disaster in the crucial first few hours. When the disaster scale is large, drone can be helpful to give an aerial view of damages.

This was especially useful for the 7.8 magnitude earthquake in Nepal that claimed the lives of 9,000 people and injured 23,000 others. The drones in Japan were extremely effective in the radiation survey, where the human accessibility was restricted. Drones can also be used for pre-disaster survey, especially for agriculture and forestry, and can help in deciding pre-disaster preparedness aspects.

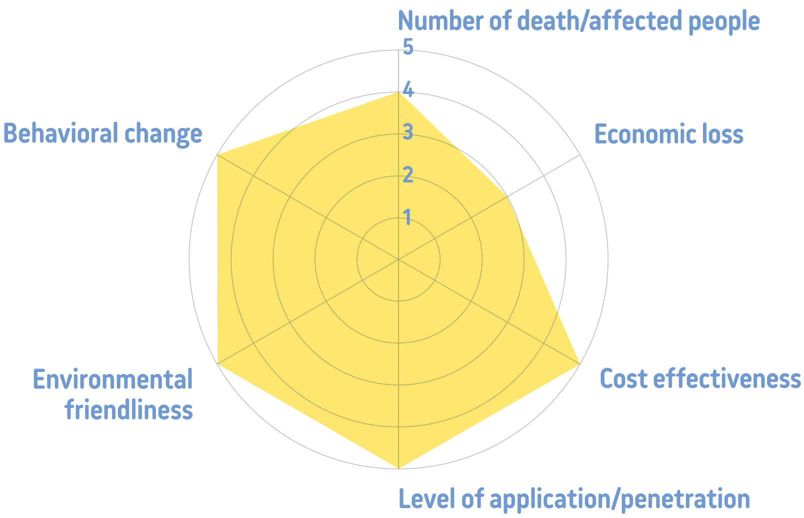
It can also help in different survey process, especially landslide risk reduction in the mountain areas. Thus, Drones are considered as one of the eight new / emerging technologies which have changed the concept of disaster management. However, there needs to have proper aviation regulation and expertise to be developed.

03 Social networking service / system (SNS)

The social network service/system (SNS), often termed as "social media," is an online space for making connections with others. SNS users create a profile and connect with others through file-sharing, emails, messages, or comments. Traditionally, disaster information was passed on through radio and television. The first SNS, namely SixDegrees.com, started in 1997 and was soon followed by Friendster, MySpace, Facebook, YouTube, Google Plus, Instagram, Twitter, LinkedIn, Reddit, Snapchat, Tumblr, Pinterest, and Vine.

The development of computers, smart phones, and tablets allows for the proliferation of SNS use. Recently, SNS has become an important tool for DRR that can make communities and societies more resilient to disasters and crises. It offers opportunities to educate people, especially the youth, on knowledge of hazards; allow collection of disaster data; give voice to people, especially during an emergency; and provide information on logistic and humanitarian needs. However, some negative effects of SNS have been observed in relation to disaster information.

Assessment



Number of death / affected people	4	SNS can help reduce deaths and affected people through preparedness and situational information
Economic loss	3	Reducing disaster economic loss can be done through better targeting of recipients
Cost effectiveness	5	Cost-effectiveness is achieved through better planning due to more data is available
Level of application / penetration	5	The concepts have been used world widely.
Environmental friendliness	5	No negative impact on the environment.
Behavioral change	5	It made behavioral changes drastically and systematically on governments as well as various stakeholders.

Era	Type	Stage
○ Before 1960s	✓ Earthquake	✓ Response
○ 1960s	✓ Flood	✓ Recovery
○ 1970s	✓ Typhoon/ Cyclone	✓ Mitigation
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○ 1990s	✓ Volcano	
✓ 2000s	✓ Landslides	
○ 2010s	✓ Others	

How did it drastically change the existing DRR status and strategies? How is it innovative?

The use of the SNS in DRR has changed the way people perceive and respond to disaster information and even to decision-making processes by government or other organizations working in disaster management. In most disasters, the first responders are the public, who then gather social capital, either directly or through SNS, in the form of the mobilization of skills, leadership, networks, and support systems.

After the Haiti earthquake in January 2010, people posted texts, photos, and personal experiences via SNSs, which led to the pouring in of resources in a very short time and a cost-effective way for donations. Through mass participation, correct information was used much more prominently in the aftermath of the Great East Japan Earthquake and Tsunami of March 2011. After an extreme event or immediate attack, SNSs can help create social cohesion and promote therapeutic initiatives through the use of media by people to inform their family and friends that they are safe.

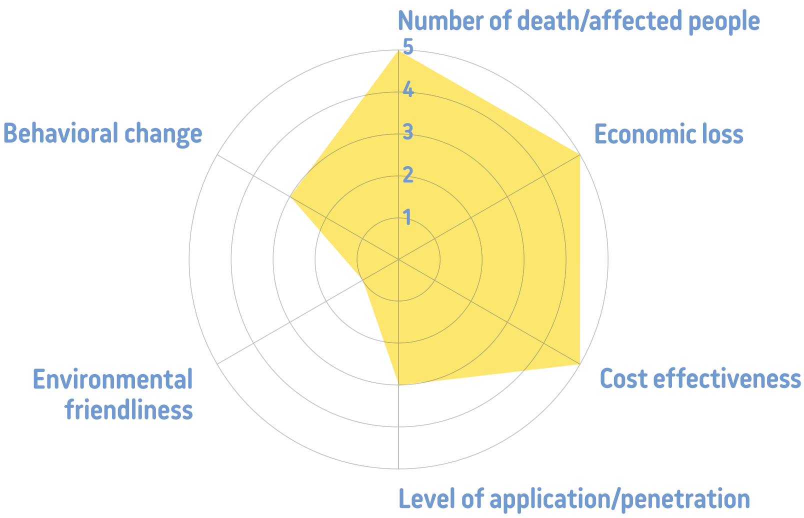
Data obtained through social media can be collected and analyzed by researchers for education and decision-making purposes. On the negative side, immediately after the 2010 earthquake in Chile, when information from government/authorities were scarce, rumors circulated about an impending earthquake and tsunami. In Indonesia and Italy, scientists had trouble with the authorities as the information they gave were used and quoted inappropriately, which lead to chaos and insecurity among people.

04

Concrete and steel: Building material and infrastructure

Concrete and steel have various advantages as the materials for the DRR structure. These materials remain strong for a long period and make it easier to maintain the structures. The materials can be used in place of wood, stone, or mud by using modern engineering with the ability to manipulate concrete and steel.

Assessment



Number of death / affected people	5	Enormous number of people are being protected from natural disasters. This cannot be achieved without concrete and steel.
Economic loss	5	Structures with these materials are protecting assets in urban areas and crucial facilities from natural disasters.
Cost effectiveness	5	Structures constructed with these materials are cost-effective as shown in various cost-benefit analyses.
Level of application / penetration	3	The materials can be used from mega- to small structures. Megastructures need managing capacity of technology and institution.
Environmental friendliness	1	Social and environment impacts by large scale infrastructure should be properly managed. Development agencies have developed safety guards for managing these impacts.
Behavioral change	3	People can live safely because of concrete and steel structures, but may lose indigenous knowledge of managing disasters. People are protected well by these structures from frequent disasters, and have less chance to suffer from disasters.

Era	Type	Stage
✓ Before 1960s	✓ Earthquake	◯ Response
◯ 1960s	✓ Flood	◯ Recovery
◯ 1970s	✓ Typhoon/ Cyclone	✓ Mitigation
◯ 1980s	✓ Tsunami	◯ Preparedness
◯ 1990s	✓ Volcano	
◯ 2000s	✓ Landslides	
◯ 2010s	✓ Others	

MLIT

How did it drastically change the existing DRR status and strategies? How is it innovative?

Concrete and steel are used widely for large structures to decrease flood and drought damage. Dams, weirs, irrigation channels, levees, and protection works can be constructed using these materials. It has become possible to construct over 300-meter height dams nowadays.

A reinforced concrete structure is common for anti-earthquake buildings as well. Without these materials, high-rise buildings cannot be constructed.

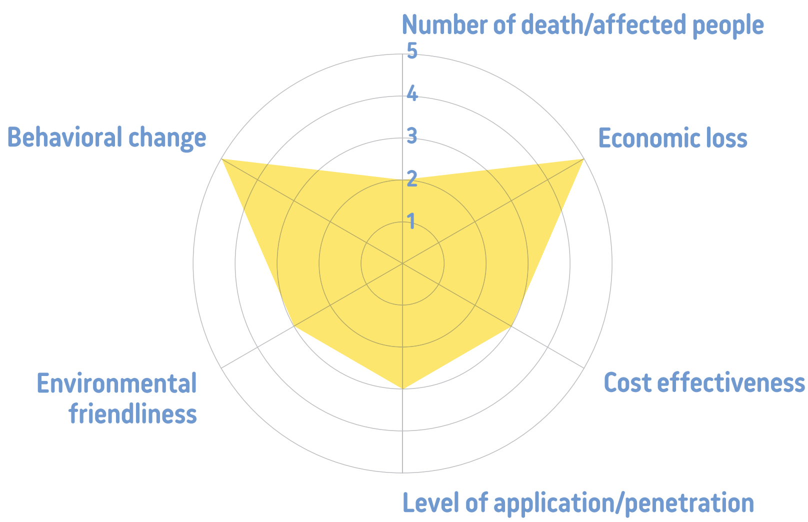
These materials are used for small structures. For example, gabion boxes, made with steel wire mesh and filled with stones, are used for preventing river erosion and landslides. Works with the gabion boxes are low-cost and easily installed without high skills at the community level.

05

Disaster risk insurance

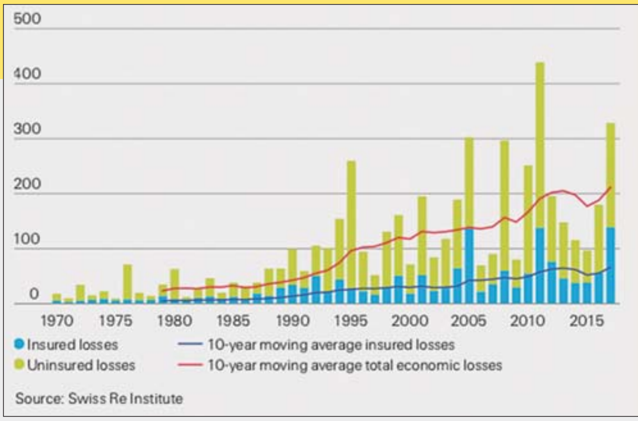
Disaster risk insurance (DRI) is increasingly recognized as a tool to deal with increasing disaster losses, strengthen resilience to external shocks, and reduce future expenditure in case of a disaster. Against a premium, DRI covers the costs incurred from extreme weather or natural disasters (e.g., earthquake, floods, and droughts). In the last 10 years, damage from disasters has reached around 1.4 Trillion USD (UNISDR, 2018). Disaster losses are measured in terms of insured and non-insured losses. The schemes cover the costs incurred from extreme weather and disasters. DRI covers hazards arising from geological, meteorological, hydrological, climatological, oceanic, biological, technological/man-made events, and increasingly complex and interlinked disasters. While insurance has been widely used in sectors like finance, trading, and health, those that cover natural disaster risks are still largely taken by private entities. In developed countries, the insurance market is dominated by private companies offering commercial products. Insurance uptake at the community level is still low. There is a choice of microfinance and insurance to alleviate poverty in developing countries. The forms of insurance policies include traditional and index-based, which are sometimes offered as bundled schemes or independently and voluntarily.

Assessment



Number of death / affected people	2	Disaster insurance covers for loss of life but not able to reduce loss of life.
Economic loss	5	Allow for accounting of losses, through comparing insured and uninsured losses.
Cost effectiveness	3	Different schemes have different effectiveness at different levels.
Level of application / penetration	3	At global and regional level and national level. Few at community and local level due to lack of awareness and affordability
Environmental friendliness	3	Linked to environmental protection (e.g. Resilient Bond). This is however at early stage.
Behavioral change	5	Greatly influence risk-informed behaviors and decision making.

Era	Type	Stage
○ Before 1960s	✓ Earthquake	○ Response
○ 1960s	✓ Flood	✓ Recovery
✓ 1970s	✓ Typhoon/ Cyclone	✓ Mitigation
○ 1980s	✓ Tsunami	○ Preparedness
○ 1990s	✓ Volcano	
○ 2000s	✓ Landslides	
○ 2010s	✓ Others	



How did it drastically change the existing DRR status and strategies? How is it innovative?

DRI forms a safety net for vulnerability in countries, groups, and communities. They allow for pooling and various innovative mechanisms to increase affordability and accessibility. Index-insurance allows for the burden of proof from the payer and a provision in changing climate. Innovations in technology and assessments of weather hazards allow for determination of options to determine the trigger for insurance payment. More innovative insurance schemes are emerging to deal with extremely costly disasters and impacts of climate change, such as Catastrophic Bonds, Resilience Bonds, and InsuResilience.

Catastrophe bonds (also known as cat bonds) such as the Caribbean Catastrophe Risk Insurance Facility (CCRIF), African Risk Capacity (ARC), and Pacific Catastrophe Risk Insurance Company (PCRIC) allow for sovereign insurance and insurance pools. CCRIF is the world's first multi-country risk pool to provide parametric insurance. International climate funds allow for increase in financial tools to support counties and communities to deal with the impacts of disasters and climate change.

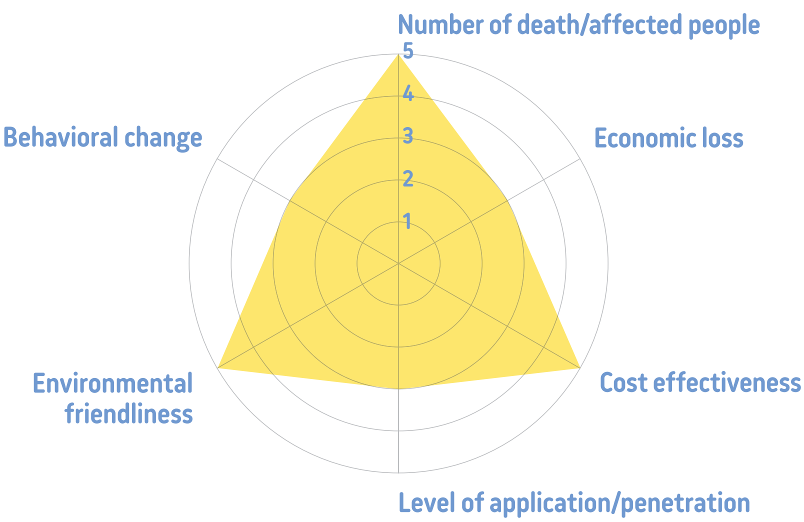
Resilience bonds are innovative since they provide a dual application of insurance with risk reduction measures, which allow for better risk knowledge and awareness. "InsuResilience" is the G7 initiative which aims to insure 400 million more people against climate risks by 2020. Weather derivatives and weather index insurance can help communities and counties to deal with abnormal or extreme weather events. At the community and individual level, micro-insurance helps small farmers, fishermen, and local laborers to deal with the impacts of flood or droughts.

