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Disaster risk reduction and innovations

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ABSTRACT

The Sendai Framework for Disaster Risk Reduction encourages investment in innovation and technology development in disaster risk management. However, needs for science and technology inputs are unmet, and there is a lack of policy making that is based on science and evidence. This paper identified three key issues that could help overcome these barriers: networking, coproduction of knowledge, and a stronger role played by academia.

A number of innovative approaches and tools have been developed for disaster risk reduction (DRR); however, it has not yet been understood what the most effective DRR innovations are. A survey was conducted among representatives of academia, government, NGOs, and the private sector to identify the most effective DRR innovations. Community-based DRR and risk management received the most votes. Half of the top-10 list was taken up with innovative approaches, which shows that both products and approaches are widely recognized as innovations, and both contribute to the improvement of existing and traditional DRR as it tackles new challenges.

To enhance the interfaces among science, technology, and policy making and the development and implementation of DRR innovations, the following is recommended: increasing coproduction with researchers and practitioners, continuing the sharing of innovation case studies, strengthening communication and dialogues among stakeholders using effective, national and local platforms, understanding that innovations are not limited to high-tech products but can be approaches as well, and pursuing research on the potential of Artificial intelligence (AI), communication tools, and innovations related to climate disaster that can improve current strategies and capacities for DRR.

1. Introduction

Successful disaster risk reduction (DRR) has exhibited a need for an improved science–policy interface for many years [1]. This depends on the recognition of science as a process for providing a basis for decision making and identifying optimal strategies and necessary countermeasures [2–4]. In addition, scientific evidence makes more accurate investment in DRR possible [5].

The science of DRR, in its widest sense, includes the natural, environmental, social, economic, health, and engineering sciences, and scientific capacities are interpreted broadly to include all relevant resources and skills of a scientific and technical nature [1,7]. In particular, the social sciences play a central role in the development of new thinking on risk, vulnerability, and poverty, as well as the human roles in DRR. The task of making the case to policy makers for substantively investing in DRR depends on the results of the social sciences for insights into politics, economics, and administration, as well as their specific contributions to the collection analysis of disaster-related data [8].

The convergence of science and technology can foster innovation [9] and is also of great importance for mitigating disaster risk. Innovation provides useful tools to cope with hazards [10]. The effectiveness of technological innovations in DRR has been proven in many cases, including early warning systems and innovations in construction to enhance the resilience of buildings and infrastructure [11].

The implementation of creative and appropriate ideas is also called innovation, as are processes that combine knowledge with new ideas in a creative way [9]. Thus, innovations are not always products, but can also take any form: process, approach, framework, concept, and other types. DRR innovations are categorized into several groups: "*innovation through interdisciplinary concepts, such as resilience; technological innovation, such as maintaining and strengthening geospatial information technologies; innovative ways to enhance the uptake of scientific knowledge in policy making and operations, such as sharing platforms; community-based innovation, such as integrating local information into DRR decision making; innovation through inclusiveness and participatory approaches, such as the perspective of young scientists; and innovation through policy coherence and improved monitoring*" [12].

The Sendai Framework for Disaster Risk Reduction (SFDRR) encourages investment in developing innovation and technology in long-term and

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solution-driven research in disaster risk management to address gaps, interdependencies, social challenges, and disaster risks. Precisely in what specific types of innovations should states invest? A survey on DRR innovation was conducted to understand the DRR innovations that have already proven effective and useful and that should be adopted as widely as possible particularly by governments and practitioners.

This paper first examines the current status of the use of science and technology in DRR and discusses and presents recommendations for overcoming that challenge. For scaling up DRR, innovative approaches and tools that are based on science and technology are required; however, precisely what DRR innovations are worth applying and investing in are little understood. If policy makers and practitioners are to take DRR measures and invest in DRR innovations, the relative effectiveness suitability of the innovations for their country or region should be understood. A survey was conducted among representatives of academia, practitioners, the private sector, and governments. This paper presents the results and an analysis of the survey in relation to DRR innovations to help understand the most effective innovations as well as the implications and observations of these conclusions.

2. Links among science, technology, and policy making

The SFDRR is a UN policy framework that strongly endorses science and technology [13]. For comparison, the term science appears nine times in the Hyogo Framework for Action (HFA), a predecessor of SFDRR, and 21 times in the SFDRR [14]. The term technology appears in the SFDRR 19 times, and the HFA mentions it three times [4,15]. This makes it clear that the emphasis on science and technology increased tremendously in the SFDRR. The application of science and technology to evidence-based policymaking is being encouraged more and more; however, current approaches and means of promoting science and technology remain insufficient. The mid-term review of the HFA, conducted before the SFDRR was adopted in 2015, identified unmet needs regarding science and technology inputs, particularly in risk assessment, practical tools to address specific risks, and economics-based evidence for advocacy purposes. In these circumstances, the demand for reducing barriers to access to science and technology, for developing science- and evidence-based policy making, and for support to developing countries in their pursuit of increased technical capacity has grown [8].

Various barriers still exist between science and policy. Successful case studies of science- and evidence-based policy making should exist, but their development is still hampered in developing countries by a number of factors, including language differences, timelines, incentive structures, and values, along with a lack of political interest and awareness, conflicting views on priorities, inadequate institutional mechanisms, limited capacities of vulnerable affected communities, and a lack of access to knowledge, technical capacity, and funding [2,8]. In addition, the lack of trust among stakeholders also forms a barrier and is caused by the absence of any space for dialog, compounded by the low priority of DRR among those most at risk, due to other pressing concerns, along with the limited time, resources, and space allotted to DRR by local actors [16]. Unfortunately, little effort has been made to close the gap between scientists and decision makers in policy and practice [17]. To overcome these barriers, what needs to be strengthened? How can the gap between scientists and policy makers be filled?

2.1. Networking

Scientists, policy makers, and other stakeholders, including the public, must engage on a regular basis [2]. Continual communication is essential, along with linking and shaping new ideas and information to the needs of decision makers. This