06

Disaster prevention radio (Bosai musen) and the telemetry system

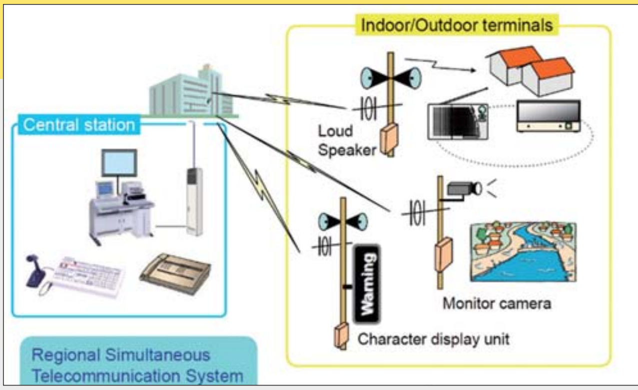
A telemetry system is used to monitor various disaster situations such as earthquakes, volcanos, floods, and environment as well as to operate DRR facilities on a real-time basis. A disaster prevention radio system in Japan, Bosai musen aims at sharing disaster information with local residents.

Assessment



Number of death / affected people	5	Telemetry and Bosai musen systems contribute to decrease the number of death and affected people by sharing disaster information with local communities.
Economic loss	3	The private sector and ordinarily people can prepare for disasters by obtaining real-time information.
Cost effectiveness	5	The cost of the system has decreased because of development ICT.
Level of application / penetration	3	A certain level of capacity and technology is required to operate the system.
Environmental friendliness	5	Social and environment impacts are minimal.
Behavioral change	3	While these systems are useful for evacuation and response. using disaster information for actions on the ground is a challenge. Risk communication with the ordinarily people is key to change people's behavior.

Era	Type	Stage
☑ Before 1960s	☑ Earthquake	☑ Response
◯ 1960s	☑ Flood	◯ Recovery
◯ 1970s	☑ Typhoon/ Cyclone	◯ Mitigation
◯ 1980s	☑ Tsunami	☑ Preparedness
◯ 1990s	☑ Volcano	
◯ 2000s	☑ Landslides	
◯ 2010s	☑ Others	



MOC

How did it drastically change the existing DRR status and strategies? How is it innovative?

The organizations concerned can collect real-time information on disasters and DRR facilities through the telemetry systems. Real-time data is essential in issuing early warning and evacuation orders. Ordinary people can also access information on the weather, rivers, and volcanos on the World Wide Web or through smartphones to prepare for disasters.

The organizations concerned can get to understand disaster situations more clearly by collecting image data and large data because of developing technology, such as optical fibers, Closed Circuit TeleVision, digitalization, and climate radars. In the 1960s, before wireless systems had been installed in Japan, observers monitored water and rain gages directly and reported the findings to the organizations concerned through telephones.

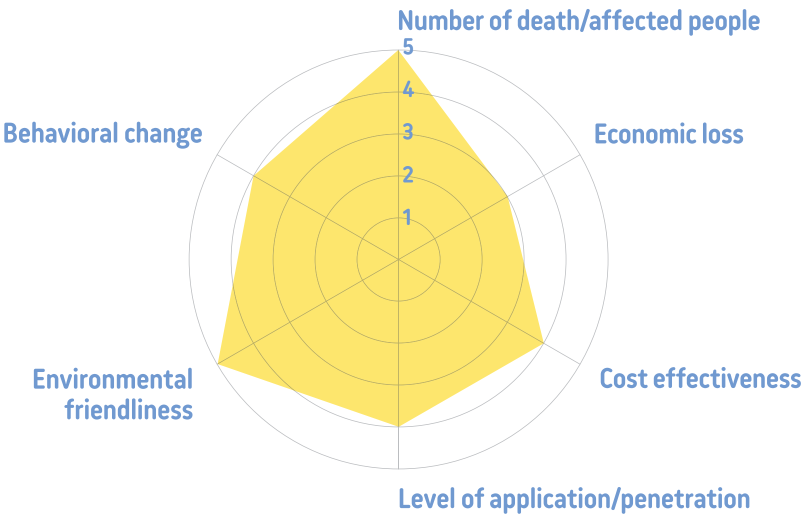
Staff can safely operate DRR facilities of pumps and gates from offices through the telemetry systems without having to stay on site. Operators can avoid facing risks of disasters from floods and tsunamis.

Local governments can issue disaster information, warnings, and evacuation orders through Bosai Musen. This system started operating in the 1950s in Japan, and consists of central stations at government offices responsible for sending information throughout towns or to individual receivers and households through loud speakers.

07 School cum cyclone shelter

School is considered as a vital infrastructure, as well as an important community facility. It is not only a place for education, but also considered as a place of community gathering, social bonding and inter generational communication. Since in most cases, local governments construct public schools, it is assumed that the schools are relatively safer building in the community, where people can take shelter in case their houses are destroyed by a disaster.

Assessment



Number of death / affected people	5	This has been very effective in reducing life losses and reduction of number of affected people
Economic loss	3	In some cases, the shelters are designed to bring the livestock, so can reduce certain economic losses
Cost effectiveness	4	The school cum shelter needs good amount of investment, but it is cost effective in terms to saving people’s lives
Level of application / penetration	4	This is quite widely used as the concept, especially in the coastal areas.
Environmental friendliness	5	No negative impact on the environment
Behavioral change	4	Effective in behavioral change, especially for early evacuation.

Era	Type	Stage
○ Before 1960s	✓ Earthquake	✓ Response
○ 1960s	✓ Flood	○ Recovery
✓ 1970s	✓ Typhoon/ Cyclone	○ Mitigation
○ 1980s	✓ Tsunami	✓ Preparedness
○ 1990s	✓ Volcano	
○ 2000s	✓ Landslides	
○ 2010s	✓ Others	

How did it drastically change the existing DRR status and strategies? How is it innovative?

The innovation presented here is a concept, which is applied to the coastal communities in developing countries. This is especially relevant in case of Bangladesh, which has been prone to severe cyclones, and in 1970s, there has been severe life and property losses in the coastal areas of the country. The coastal delta areas being relatively flat, there is no higher ground to evacuate during the coastal storm surges. Then came the concept to develop cyclone shelters in the coastal areas as 3-4 stories strong concrete buildings, where people could evacuate during the cyclone and take shelter. However, the question comes on how to maintain those buildings in the regular time.

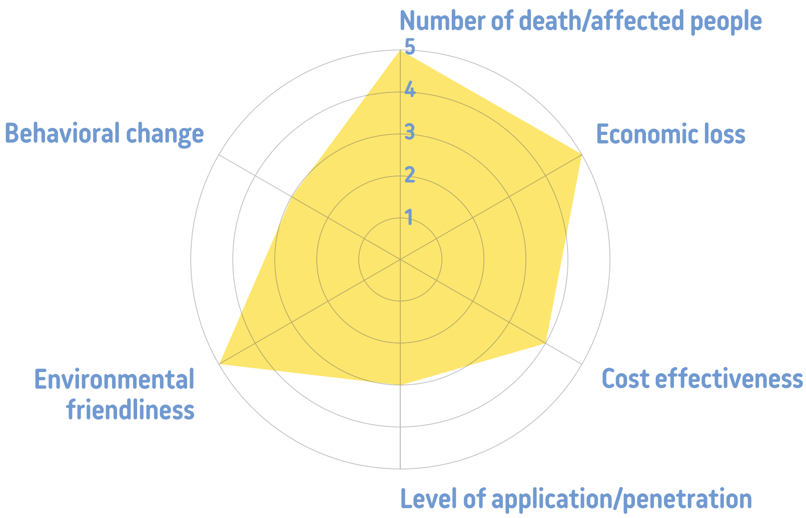
The innovative approach of using the shelters as the schools would address the education issues in the rural communities. By using them as schools would also familiarize communities as their locations and facilities, which would facilitate evacuation before the cyclone. Red Cross and Red Crescent Society applied this concept in the coastal areas of Bangladesh in mid 1970s, which has been then taken up by several donor agencies to promote widely in the country. Now-a-days, this is a popular concept in other delta areas, which are prone to coastal hazards like cyclone/ typhoon and storm surge.

08 Seismic code

Building structures resilient to ground shaking are crucial in mitigating damage from earthquakes.

Seismic codes are designed to protect human lives and property from the earthquakes.

Assessment



Number of death / affected people	5	By implementing building code, enormous number of people's lives can be saved from earthquakes.
Economic loss	5	Assets also can be protected from earthquakes.
Cost effectiveness	4	Government organizations need administration costs of introducing and implementing the building code.
Level of application / penetration	3	A certain level of capacity and technology is needed.
Environmental friendliness	5	Social and environment impacts are minimal.
Behavioral change	3	Introducing and implementing building code needs behavioral change.

Era	Type	Stage
☑ Before 1960s	☑ Earthquake	◯ Response
◯ 1960s	◯ Flood	◯ Recovery
◯ 1970s	◯ Typhoon/ Cyclone	☑ Mitigation
◯ 1980s	◯ Tsunami	◯ Preparedness
◯ 1990s	◯ Volcano	
◯ 2000s	◯ Landslides	
◯ 2010s	◯ Others	

Presidential palace at the Haiti earthquake
https://www.unmultimedia.org/s/photo/detail/424/0424989.htm

How did it drastically change the existing DRR status and strategies? How is it innovative?

The Haiti earthquake in 2010 demonstrates the importance of seismic codes. A 7.0 magnitude earthquake struck the country when an official building code failed to function. The earthquake damaged more than 180,000 homes, killing some 220,000 people. Since crucial facilities for disaster management, such as hospitals, schools, the presidential palace, and government offices, had collapsed, response activities were hindered.

Some countries have revised building codes according to the surveys of damage to buildings by major earthquakes and have strengthened societies' resilience to earthquakes. Following the Messina Straits earthquake that killed some 80,000 people in 1908, the Italian government issued the first seismic code. The code stipulates the seismic ratio (seismic acceleration divided by the gravity acceleration) at 1/12 for the first floor and 1/8 for the floors above. The government has also revised the code several times, and the current code covers the whole country.

In Japan, the Great Kanto Earthquake killed more than 100,000 people in 1923. The government introduced a seismic code in 1924, which is the first nationwide seismic code in the world. The current code aims at ensuring that human lives are not threatened by any scale of earthquakes, and specifies that buildings should withstand a lateral force equal to the building's weight. Human loss limited the minimum scale of 200 people despite the Mw 9.0 Great East Japan Earthquake in 2011.

Developing countries face difficulties in introducing and enforcing seismic codes. Government organizations, especially local governments, need to develop legal systems, permission procedures, and institutions. However, they do not have enough capacity, such as skilled experts and financial resources. Also, more public awareness activities are needed in the private sector and for house owners to apply seismic codes to buildings.

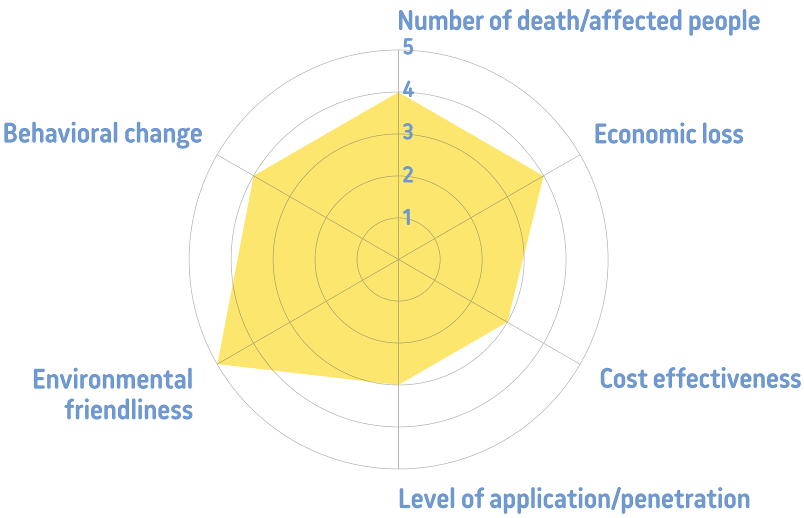
09

Seismic micro-zonation

Seismic micro-zonation is defined as the process of subdividing a potential seismic or earthquake prone area into zones with respect to some geological and geophysical characteristics of the sites such as ground shaking, liquefaction susceptibility, landslide and rock fall hazard, earthquake-related flooding, so that seismic hazards at different locations within the area can correctly be identified[1]. Micro-zonation provides the basis for site-specific risk analysis, which can assist in the mitigation of earthquake damage. In micro-zonation map, the data of buildings, infrastructures are also added. In most general terms, seismic micro-zonation is the process of estimating the response of soil layers under earthquake excitations and thus the variation of earthquake characteristics on the ground surface, and its impacts on the building and infrastructures.

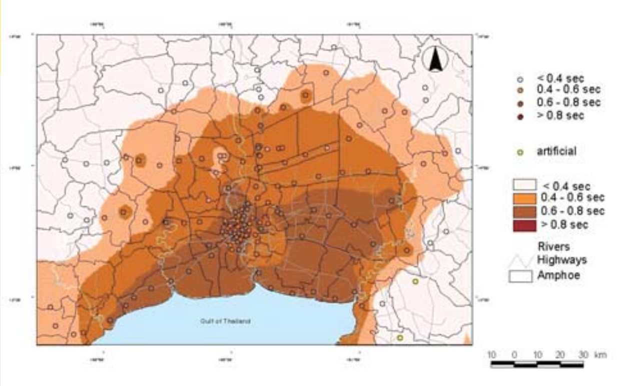
[1] https://en.wikipedia.org/wiki/Seismic_microzonation

Assessment



Number of death / affected people	4	Micro-zonation is the first tool. It does not help in reducing the number of losses, unless it is used for planning.
Economic loss	4	Similar to death / affected people, it helps only it is planned and used properly.
Cost effectiveness	3	It is rather costly process, and most of the time, obtaining data is a real challenge.
Level of application / penetration	3	Penetration is rather slow, and needs more collective efforts.
Environmental friendliness	5	No negative impact on the environment
Behavioral change	4	When properly done, it provides a good overview of the damages, and thus can be used for behavior change.

Era	Type	Stage
○ Before 1960s	✓ Earthquake	✓ Response
✓ 1960s	○ Flood	✓ Recovery
○ 1970s	○ Typhoon/ Cyclone	✓ Mitigation
○ 1980s	○ Tsunami	✓ Preparedness
○ 1990s	○ Volcano	
○ 2000s	○ Landslides	
○ 2010s	○ Others	



How did it drastically change the existing DRR status and strategies? How is it innovative?

The first attempt of seismic micro-zonation of any urban area i.e. an industrial as well as population center was carried out in city of Yokohama, Japan in 1954 considering various zones, corresponding soil conditions and design seismic coefficients for different types of structures located in that different zones. Seismic micro-zonation is the first step in earthquake risk mitigation study and requires multi-disciplinary approach with major contributions from the field of geology, seismology, geophysics, geotechnical, structural engineering and planning. This not only identifies the sub-surface condition, but when the data of buildings and other infrastructures (like road, water, electricity, gas pipelines) etc. are added, it shows the vulnerability of the buildings and/or infrastructures. Thus, it provides a very good tool for developing risk reduction plan for earthquakes.

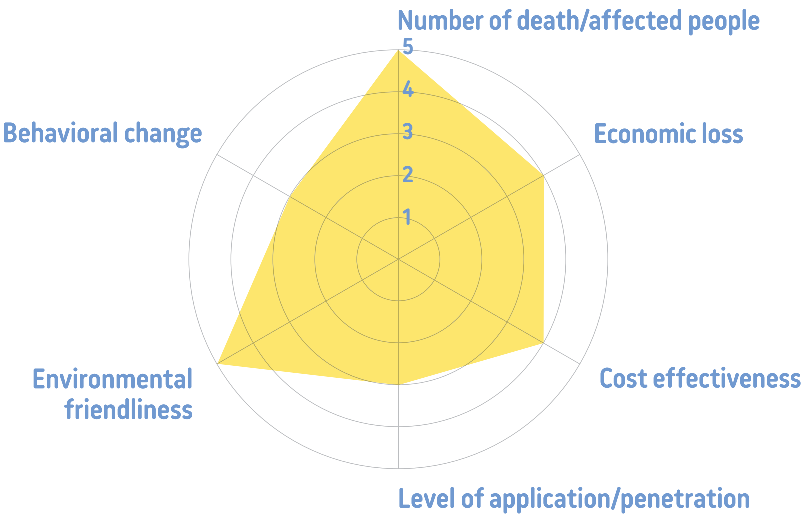
10

Earthquake early warning for high speed train

Earthquakes are difficult to predict. Usually, the challenge of the earthquake early warning system is the time between the warning is issued and the earthquake hits. The P wave of earthquake is detected earlier than the S wave, and thus, the gap between the P and S waves are used to issue the early warning. The time difference is usually very small for human beings to react, however, this is used to stop the machines and vehicles, like high speed trains, called Shinkansen, in Japan.

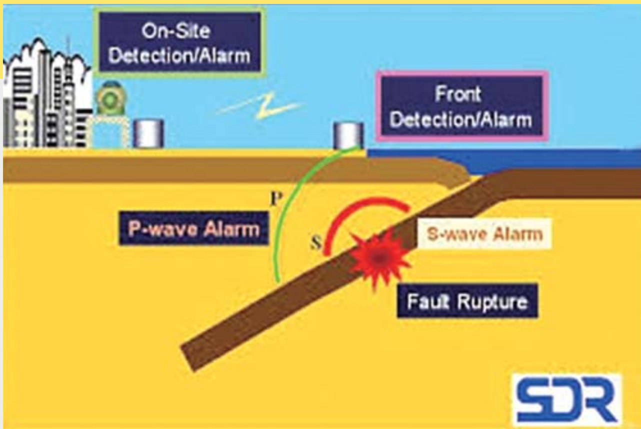
The system called Urgent Earthquake Detection and Alarm System (UrEDAS) is made up of seismometers installed at different locations. As with the Shinkansen seismometer, when they detect earthquake-induced tremors, they determine the expected effect of the earthquake and send out warning signals to cut the power supply to the trains.

Assessment



Number of death / affected people	5	Saved people's lives with no accident
Economic loss	4	Saved economic losses also
Cost effectiveness	4	Good cost effectiveness
Level of application / penetration	3	Need more penetration in different countries and regions
Environmental friendliness	5	No negative impact on the environment
Behavioral change	3	Difficult to say, but influenced to certain way by non-accident.

Era	Type	Stage
○ Before 1960s	✓ Earthquake	✓ Response
○ 1960s	○ Flood	○ Recovery
✓ 1970s	○ Typhoon/ Cyclone	○ Mitigation
○ 1980s	○ Tsunami	○ Preparedness
○ 1990s	○ Volcano	
○ 2000s	○ Landslides	
○ 2010s	○ Others	



How did it drastically change the existing DRR status and strategies? How is it innovative?

For an earthquake, the necessary qualities for early warning systems may be summarized as: 1) **Fully Automated:** As the time margin is limited, the facility should be directly controlled without human judgment, 2) **Quick and Reliable:** As there is limited time to respond to earthquake motion, this kind of system is required to be quick and reliable, 3) **Small and Cheap:** To install easily, the system must be small and cheap, 4) **Independence:** To issue fail-safe alarms, the system must be independent of other systems, 5) **Easy to Connect Network:** To deliver the earthquake information, the system must be easy to connect network, and 6) **Accuracy is Better:** For the alarm, accuracy of the information is not such a serious problem[1].

UrEDAS, is the first real-time P-wave alarm system in practical use in the world. It is able to process digitized waveforms step by step without storing the waveform data. As the amount of processing does not differ whether or not an earthquake occurs, system failure due to overload will not occur. The quakeproof systems and reinforcement works extremely effectively, could not, however, save the railways from avoiding any damage. However, it could avoid major accidents, and could save people's lives, in a high earthquake prone country like Japan, and thus considered a major innovation in disaster risk reduction.

[1] Nakamura Y., Saita J. (2007) UrEDAS, the Earthquake Warning System: Today and Tomorrow. In: Gasparini P., Manfredi G., Zschau J. (eds) Earthquake Early Warning Systems. Springer, Berlin, Heidelberg

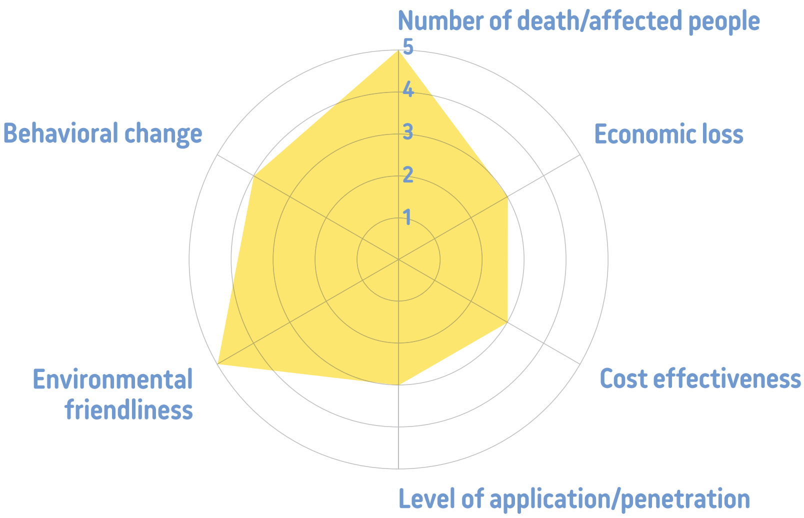
11

Doppler radar

A Doppler radar is the specialized radar that uses the Doppler effect to produce velocity data about objects at a distance. In 1960, research on the application of Doppler radar for probing the atmosphere began to have meteorological applications[1]. The Doppler effect is a frequency shift caused by radar waves bouncing off a moving object. It is similar to the way a train horn changes pitch as the train passes you. In radar, this change of "pitch" in the reflected radar signals can be interpreted by circuits in the radar receiver and used to determine the speed of a storm. This is particularly important for severe storms such as tornadoes and hurricanes. The latest Doppler radar sets locate feature of tornadoes that provide meteorologists with the information needed to issue reliable hazard warnings tens of minutes before a tornado even touches the ground.

[1] https://ethw.org/Radar_and_Weather_Forecasting

Assessment



Number of death / affected people	5	This has been very effective in reducing life losses and reduction of number of affected people, especially by providing timely early warning
Economic loss	3	It has reduced economic losses by predicting cyclones and tornado
Cost effectiveness	3	This is rather costly, and needs certain level of external funding for developing countries.
Level of application / penetration	3	Penetration of Doppler radar is yet to be seen, mainly because of its relatively high cost and maintenance.
Environmental friendliness	5	No negative impact on the environment
Behavioral change	4	Certain level of effectiveness in behavioral change, however, the key challenge remains for actual evacuation behavior.

Era	Type	Stage
◯ Before 1960s	◯ Earthquake	✓ Response
◯ 1960s	✓ Flood	◯ Recovery
✓ 1970s	✓ Typhoon/ Cyclone	◯ Mitigation
◯ 1980s	◯ Tsunami	✓ Preparedness
◯ 1990s	◯ Volcano	
◯ 2000s	◯ Landslides	
◯ 2010s	✓ Others (Tornado)	

How did it drastically change the existing DRR status and strategies? How is it innovative?

One of the crucial issues in developing country is early warning for wind related hazards, since a signify art of its population lives on the coastal areas. Back in 1970, when the cyclone Bhola hits Bangladesh, the casualty was estimated to be over 500,000. One of the key reasons is mentioned as lack of early warning. However, the classic preparedness and effectiveness of early warning was observed in 2009 during Cyclone Aila, when a similar event caused a casualty of 190 people. This is often attributed to a very timely and advanced early warning using Doppler Radar, availability of school cum shelter in coastal areas, and volunteer networks, which enhance the timely evacuation.

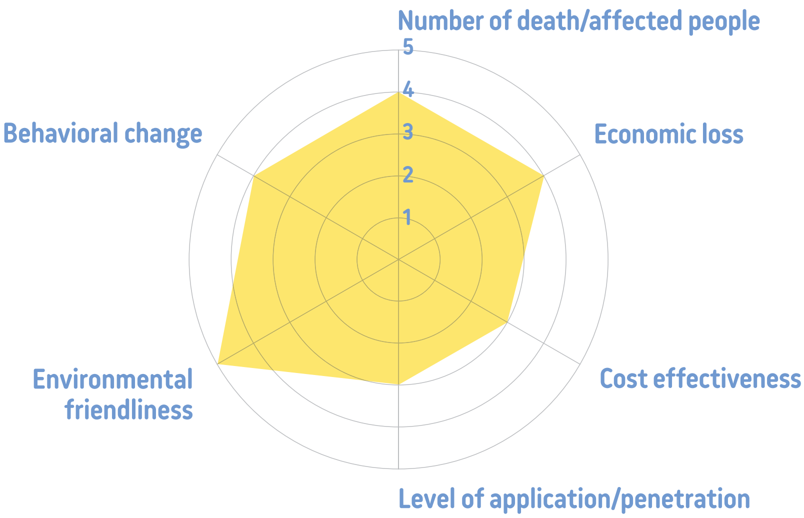
Thus, while the radar only cannot reduce the casualty, but it is the first step to provide advanced early warning system. That helps a lot in the evacuation planning and other related preparedness before the cyclone/typhoon or tornado (with a shorter lead time) hits the land.

12 Disaster resilient materials

Various materials have been developed to mitigate damages caused by disasters. Waterproof materials are used for temporal measures to protect assets from flooding, while embankments, floodgates, and other structural measures are permanent solutions.

To manage fires it is most effective to finish interior decoration of walls and ceilings of buildings with fireproof materials that are hardly ignited with ordinary fire source or do not ignite.

Assessment



Number of death / affected people	4	While these are not permanent solutions, floodwater can be controlled during flooding. Fireproof materials have contributed to decrease fire events.
Economic loss	4	Temporal barriers are effective to protect crucial facilities, such as underground shopping malls or metro stations, from flooding. The house was made of flammable materials such as straw and wood
Cost effectiveness	3	As temporal solutions, these are efficient solutions. Affordable fireproof materials have been developed.
Level of application / penetration	3	A certain level of capacity and technology is required to produce these materials.
Environmental friendliness	5	Social and environment impacts are minimal.
Behavioral change	3	Response mechanisms need to be established to respond to floods and fire.

Era	Type	Stage
✓ Before 1960s	○ Earthquake	✓ Response
○ 1960s	✓ Flood	○ Recovery
○ 1970s	○ Typhoon/ Cyclone	○ Mitigation
○ 1980s	○ Tsunami	✓ Preparedness
○ 1990s	○ Volcano	
○ 2000s	○ Landslides	
○ 2010s	✓ Others	

How did it drastically change the existing DRR status and strategies? How is it innovative?

Temporary and demountable flood protection materials can reduce flood damage by closing pathways for floodwater and restricting its spread. Various temporary defense products becomes available. Piling sandbags are widely used for temporary measures to secure additional heights of flood barriers for the long time. Water bags are used instead of sandbags to place on embankment or towns to protect flooding in urban areas where sands would be unavailable. These bags can be easily moved and installed on-site. Steel sheets can close the entrances of metros and underground malls, which are vulnerable to inundation.

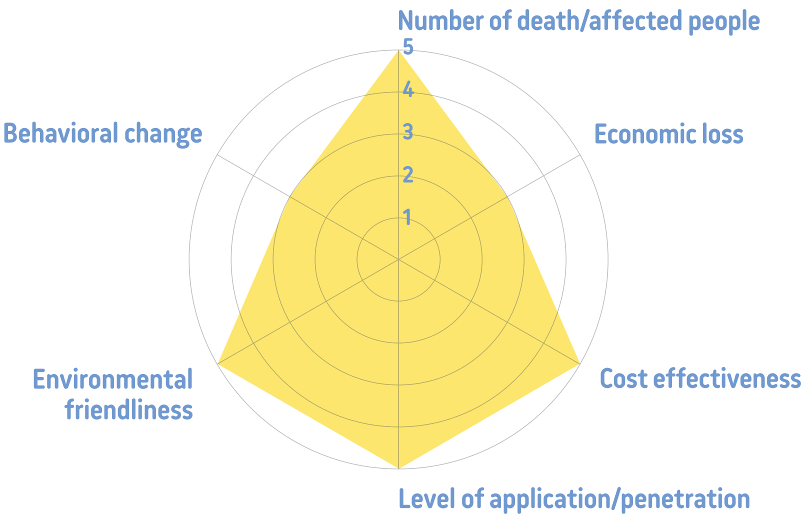
Large-scale fires have destroyed cities throughout the world. For example, Edo, the former Tokyo, where houses were made of flammable materials of straws and woods had repeatedly suffered large-scale fires from the 16th century until 19th century. These fires left several thousands or over ten thousands death. Because of development and use of fireproof materials, the number of large-scale fires decreased. Also, firefighters, electricians, and oil drillers use flame-retardant clothing made of fibers and fabrics and can conduct their duties more safely.

13

Rain water harvesting

Rain water is an essential part of human life in many sense over historic time. One of the direct relevance of rain water is rain fed agriculture, which is still a common practice in the most of the developing countries. However, rain water is increasingly becoming the source of drinking water in water scare areas, both in the aril climate as well as in the coastal zones, where the safe drinking water is becoming an increasing problem due to increasing salinity and other freshwater scarcity problems.

Assessment



Number of death / affected people	5	This has been very effective in reducing life losses and reduction of number of affected people, especially on health impacts
Economic loss	3	It has reduced losses on agriculture sector in arid areas. For coastal areas, in some cases, it has helped in vegetable garden etc.
Cost effectiveness	5	This is extremely cost effective, and use simple technique
Level of application / penetration	5	Because of it simplicity, it can have larger penetration and replication.
Environmental friendliness	5	No negative impact on the environment
Behavioral change	3	Certain level of effectiveness in behavioral change, however, the key challenge remains in the urban areas.

Era	Type	Stage
☑ Before 1960s	◯ Earthquake	☑ Response
◯ 1960s	◯ Flood	◯ Recovery
◯ 1970s	◯ Typhoon/ Cyclone	◯ Mitigation
◯ 1980s	◯ Tsunami	☑ Preparedness
◯ 1990s	◯ Volcano	
◯ 2000s	◯ Landslides	
◯ 2010s	☑ Others (Drought)	

How did it drastically change the existing DRR status and strategies? How is it innovative?

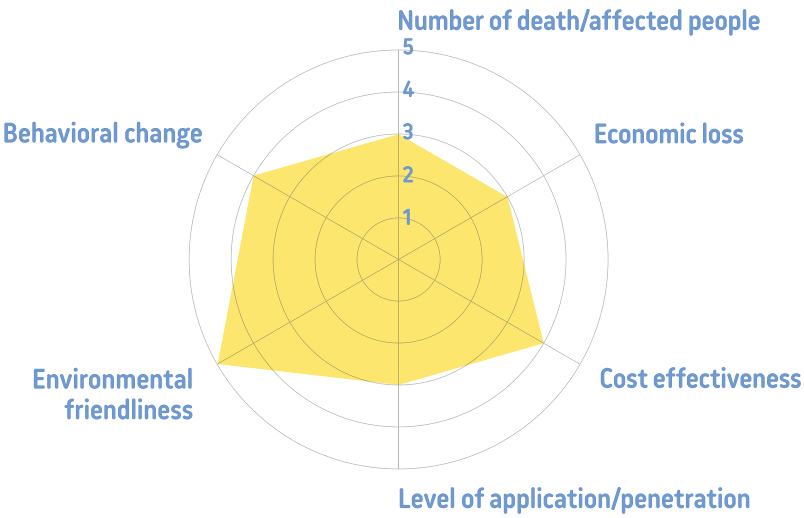
In many arid areas, rain water harvesting is practiced in household level, and becomes the key source of drinking water for the family. Modern day rain water harvesting system is based on the same old and basic principle, with some inputs from the improvements in the slope of the roof, water collection process (like use to appropriate pipes, and water retention tank). In several arid areas, rain water harvesting system has become part of the public building code, and it is part of the schools, offices and other government facilities. Rain water harvesting is also an integral component of green retrofitting of private buildings in many arid cities.

In coastal areas, rain water harvesting is found to be effective for wider community usage, and rain water from several neighboring house roofs are collected together in a larger tank to be used for the 4-5 families collectively. This has helped in solving drinking water problem in the coastal communities, where salinity, Arsenic (in underground water) are perennial problems for safe drinking water. This rainwater harvesting system is very effective to reduce water stress, and thereby decrease the water related health issues.

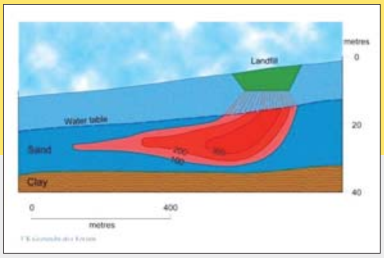
14 Electricity resistant survey

Electrical resistance survey (ERS) is one of the methods used in archaeological geophysics, as well as in engineering geological investigations. In this type of survey electrical resistance meters are used to detect and map subsurface objects or aquifer. The purpose of electrical surveys is to identify groundwater zones, their geometry, variation in salinity, and direction of water movement. In the simplest form of electrical resistivity method, a known amount of electrical current is passed into the ground through a pair of electrodes, which generates electronic signals.

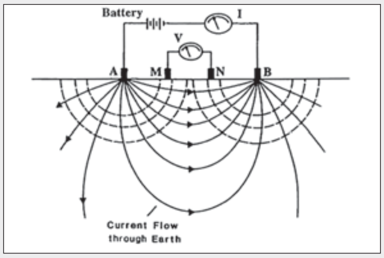
Assessment



Number of death / affected people	3	ERS has significantly contributed to determination of underground water patterns, , and have contributed to increase in availability of water sources.
Economic loss	3	ERS has potentially have reduced the cost for well digging.
Cost effectiveness	4	Being simple technology, it is relatively low cost solution.
Level of application / penetration	3	ERS has been widely used, but it is still at research stage in its application in developing countries.
Environmental friendliness	5	No negative impact on the environment
Behavioral change	4	It made behavioral changes in understanding and handling of underground water sources.



Era	Type	Stage
✓ Before 1960s	◯ Earthquake	✓ Response
◯ 1960s	◯ Flood	✓ Recovery
◯ 1970s	◯ Typhoon/ Cyclone	✓ Mitigation
◯ 1980s	◯ Tsunami	✓ Preparedness
◯ 1990s	◯ Volcano	
◯ 2000s	◯ Landslides	
◯ 2010s	✓ Others (Drought)	



https://www.nature.com/scitable/knowledge/library/identifying-groundwater-contamination-using-resistivity-surveys-at-87665012

How did it drastically change the existing DRR status and strategies? How is it innovative?

ERS allows determination of depth and location of aquifers which in many countries rely on past experiences. It is true however that the levels of aquifers change due to rainfall patterns and geographical characteristics of the area. When combined with constant monitoring of water levels of the wells in the area, as well as rainfall patterns, one can determine the area where rainfall patterns have direct consequence to water level, and where it is unlikely to influence. Particularly in drought affected area where water available is already scares, such preciseness of understanding underground water availability and characteristic, including contamination trends, play a key factor in the community's resilience.

30 innovations for DRR :

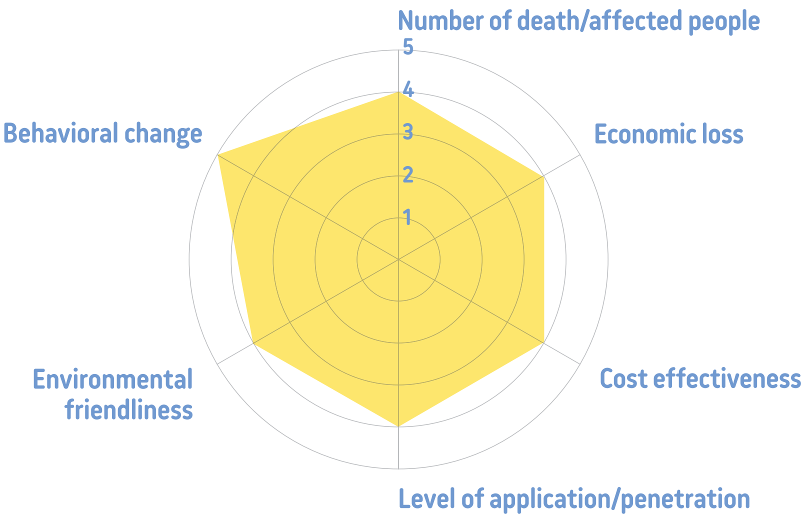
APPROACHES

01. Community-based disaster risk reduction/risk management
02. Hyogo Framework for Action (HFA)
03. Hazard mapping
04. National platforms for disaster risk reduction
05. Safe schools and hospitals
06. Assessments and index approach: Vulnerability, resilience, sustainability
07. Crowdsourcing
08. Sphere standard
09. Terminologies of resilience and vulnerability (R&V)
10. Post Disaster Needs Assessment
11. Transnational initiative on resilient cities
12. Mobile payment: A tool for accessing distribution/funds after a disaster
13. A dollar for DRR saves seven dollars in disaster response/recovery
14. Traditional practices and evacuation behaviors
15. Indigenous DRR technology
16. River engineering

01 Community-based disaster risk reduction/risk management

Disaster response, recovery, and risk reduction are considered major responsibilities of governments. However, it is now obvious that just the support and intervention of governments are not sufficient to tackle the globally increasing disaster issues. In addition, the need to address small- and medium-scale hazards that affect local people every year is getting increasingly important. Community-Based Disaster Risk Reduction (CBDRR) or Community-Based Disaster Risk Management (CBDRM) is a community- and people-centered approach which especially encourages the involvement of local stakeholders who understand the major challenges and resources at the local level.

Assessment



Number of death / affected people	4	With involvement of communities, the DRR efforts was much strengthened.
Economic loss	4	Communities could protect their assets by learning preparedness and DRR with this approach.
Cost effectiveness	4	At the initial stage, it requires technical support by international and national level for capacity development and project activities.
Level of application / penetration	4	The importance of this approach has been understood widely, however, there should be cases local communities and authorities could not receive any support for implementing the approach and activities.
Environmental friendliness	4	Negative impact on the environment should be reduced by the involvement of local people.
Behavioral change	5	It increased the participation of communities and changed mindset of especially international actors.

Era	Type	Stage
○ Before 1960s	✓ Earthquake	✓ Response
○ 1960s	✓ Flood	✓ Recovery
○ 1970s	✓ Typhoon/ Cyclone	✓ Mitigation
✓ 1980s	✓ Tsunami	✓ Preparedness
○ 1990s	✓ Volcano	
○ 2000s	✓ Landslides	
○ 2010s	✓ Others	

How did it drastically change the existing DRR status and strategies? How is it innovative?

The CBDRR or CBDRM approach is crucial because it creates a local ownership that leads to sustainability, addresses local hazards, and maximizes local resources.

1) Sustainability: Without communities understanding the DRR concept, DRR will never become a part of their culture and reduce vulnerability, which requires sustainable and long-term efforts. CBDRR/DRM emphasizes the capacity development of communities and will act as a base for the success of long-term and sustainable DRR efforts.

2) Reducing vulnerability to local hazards: Although large-scale disasters easily attract the attention of media and people, the impacts of small- and medium-scale hazards are higher at a local level because of their frequent occurrence. To respond to and prepare for these hazards, it is crucial that communities take initiatives. This is because the people are in the best position to reduce risks as they understand the local problems, vulnerability, and those who need extra support, e.g., children, elderly, and people with disabilities.

3) Local assets: Communities can be a great asset for DRR as they understand the pattern of hazards, possess knowledge from the local stories as well as from history of the place as to which assets could be or not be useful and so on. Moreover, by giving ownership to communities, the programs and projects initiated by international organizations and NGOs could also be strengthened and made sustainable.

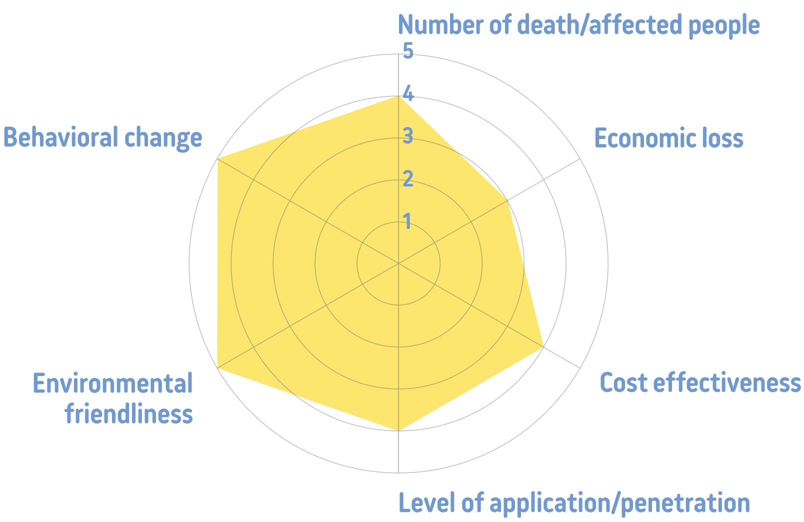
02 Hyogo Framework for Action (HFA)

The Hyogo Framework for Action (HFA) was adopted by 168 countries at the UN World Conference on Disaster Reduction held in Kobe, Japan, in January 2005. It was a 10-year plan to guide national and international efforts to reduce hazard risks and vulnerability and included five priority actions:

1) Making disaster risk reduction a policy, institutional strengthening,
2) Risk assessment and early warning systems
3) Education, information and public awareness
4) Reducing underlying risk factors
5) Preparedness for effective response

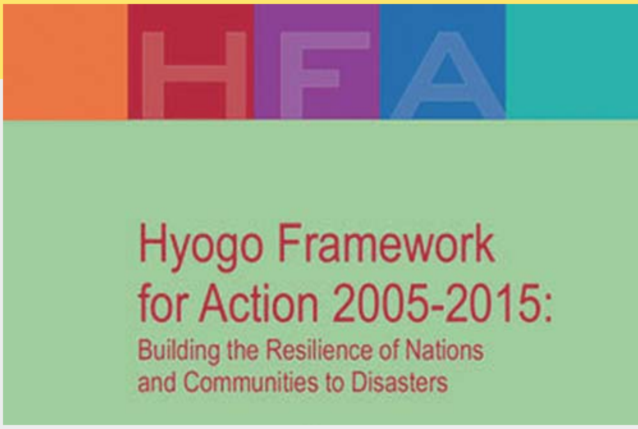
It was the first international framework to identify and address the tasks and responsibilities of various stakeholders such as governments, international and regional organizations, civil society organizations, the private sector, academia, media and communities and encouraged their active involvement and collaboration to develop and scale up DRR initiatives.

Assessment



Number of death / affected people	4	HFA led various DRR initiatives at all levels.
Economic loss	3	HFA contributed to reducing economic loss but still there is a need for working harder for reducing economic loss.
Cost effectiveness	4	The promotion of HFA required certain amount of cost but it was very effective and worth the investment.
Level of application / penetration	4	HFA had a high awareness globally, but there is some room for further awareness raising on this global strategy especially at local level.
Environmental friendliness	5	No negative impact on the environment
Behavioral change	5	It made behavioral changes drastically and systematically on governments as well as various stakeholders.

Era	Type	Stage
◯ Before 1960s	✓ Earthquake	✓ Response
◯ 1960s	✓ Flood	✓ Recovery
◯ 1970s	✓ Typhoon/ Cyclone	✓ Mitigation
◯ 1980s	✓ Tsunami	✓ Preparedness
◯ 1990s	✓ Volcano	
✓ 2000s	✓ Landslides	
◯ 2010s	✓ Others	



How did it drastically change the existing DRR status and strategies? How is it innovative?

The role of the HFA was extremely significant in the sense that it brought all the stakeholders into a common system of coordination and clearly addressed the five priority actions at all levels. In addition, it identified some issues that need to be considered while carrying out the key activities under the priority actions: the importance of the multi-hazard approach for all actions; the gender perspective; community and volunteer participation; capacity development, and technology transfer.

The HFA also emphasized a strong linkage between DRR and development and the importance of the participation of local stakeholders. Eventually, it became a driving force in taking DRR measures to contribute to the HFA implementation. Various mechanisms and instruments, such as the Global Platform for DRR, National Platforms for DRR, and the Global Assessment Report on DRR, were developed for the stakeholders to discuss the progress of and challenges in the HFA implementation and to learn from each other's experiences. Based on these platforms, new partnerships and collaborations were formed among different stakeholders. DRR was no longer a major responsibility of the national government, but was understood as something to be achieved through the active participation, support, and contribution of all the stakeholders.

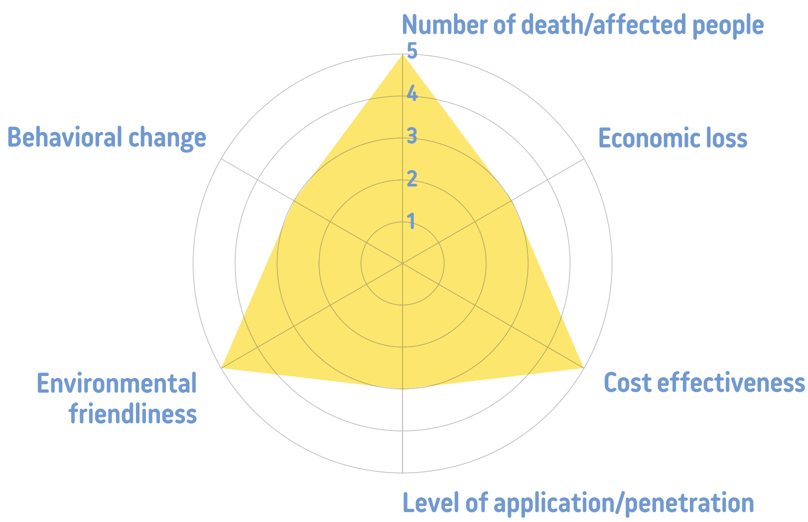
In order to ensure the progress of its implementation, the HFA Monitoring and Progress Review process was facilitated at the national, regional, and international levels to capture key trends and areas of progress and challenges at all levels with regard to achieving the strategic goals of the HFA. This process encouraged governments, in particular, to take initiatives or further steps in their own DRR strategies and contribute to the HFA implementation.

03

Hazard mapping

Hazard maps provide graphic information on the risks of disasters such as earthquakes, floods, landslides, tsunamis, and volcanic eruptions. They serve as a basis to formulate relevant policies and counter-measures of disaster risk reduction. In addition, Japanese hazard maps include other information on evacuation routes, shelters, and response resources.

Assessment



Number of death / affected people	5	Hazard maps can support to guide and facilitate prompt evacuation and save people's lives from disasters.
Economic loss	3	Information of Hazard maps are useful to properly guide urban development.
Cost effectiveness	5	Comparing structural measures, producing hazard maps need lower costs.
Level of application / penetration	3	Various methods can be used according to technological levels.
Environmental friendliness	5	Social and environment impacts are minimal.
Behavioral change	3	Hazard maps are useful tools to raise public awareness.

Era	Type	Stage
◯ Before 1960s	✓ Earthquake	◯ Response
◯ 1960s	✓ Flood	◯ Recovery
◯ 1970s	✓ Typhoon/ Cyclone	◯ Mitigation
✓ 1980s	✓ Tsunami	✓ Preparedness
◯ 1990s	✓ Volcano	
◯ 2000s	✓ Landslides	
◯ 2010s	✓ Others	

Source: MLIT

How did it drastically change the existing DRR status and strategies? How is it innovative?

Ordinary people can use information from the hazard maps for preparedness and evacuation. Also, the information is useful in formulating urban plans and land use plans to integrate disaster risk reduction in infrastructure development, to raise public awareness, and to prepare for evacuation. In Japan, the first hazard map of flooding was opened to the public in Yokohama City in the Tsurumigawa river basin in 1981.

Risk areas and intensity can be estimated by using numerical models. Precise assessment is possible, and the effects of the disaster prevention structures can be taken into account. Using numerical models requires technology and hydrological and topographical data. If numerical models are not available, historical records of inundation areas can be used. This is a simple and low-cost method. However, the construction of disaster reduction facilities and development activities cannot be reflected in hazard maps.

By involving local communities in production processes, the views of the community members as well as counter-measures of evacuation and preparedness can be reflected on the hazard maps. Risk perception gaps between local communities, governments, and experts can be bridged.

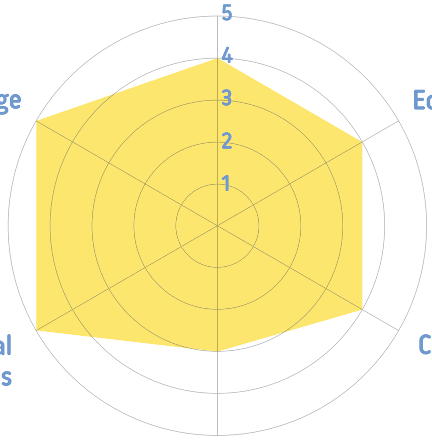
Users should be aware of the limitations and uncertainty of hazard maps. For example, hazard maps usually cover the risk areas of one or a limited number of scenarios and show unnecessary scenarios of maximum-possible hazards. Risk information produced by simulation are not perfect because of the limitation of topographical information and numerical models.

04 National platforms for disaster risk reduction

National platforms are nationally owned and led multi-stakeholder coordination mechanisms for DRR. They aim to bring relevant expertise at the country level to support effective coordination, implementation, and monitoring of DRR at the national level. They encourage the participation of representatives of all stakeholders involved, such as the government, international organizations, NGOs, academic institutions, the private sector, and the media.

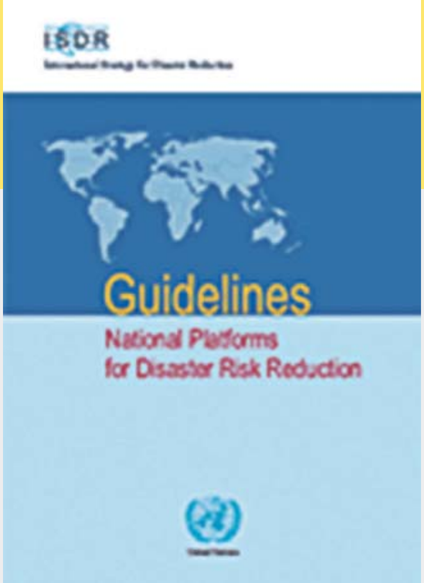
The Sendai Framework for Disaster Risk Reduction places strong emphasis on the critical role played by national platforms in supporting the implementation, monitoring, and review of the framework through effective coordinated action at the national level and appropriate linkages with the local level. It also calls for greater investments to support national platforms, which would allow them to perform their function effectively and increase their legitimacy and accountability at the national level.

Assessment



Number of death / affected people	4	NP led the development of a new partnership and initiative to reduce number of death and affected people.
Economic loss	4	NP may not have directly contributed to reducing economic loss but contributed to strengthen response capacity among various stakeholders.
Cost effectiveness	4	To have good number of participation by various stakeholders is challenging, not costly but time-consuming. It is important for government to understand its value of multi-stakeholder involvement.
Level of application / penetration	3	64 countries has so far developed this platform. It is nearly one third of the countries adopted the SFDRR. Much efforts is needed to strengthen the form of NP.
Environmental friendliness	5	No negative impact on the environment
Behavioral change	5	It increased the participation in DRR activities by the private sector, the media and academia as well as the awareness raising.

Era	Type	Stage
○ Before 1960s	✓ Earthquake	✓ Response
○ 1960s	✓ Flood	✓ Recovery
○ 1970s	✓ Typhoon/ Cyclone	✓ Mitigation
○ 1980s	✓ Tsunami	✓ Preparedness
○ 1990s	✓ Volcano	
✓ 2000s	✓ Landslides	
○ 2010s	✓ Others	



How did it drastically change the existing DRR status and strategies? How is it innovative?

The importance and need for multi-stakeholder collaboration have been highlighted on various occasions. However, it is often done on an ad-hoc basis. In addition, most of the time, collaboration is agreed upon only with major and traditional stakeholders such as, the government, internal organizations, and NGOs, which have been involved in DRR activities for many years and already have good knowledge of DRR. Thus, it is rare for a new partnership and collaboration to be established.

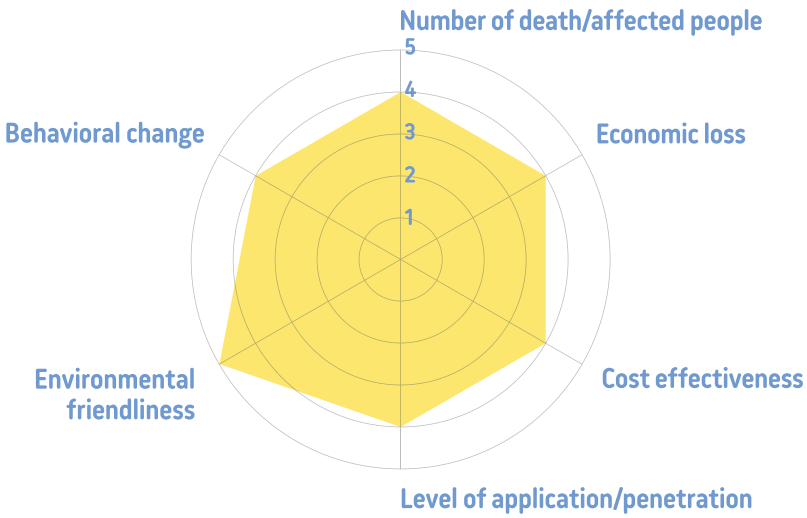
Forming a national platform allowed inviting non-traditional DRR stakeholders such as the private sector, academia, and media into the discussion on a national DRR strategy and capacity development. Eventually, a new collaboration and involvement of more stakeholders in DRR has been achieved through national platforms. Furthermore, linking science and technology with policy making is one of the crucial goals in the current DRR strategies, and it can also be facilitated through the platforms. Also, the mechanism contributed to the DRR reporting process and was seen as a means of validation through consultative, participatory and representative processes channeled by the platforms.

05 Safe schools and hospitals

As a part of the Making Cities Resilient campaign, UNISDR highlighted the urgent need to disaster-proof public services and infrastructure such as schools and hospitals is evident when earthquakes, typhoons and cyclones destroy thousands of these essential facilities globally. A global safe schools and safe health structures campaign in disaster-prone areas with voluntary commitments was announced at the Third UN World Conference for Disaster Risk Reduction in Japan in 2015.

The One Million Safe Schools and Hospitals initiative encourages people, organizations, companies and governments to pledge to make a school or hospital safe and resilient to disasters. When schools are damaged, learning opportunities are disrupted, and the quality of education drops. When hospitals and health facilities are destroyed, the treatment of the sick is hampered and saving of victims during a catastrophe becomes difficult. Consequently, this initiative is a global advocacy effort to make schools and hospitals safe from disasters

Assessment



Number of death / affected people	4	Due to retrofitting of buildings, it is considered that the number of death of students and in hospitals were reduced.
Economic loss	4	The cost for recovery could be saved with retrofitting and safe facilitates.
Cost effectiveness	4	The campaign itself does not cost, however, the implementation requires certain level of budget.
Level of application / penetration	4	At this point, it is difficult to prove the effectiveness of this campaign, however, the awareness of the impotence and link with DRR and health and education could be increased.
Environmental friendliness	5	No negative impact on the environment is considered.
Behavioral change	4	It is considered the campaign made influence on decision making in education and health sectors, however, the actual implementation is not clear yet.

Era	Type	Stage
○ Before 1960s	✓ Earthquake	✓ Response
○ 1960s	✓ Flood	✓ Recovery
○ 1970s	✓ Typhoon/ Cyclone	✓ Mitigation
○ 1980s	✓ Tsunami	✓ Preparedness
○ 1990s	✓ Volcano	
✓ 2000s	✓ Landslides	
○ 2010s	✓ Others	

How did it drastically change the existing DRR status and strategies? Why is it innovative?

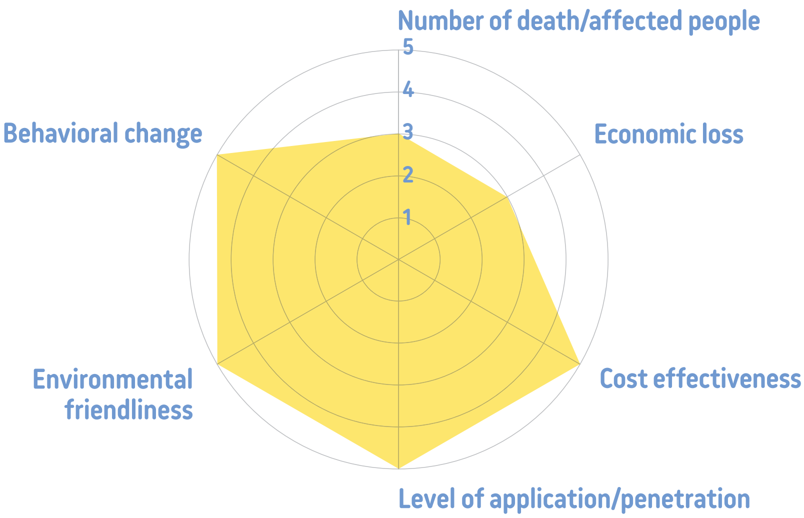
Reducing damage to schools and hospitals and their quick recovery from disaster are extremely important as these two facilities could also be used as evacuation centers. Moreover, hospitals need to treat the injured and maintain their regular operation under emergencies. However, the close link between health or education and DRR is often not adequately understood. To empathize the close connection and link between these areas is indispensable.

UNISDR, in collaboration with WHO, UNESCO, UNICEF, World Bank, ADB and other partners, initiated the campaign for the safe school and hospitals aiming to raise public awareness and create a demand for safe schools, hospitals, and other health facilities. The objectives of the initiative are to protect the lives of school children and the sick by ensuring that proper safety measures are installed, to ensure the continuity of hospital functions even after a disaster strikes, and to improve the risk reduction capacity of all school and hospital stakeholders. There are no concrete results of this campaign; however, the awareness on safe schools, hospitals, and health facilities has markedly increased.

06 Assessments and index approach: Vulnerability, resilience, sustainability

The 21st Century is the sustainability century by which the 17 Sustainable Development Goals were adopted in 2015 adopted to supersede the 8 Millennium Development Goals adopted in 2000. Goals and targets specifications is the new mode of governing sustainability. Development and humanitarian organizations have long used Vulnerability Assessment as a tool to determine how shocks and changes including from disasters affect communities. The International Federation for Red Cross/Red Crescent (IFRC) has used and developed the assessment tool over the last 10 years. Vulnerability index is often comprised of hazard, risk, vulnerability assessment together with response and risk reduction plans. Similarly, the Resilience or Sustainability indexes are other approaches to determine progress achieving sustainability. These indexes are mostly applied at city level, comparing progress worldwide. The Resilient Cities campaign by the UNISDR outlines the Ten Essentials to implement the Sendai Framework at local level. The Arcadis' Sustainable Cities Index for example has three components of People, Planet and Profit to represent the three pillars of sustainability, the environment, society and economy.

Assessment



Number of death / affected people	3	Increased preparedness at city level strongly allow for reduction in number of deaths and people affected.
Economic loss	3	Reducing disaster economic loss is one of the major component of vulnerability assessment but not directly resulted from the data
Cost effectiveness	5	Cost-effectiveness is achieved through integrated actions at city level not only in dealing with disasters, but also poverty, climate change, urbanization, etc.
Level of application / penetration	5	The concepts have been used world widely.
Environmental friendliness	5	No negative impact on the environment.
Behavioral change	5	It made behavioral changes drastically and systematically on governments as well as various stakeholders.

Era	Type	Stage
◯ Before 1960s	✓ Earthquake	✓ Response
◯ 1960s	✓ Flood	✓ Recovery
◯ 1970s	✓ Typhoon/ Cyclone	✓ Mitigation
◯ 1980s	✓ Tsunami	✓ Preparedness
✓ 1990s	✓ Volcano	
◯ 2000s	✓ Landslides	
◯ 2010s	✓ Others	

11 SUSTAINABLE CITIES AND COMMUNITIES

100 INCLUSIVE CITIES INDEX AND CHALLENGE

How did it drastically change the existing DRR status and strategies? How is it innovative?

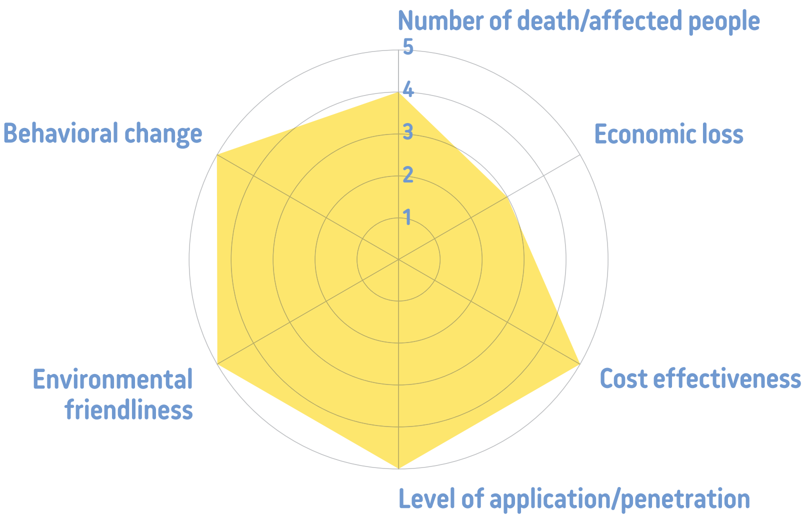
This assessment and index approach is innovative since it can be applied from global down to the local and community level. Especially at the community level, the processes of conducting the assessment allow for participation of vulnerable and minority group who would otherwise be left out. The participatory processes allow for determining people's exposure and capacity to withstand shocks from natural hazards. It is a space to discuss and agree on community-based disaster preparedness strategies. The availability of the assessments and index allow for local priorities to be decided and included in the more formal development planning processes in the village/local government. These tools also allow visualization (often through combination with GIS) which can be used for more effective communication of disaster hazard, vulnerability and risks.

The Resilience and Sustainable Cities indexes allow for comparison of cities' progress toward sustainability. The index allows for better identification of priorities for actions within cities. The processes and data requirements in measuring different components within the index allow for identification and collection of data which will be useful for planning and evaluation. Achievement of these indexes allow for cross-learning between stakeholders within cities and between cities transnationally.

07 Crowdsourcing

With wide spread mobile and smartphone users, crowdsourcing allows obtaining of real-time and local information. This technology allows pooling the public's contribution on the location of evacuees, needs of disaster affected communities, locations of contaminated water sources, identification of location-at-risk of future disasters, etc. Crowdsourcing and such citizen science and participatory mapping are gaining recognition within disaster risk reduction community.

Assessment



Number of death / affected people	4	Crowdsourcing allows disaster responders and authorities to access more real-time local information.
Economic loss	3	It allows analysis of infrastructural risks at the local level.
Cost effectiveness	5	Being voluntary contribution of data, users could access without much cost involved.
Level of application / penetration	5	Crowdsourcing has a high awareness globally, and locally.
Environmental friendliness	5	No negative impact on the environment.
Behavioral change	5	It made behavioral changes drastically and systematically within aid sector.

Era	Type	Stage
◯ Before 1960s	✓ Earthquake	✓ Response
◯ 1960s	✓ Flood	✓ Recovery
◯ 1970s	✓ Typhoon/ Cyclone	✓ Mitigation
◯ 1980s	✓ Tsunami	✓ Preparedness
◯ 1990s	✓ Volcano	
✓ 2000s	✓ Landslides	
◯ 2010s	✓ Others	

American Red Cross 2015 :
https://www.preparecenter.org/sites/default/files/case_study_community_mapping_aug6.pdf

How did it drastically change the existing DRR status and strategies? How is it innovative?

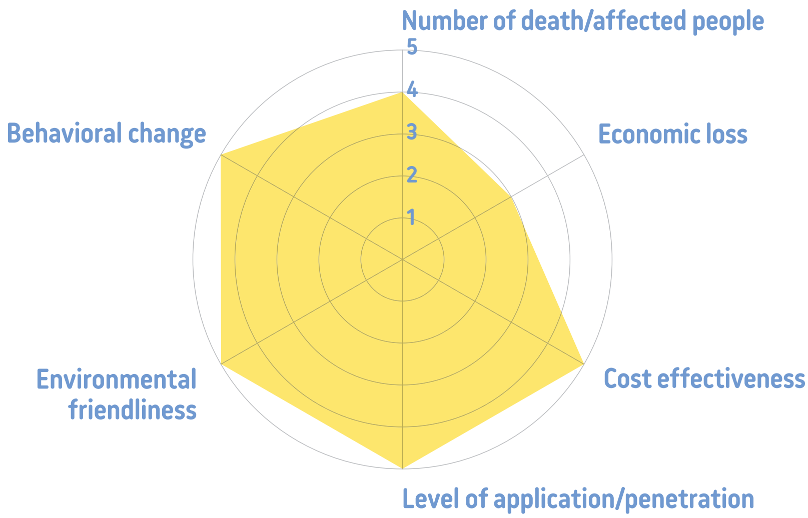
The biggest benefit of crowdsourcing is that one can obtain information from wider public, which opens the door to vast amount of real-time and local information. Analyzing disaster risk information from macro-level data limits the analysis of the impact at the local level. When the crowdsourcing of local data is integrated into risk reduction analysis and plans, it can prompt further local actions based on local risks. Another important impact of crowdsourcing in risk assessment is that the process itself becomes a way in which participating communities learn about their risks; thus an avenue of disaster risk communication.

08 Sphere standard

The Sphere Standard was established in 1997, and it became the most widely known and recognized set of common principles and universal minimum standards for humanitarian assistance, enabling humanitarian actors to ensure quality and accountability in their work.

The Handbook collects evidence-based universal minimum standards in four life-saving sectors: water supply, sanitation and hygiene promotion; food security and nutrition; shelter, settlement and non-food items; and health action. Based on moral and legal principles spelled out in the Humanitarian Charter, it also defines Protection Principles and Core Standards which inform any humanitarian response in a spirit of quality and accountability to the affected populations. (http://www.sphereproject.org/about/)

Assessment



Number of death / affected people	4	Sphere led more timely and effective response, which significantly reduced the number of secondary deaths and affected people.
Economic loss	3	Sphere's motive is always on saving lives, but companion standard 'Minimum Economic Recovery Standards' was adopted.
Cost effectiveness	5	Being voluntary commitments, users could access without much cost involved.
Level of application / penetration	5	Sphere had a high awareness globally, and locally.
Environmental friendliness	5	No negative impact on the environment.
Behavioral change	5	It made behavioral changes drastically and systematically within aid sector.

Era	Type	Stage
◯ Before 1960s	✓ Earthquake	✓ Response
◯ 1960s	✓ Flood	✓ Recovery
◯ 1970s	✓ Typhoon/ Cyclone	✓ Mitigation
◯ 1980s	✓ Tsunami	✓ Preparedness
✓ 1990s	✓ Volcano	
◯ 2000s	✓ Landslides	
◯ 2010s	✓ Others	

How did it drastically change the existing DRR status and strategies? How is it innovative?

It was the initiative that set the principle that 'doing good is not enough', and the aid sector had to put more efforts in professionalizing the sector; big lesson learnt from bitter experience at Rwanda refugee crisis in 1990's. Sphere's unique characteristic as 'voluntary commitments' allowed relatively easy access to those who were willing to professionalize their response, and as a result Sphere is used in almost 150 countries around the world. The handbook is also translated into 29 languages.

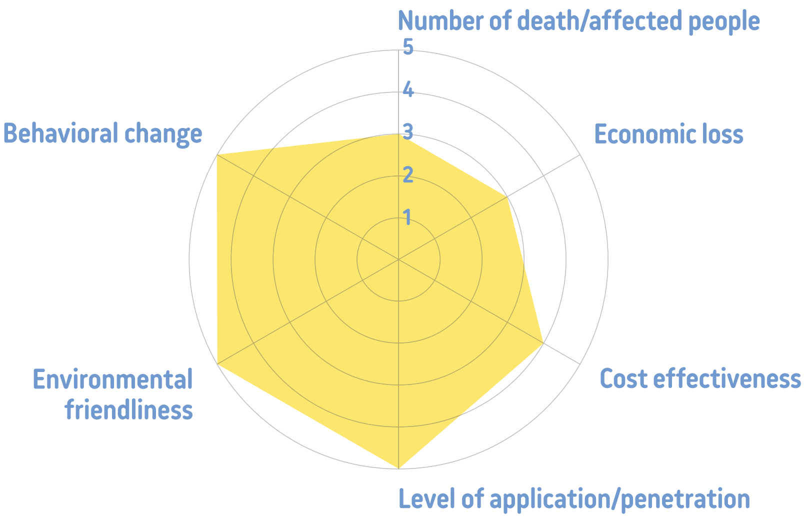
Sphere handbook is revised periodically, and the most recent version is Sphere 2018. The organization has recently restricted and the new website is http://www.spherestandards.org/.

09

Terminologies of resilience and vulnerability (R&V)

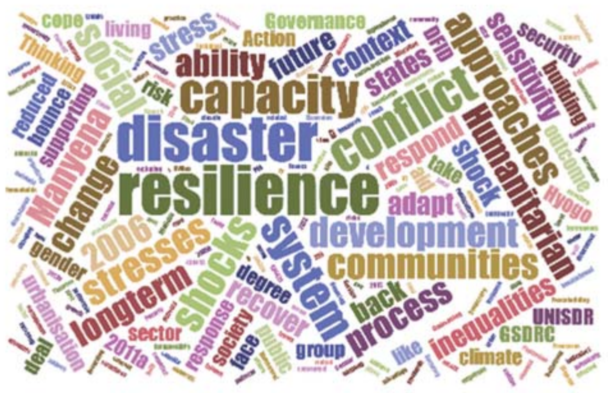
The terms "resilience" and "vulnerability" have been used in disaster research and practices. Resilience, as a scientific concept, has been used in biology, ecology, economy, engineering, and social-ecological system analysis. The two concepts have gained worldwide recognition in the disaster field when they were used as key concepts to understand disasters and DRR, especially in the HFA 2005-2015 and the SFDRR 2015-2030. The UNISDR defines resilience as "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 through the preservation and restoration of its essential basic structures and functions through risk management", and vulnerability as "The conditions determined by physical, social, economic and environmental factors or processes which increase the susceptibility of an individual, a community, assets or systems to the impacts of hazards."

Assessment



Number of death / affected people	3	Greater understanding on R&V will help to reduce dumber of deaths / affected people.
Economic loss	3	Greater understanding on R&V will help to reduce dumber of deaths / affected people.
Cost effectiveness	4	Understanding R&V will allow better targeting of vulnerability groups which in turn help to research cost-effectiveness.
Level of application / penetration	5	The concepts have been used world widely.
Environmental friendliness	5	No negative impact on the environment
Behavioral change	5	It made behavioral changes drastically and systematically on governments as well as various stakeholders.

Era	Type	Stage
◯ Before 1960s	✓ Earthquake	✓ Response
◯ 1960s	✓ Flood	✓ Recovery
◯ 1970s	✓ Typhoon/ Cyclone	✓ Mitigation
◯ 1980s	✓ Tsunami	✓ Preparedness
◯ 1990s	✓ Volcano	
✓ 2000s	✓ Landslides	
◯ 2010s	✓ Others	



How did it drastically change the existing DRR status and strategies? How is it innovative?

Within the scientific community, the concept of vulnerability has been subjected to many debates, studies, discussions, and eventually turned into a proposal for resilience and vulnerability frameworks. Both terms offer a broader and more integrated view of how nations and communities are vulnerable and how their resilience can be enhanced. This enables an integrated and comprehensive understanding of the dynamics and root causes of disasters.

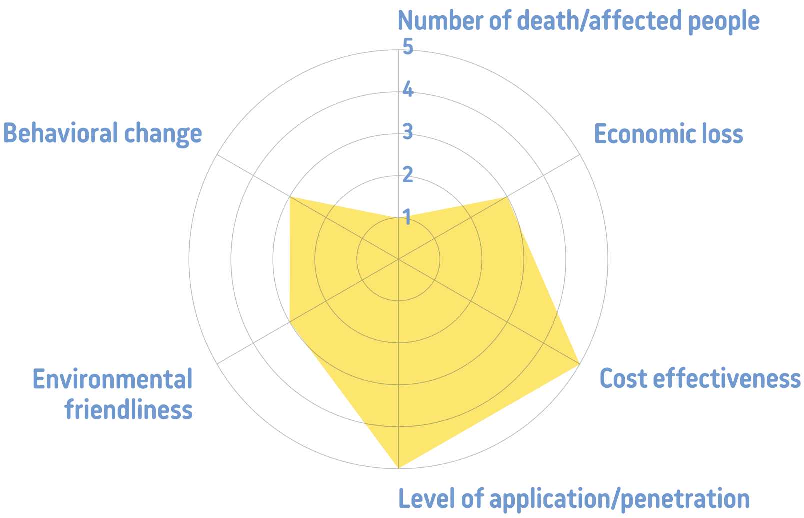
In practice, development and humanitarian organizations proposed and utilized develop Resilience and Vulnerability (R&V) Assessment Frameworks as tools for integrated understanding and engagement with communities. With the help of a participatory-based method, these frameworks help in better understanding how inequality influences vulnerability.

At the higher level, formal discussions between stakeholders are conducted through mapping and assessment exercises. Development and humanitarian organizations are developing and using various Disaster R&V frameworks. Resilient initiatives such as Resilient Nations, Resilient Cities, and Resilient Communities programs are being implemented everywhere. Funding for resilience initiatives, such as the 100RC program, is obtained from financial tools like Resilience Bonds and Resilient Infrastructure.

10 Post Disaster Needs Assessment

The Post-Disaster Needs Assessment (PDNA) is a methodology for estimating the physical damages, economic losses, and recovery costs following natural disasters. According to PDNA, government, international organizations, and assistant agencies can formulate recovery and rehabilitation frameworks and plans, identify appropriate projects, and arrange financing.

Assessment



Number of death / affected people	1	PDNA is a post-disaster process, and cannot directly contribute to mitigate damage.
Economic loss	3	While PDNA does not decrease economic losses as preparedness measure, the assessment contribute to effective economic recovery.
Cost effectiveness	5	PDNA is an efficient process.
Level of application / penetration	5	Developing countries with limited capacity can be supported by international organizations and assistance agencies.
Environmental friendliness	3	Social and environment impacts are considered for rehabilitation projects to some extent.
Behavioral change	3	PDNA supports quality recovery.

Era	Type	Stage
◯ Before 1960s	✓ Earthquake	◯ Response
◯ 1960s	✓ Flood	✓ Recovery
✓ 1970s	✓ Typhoon/ Cyclone	◯ Mitigation
◯ 1980s	✓ Tsunami	◯ Preparedness
◯ 1990s	✓ Volcano	
◯ 2000s	✓ Landslides	
◯ 2010s	✓ Others	

MLIT

How did it drastically change the existing DRR status and strategies? How is it innovative?

The United Nations Economic Commission for Latin America and the Caribbean developed the methodology for damage and loss assessment of disasters in 1972. Based on this methodology, PDNA was developed.

Duplication of needs assessment efforts by various organizations can be avoided by participating in the PDNA process. If various organizations conduct assessment separately, limited resources, such as local staff and transportation, would be wasted under severe conditions following disasters.

The PDNA process initiates coordination of recovery efforts. Various stakeholders, such as assistance agencies, international organizations, and civil society organizations, can share the common information using PDNA.

Ideally, the affected country governments are expected to lead the process. Assistance agencies support the process if necessary. Training and assessment are conducted to build the capacity of experts at normal times.

The experts in various sectors conduct field surveys and develop sector-wide damage and loss assessments. The following sectors are covered:

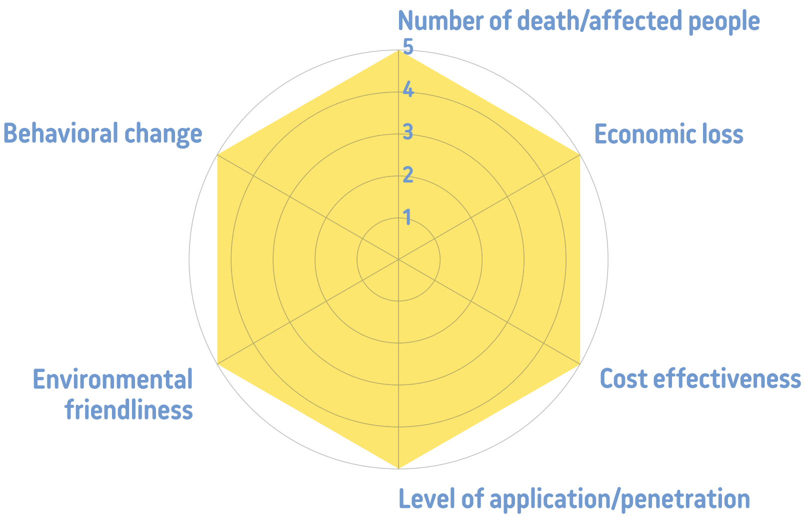
al: housing, education, health, and culture;

- Social: housing, education, health, and culture;
- Infrastructure: water and sanitation, community infrastructure,
- Energy and electricity, transport, and telecommunications;
- Productive: agriculture, livestock and fisheries, commerce and industry, and tourism;
- Macro-economy: GDP, fiscal deficit and balance of trade;
- Finance: banks and non-banking financial institutions;
- Cross-cutting themes: governance, disaster risk reduction, employment and livelihoods, environment, and gender;
- Human development: poverty and human development.

11 Transnational initiative on resilient cities

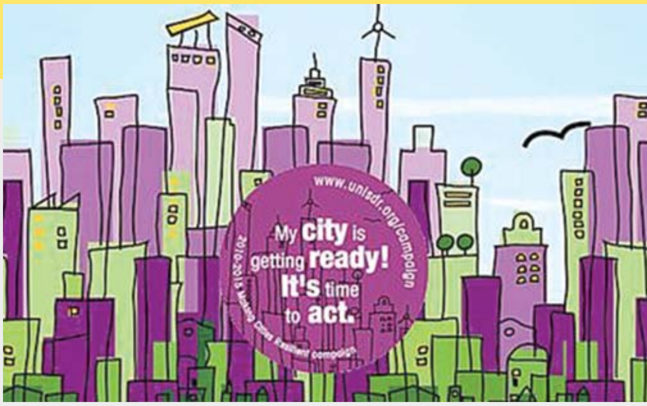
The Hyogo Framework for Action (HFA) aims to make nations and communities resilient to disasters. One of the key campaigns in implementing the HFA is the Resilient Cities Program. The "Making Cities Resilient" campaign addresses issues of local governance and urban risks while drawing upon previous UNISDR campaigns on safer schools and hospitals as well as on the sustainable urbanization principles developed in the UN-Habitat World Urban Campaign 2009-2013. Several international agencies are also implementing similar programs. One of the most notable is the 100 Resilient Cities (100 RC) program by the Rockefeller Foundation.

Assessment



Number of death / affected people	5	Increased preparedness at city level strongly allow for reduction in number of deaths and people affected.
Economic loss	5	Reducing disaster economic loss is one of the major aim of building resilient cities.
Cost effectiveness	5	Cost-effectiveness is achieved through integrated actions at city level not only in dealing with disasters, but also poverty, climate change, urbanization, etc.
Level of application / penetration	5	The concepts have been used world widely.
Environmental friendliness	5	No negative impact on the environment.
Behavioral change	5	It made behavioral changes drastically and systematically on governments as well as various stakeholders.

Era	Type	Stage
○ Before 1960s	✓ Earthquake	✓ Response
○ 1960s	✓ Flood	✓ Recovery
○ 1970s	✓ Typhoon/ Cyclone	✓ Mitigation
○ 1980s	✓ Tsunami	✓ Preparedness
○ 1990s	✓ Volcano	
○ 2000s	✓ Landslides	
✓ 2010s	✓ Others	



How did it drastically change the existing DRR status and strategies? How is it innovative?

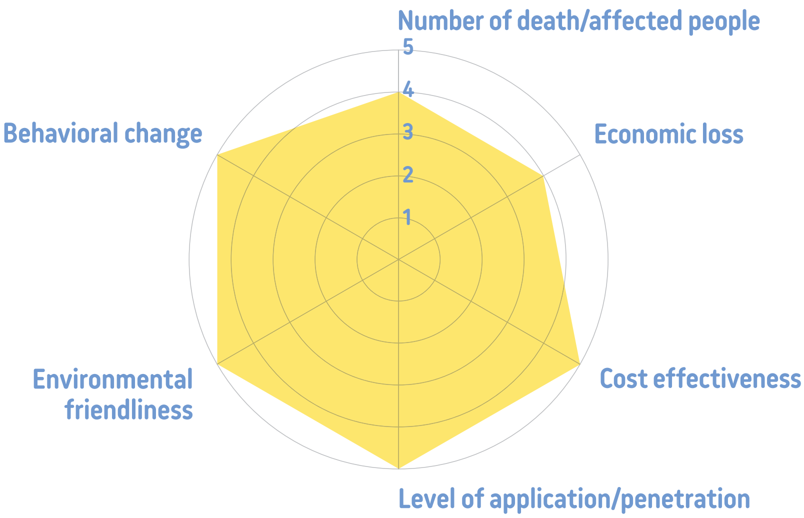
The concept of resilient cities is innovative in many ways. It calls for strengthening the roles of cities in urban DRR. The cities that participated in this campaign can share experiences and learn among them. It facilitates and strengthens the policy relevance and advocacy of cities in international advocacy. Cities are recognized as key stakeholders in the related meeting of the UNISDR, UN-Habitat, and UNFCCC. Through targeting issues at the city level, integrated actions can be taken, and win-win solutions are generated to deal with urban disasters, addressing urban poverty, urban climate issues on mitigation and adaptation. Sometimes, cities take actions when the national government refuses to act, as is the case in the US. Mayor Bloomberg of New York is appointed as a special envoy for cities and climate change.

12

Mobile payment: A tool for accessing distribution/ funds after a disaster

Mobile payment, known with services such as Mpay or M-PESA, is a form of payment through mobile networks which enabled access to financial services even for people who didn't have access to official banking. It is estimated that 2 billion people around the world are 'unbanked', whereas the number of 'unbanked' people possessing mobile phones are increasing. The payment can be made for utilities, services, goods, etc. and it enabled millions of 'unbanked' people to access financial tools. It helps affected people to access cash distribution after a disaster and make transactions locally without going to nearby city center.

Assessment



Number of death / affected people	4	Mobile payment allows provision of financial services to unbanked population, which allows early recovery investment.
Economic loss	4	Mobile payment allows faster and small-scale transfer to be made for local businesses and individuals.
Cost effectiveness	5	Users can access the services with minimal cost/investment.
Level of application / penetration	5	It has become worldwide phenomenon.
Environmental friendliness	5	No negative impact on the environment.
Behavioral change	5	It made cash-transfer safer and more mainstreamed within aid sector.

Era	Type	Stage
◯ Before 1960s	✓ Earthquake	✓ Response
◯ 1960s	✓ Flood	✓ Recovery
◯ 1970s	✓ Typhoon/ Cyclone	◯ Mitigation
◯ 1980s	✓ Tsunami	◯ Preparedness
◯ 1990s	✓ Volcano	
✓ 2000s	✓ Landslides	
◯ 2010s	✓ Others	

How did it drastically change the existing DRR status and strategies? How is it innovative?

Mobile payment tools have drastically changed how people access goods and services through repayments done with mobile phones. For instance, it has diversified access to energy sources (e.g. solar energy pay as you go model). It enabled those without a credit to receive loans the options of accessing financial tools to re-build their livelihood after disasters. Furthermore, in the aftermath of disaster where it is difficult to obtain cash, mobile payment allows access to monetary credits necessary to buy the daily necessities for survival. It also allows payment to employees even when bank system is not functioning due to the damage in infrastructure. By integrating mobile payment into disaster preparedness plan, it can ensure a real time access to monetary credits by disaster affected communities at all phases of disaster management.

13

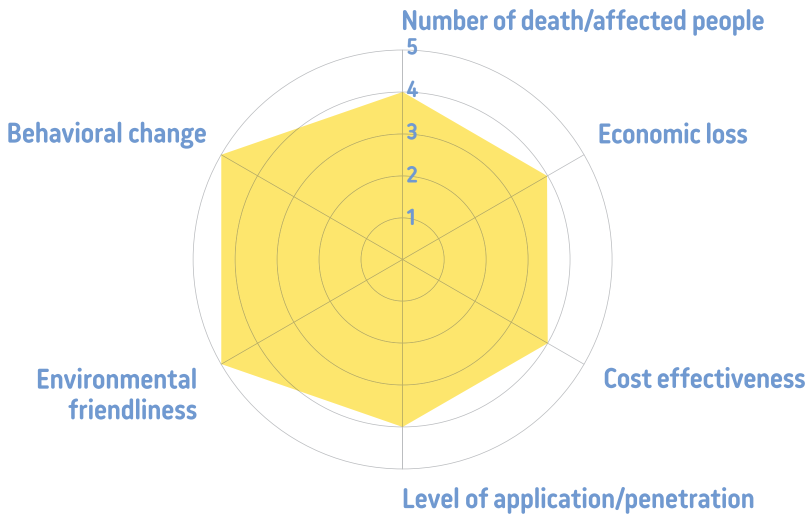
A dollar for DRR saves seven dollars in disaster response/recovery

The quote "DRR saves $7 for every $1 invested" has been used very widely to prove the effectiveness of DRR and to shift the focus from disaster response to DRR and preparedness. This statement was impactful as it increased people's understanding of DRR and showed the evidence of its effectiveness with the numbers.

However, recently, there has been a discussion about whether the quote considers all the elements of DRR cost-effectiveness as most of the DRR measures follow non-structural approaches such as education, policy, and planning. In addition, the citation that led to the figure in the quote are not verifiable, and the calculations or methods used are not clear[i]. Currently, various studies have been conducted to prove DRR cost-effectiveness not only based on this simple figure but also in multiple other ways.

[i] Kelman, I (2014) Background note: Disaster Mitigation is Cost Effective (http://siteresources.worldbank.org/EXTNWDR2013/Resources/8258024-1352909193861/8936935-1356011448215/8986901-1380568255405/WDR14_bp_Disaster_Mitigation_is_Cost_Effective_Kelman.pdf)

Assessment



Number of death / affected people	4	It increased the understanding of DRR importance and increased the investment in DRR.
Economic loss	4	Increased DRR projects and investment reduced damage and impact.
Cost effectiveness	4	No cost is required to disseminate the message.
Level of application / penetration	4	The message was widely disseminated however how much it was implemented is another question.
Environmental friendliness	5	No negative impact on the environment.
Behavioral change	5	The understanding towards DRR and preparedness could be changed.

Era	Type	Stage
○ Before 1960s	☑ Earthquake	○ Response
○ 1960s	☑ Flood	○ Recovery
○ 1970s	☑ Typhoon/ Cyclone	☑ Mitigation
○ 1980s	☑ Tsunami	☑ Preparedness
☑ 1990s	☑ Volcano	
○ 2000s	☑ Landslides	
○ 2010s	☑ Others	

How did it drastically change the existing DRR status and strategies? How is it innovative?

It may not be only because of this figure, but the quote helped people to start paying attention to DRR or to invest in effective disaster preparedness. For instance, some countries such as Indonesia and Philippines have invested heavily, and continue to do so, in reducing risk levels, often allocating much higher volumes for this than for international financing[ii]. These countries are extremely disaster-prone; therefore, the need for DRR can also be understood based on their past experiences.

It is important that the countries/organizations that have not been heavily affected by disasters in the past also understand the importance and cost-effectiveness of DRR. For this purpose, further research is needed. Moreover, the findings and results would have to be delivered in such a way that they are easily understandable and convincing for the policy and decision makers.

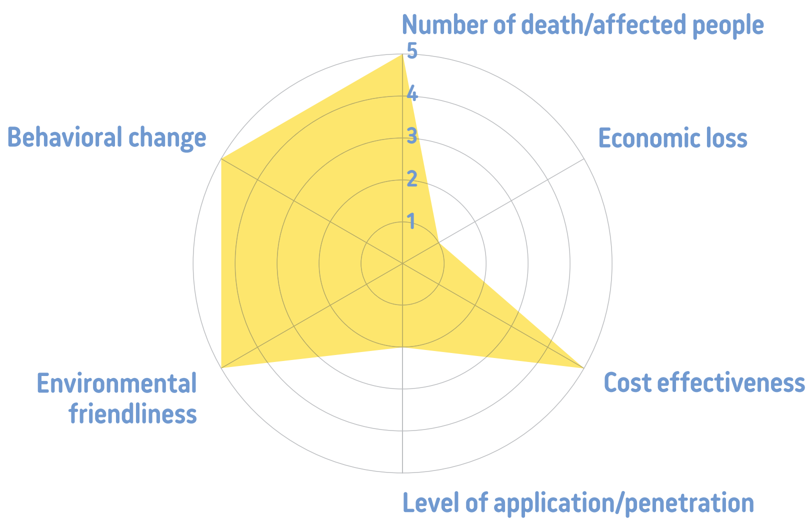
[ii] Kellett, J and Caravani, A (2013) Financing Disaster Risk Reduction: A 20-year story of international aid

14

Traditional practices and evacuation behaviors (SMONG from Simeuleu Island, Indonesia, and Tendengko from Tohoku, Japan)

The 2004 Indian Ocean Tsunami (IOT) and the 2011 Great East Japan Earthquake (GEJE) and tsunami are the two deadliest and most destructive tsunami-related disasters ever recorded in modern history. The IOT epicenter was off Sumatra, Indonesia, while the GEJE epicenter was near Tohoku, Japan. While Indonesia was affected the most, deaths and destruction occurred mostly in the mainland of Sumatra. One place that stood out with only seven deaths was the Simeulue Island. The oral history and indigenous knowledge (IK) of Smong (translates to tsunami or tidal waves) that was passed through generations saved the islanders. Stories recounting the 1907 tsunami were passed on from generation to generation, which influenced the community to run up to the hills after a very strong shake. Along the Tohoku/Sanriku coasts, the term "Tsunami Tendenko" has been handed down through generations and it is known only locally. It calls for people to escape separately when a tsunami is anticipated and to run uphill as quickly as possible even if they must leave their parents or children. The priority is to save oneself, which is a foreign concept to the family-oriented/communal Japanese.

Assessment



Number of death / affected people	5	*Smong and Tendenko* has helped to reduce number of deaths from the earthquake and tsunami dramatically
Economic loss	1	*Smong and Tendenko* has not able to reduce number of economic loss since the community suffered very bad damage
Cost effectiveness	5	The story was passed through generations on how to detect and survive from tsunami
Level of application / penetration	2	Within the closed-knitted community, the concept has been successfully introduced, but not to those outside. Though, there is increasing scientific recognition and media reporting on the concepts.
Environmental friendliness	5	No negative impact on the environment
Behavioral change	5	It made behavioral changes drastically and systematically on governments as well as various stakeholders.

Era	Type	Stage
✓ Before 1960s	✓ Earthquake	○ Response
○ 1960s	○ Flood	○ Recovery
○ 1970s	○ Typhoon/ Cyclone	○ Mitigation
○ 1980s	✓ Tsunami	✓ Preparedness
○ 1990s	○ Volcano	
○ 2000s	○ Landslides	
○ 2010s	○ Others	

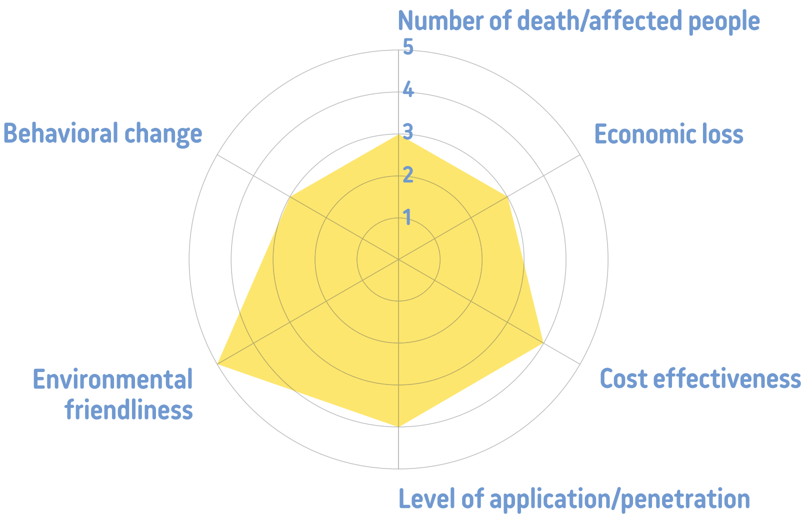
How did it drastically change the existing DRR status and strategies? How is it innovative?

The two concepts of Smong or Tendenko are innovative since they originate from local wisdom, knowledge, and practices of the Indonesian and Japanese communities. The concepts show that tsunamis have been occurring in the past and the communities, over time, have accumulated relevant knowledge and wisdom and passed them on to their next generations. The concept of Smong allows the community to quickly identify the signs of a strong earthquake and possible tsunami and take the early action of running away from the coast to higher ground. The Tendenko goes against the Japanese strong community cohesiveness and calls for an exception since it is an emergency. Moreover, both concepts are known only locally with very little (before the events) introduction to the larger communities, such as the scientific and policy communities.

15 Indigenous DRR technology

Every country has fought against disasters throughout its history and developed indigenous technologies for flood prevention and water resource management. They used local materials of stone and wood for the structures. Some structures are still functioning throughout the world.

Assessment



Number of death / affected people	3	Measures using indigenous technology is effective, but cannot be used at large scale.
Economic loss	3	These measures are local solutions and cannot be used at large scale.
Cost effectiveness	4	These are low-cost measures.
Level of application / penetration	4	Practices and technology are needed to be shared.
Environmental friendliness	5	These are eco-friendly measures.
Behavioral change	3	Community efforts are required to implement these measures.

Era	Type	Stage
☑ Before 1960s	☐ Earthquake	☐ Response
☐ 1960s	☑ Flood	☐ Recovery
☐ 1970s	☐ Typhoon/ Cyclone	☑ Mitigation
☐ 1980s	☐ Tsunami	☐ Preparedness
☐ 1990s	☐ Volcano	
☐ 2000s	☐ Landslides	
☐ 2010s	☑ Others	

Soda mattress in Lao PDR Source: MLIT

How did it drastically change the existing DRR status and strategies? How is it innovative?

Dujiangyan was constructed to protect the Chengdu Plain from flooding and to provide irrigation water in the plain in the 2nd century BC in Sichuan, China. This structure is still functioning, irrigating agriculture fields of over 5,300 square kilometers.

Tank cascade systems have evolved in dry areas in Sri Lanka since the 3rd century BC to manage water for agriculture. Some 12,000 tanks are in use.

In Japan, local communities were forced to protect their own communities. They constructed Waju (ring dykes), surrounding the communities to protect their lives, houses, and paddy fields from floods. Before modernization in the late 19th century, Japan had limited technology and financial resources to protect society from floods. Emperors, Bakufus, and shogunate (or federal lords) protected strategic areas only, such as capitals, castles, major towns, and major irrigation facilities.

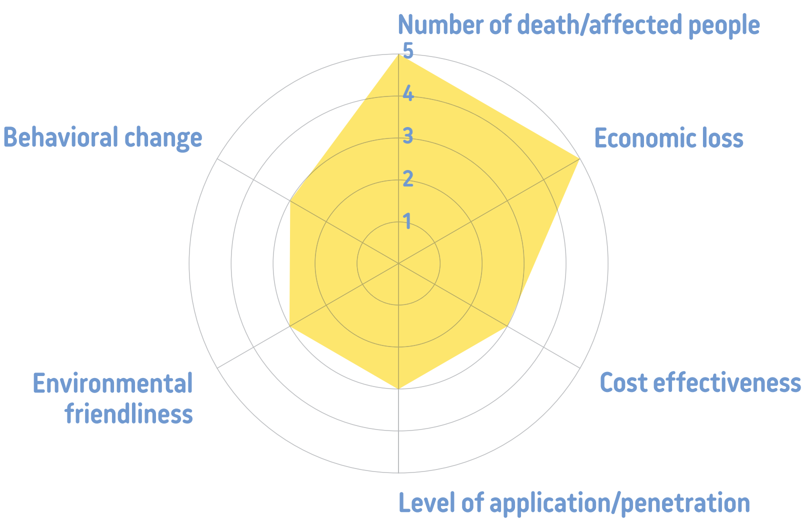
Structure measures using indigenous technology have recently been applied as eco-friendly measures of river works, instead of concrete works. These measures are made of natural materials such as wood and stone. Also, these measures are used in developing countries as a low-cost solution. For example, soda-mattresses, which are made of brushwood, wild twigs, wooden piles, and stones, are used for the prevention of riverbank erosion in developing countries, with the Japanese assistance. The mattresses are flexible as they follow the riverbed changes, while concrete works are solid and can be broken by riverbed change. Furthermore, the materials are available locally.

16

River engineering

Every country has developed technologies for flood prevention and water resource management according to natural, topographical, and hydrological conditions. However, indigenous technology often has the limitation of the scientific basis. When Japan was established following the Meiji Revolution in the late 19th century, the country introduced western technology in river engineering for preventing floods and developing water resources. Other countries, such as Mexico and China, also started introducing river engineering from western countries, with the Japanese assistance.

Assessment



Number of death / affected people	5	Western technology is currently used at large scale.
Economic loss	5	Western technology is used at large scale.
Cost effectiveness	3	Applying some technology, such as long dykes and dams, need large costs.
Level of application / penetration	3	Capacity building is needed to apply the technology.
Environmental friendliness	3	Some technology need management measures of environmental and social impacts.
Behavioral change	3	Experts became to use scientific knowledge and data analysis.

Era	Type	Stage
✓ Before 1960s	○ Earthquake	○ Response
○ 1960s	✓ Flood	○ Recovery
○ 1970s	○ Typhoon/ Cyclone	✓ Mitigation
○ 1980s	○ Tsunami	○ Preparedness
○ 1990s	○ Volcano	
○ 2000s	○ Landslides	
○ 2010s	○ Others	

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How did it drastically change the existing DRR status and strategies? How is it innovative?

Dutch engineers introduced the scientific approach of river engineering in Japan. While Japan had constructed flood prevention facilities throughout its history of nearly 2,000 years, experts developed their technology based mainly on experimentation. The Dutch engineers guided the Japanese engineers to develop monitoring stations to collect hydrological information essential for river planning. They produced the first textbook on the surveying and designing of river facilities. They also introduced the concept of designing flood volumes as a basis for planning facilities of flood prevention, such as dykes and channels. Japanese experts have developed technology based on these concepts and currently use such technology on a large scale.

Johannis de Rijke, a Dutch engineer, came to Japan in 1873 and stayed for 30 years until 1903. He was engaged in flood prevention in major rivers throughout the country, including Yodogawa River and Joganji River. He emphasized on managing sedimentation in upper stream and river channels, promoting water transportation, and formulating plans at a river basin scale.

Other countries have also introduced western river engineering. Mexican engineers received training from the US Bureau of Reclamation and promoted dam and irrigation projects in Mexico. China founded training institutes based on European and American models in the late 19th and early 20th centuries. China received technical advice from Soviet engineers for constructing dams and river structures in the 1950s. Engineering firms, NGOs, research institutes, and universities in the Netherlands are delivering technical solutions to developing countries. Japan has also supported training engineers, mainly in Asian countries, including Indonesia and the Philippines, under official development assistance.

Summary of survey result on the innovations for DRR: products and approaches

Summary of survey result

The online survey related to the 30 Innovations in DRR publication was conducted from December 2018 to January 2019. In total, 228 answers were received. The breakdown of responses were universities (145), government (30), NGOs (24), the private sector (6), international organizations (16), and others (7). The question asked participants to select three innovations considered most effective. The top ten innovations selected were as follows:

Innovations	
1.	Community-based disaster risk reduction/risk management
2.	Hazard mapping
3.	GIS and remote sensing
4.	Assessments and index approach: Vulnerability assessment, resilience, sustainability
5.	Disaster risk insurance
6.	National platforms for disaster risk reduction
7.	Social networking service/system (SNS)
8.	Drones
8.	Disaster resilient materials
10.	Indigenous DRR technology
10.	Crowdsourcing

Of the top ten innovations, five were products (GIS and remote sensing, Disaster risk insurance, SNS, Drones, and Disaster resilient materials), and six were approaches (CBDRR, Hazard mapping, Assessments and index approach, National platforms, Indigenous DRR technology, and Crowdsourcing). These innovations are considered very effective; however, the application is not always simple.

Several aspects need to be considered, such as applicability for specific hazard types, budget, availability of knowledge and technology, and human resources. There are many possibilities of collaboration to mobilize funding. Particularly, the private sector and academia could be good partners for the practitioners.

Normally, when innovations are discussed, they are often considered as products applied to advanced technology. However, in this survey, the innovation considered most effective in DRR was not a product but an approach, CBDRR. This shows that it is not ideal to rely only on advanced technology; instead, it is also very important to devise a key conceptual approach that serves as the guiding principles and framework for implementing DRR efforts and the application of technology and innovations in actual practice. When DRR efforts that combine both products and approaches are implemented, the most effective and efficient DRR strategies and efforts will be created.

Appendix

Acknowledgement

We would like to express our deepest gratitude to everyone who responded to the survey on the innovations for DRR. Also, we greatly appreciate the input of Ms. Mariko Onodera (IRIDeS, Tohoku University) and Ms. Sayaka Kobayashi (IRIDeS, Tohoku University). Ms. Onodera dedicated her time and effort to survey and graphic development. Ms. Kobayashi worked diligently to compile the case studies and on cover page design. Without their hard work, this publication would not have been possible.

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APRU
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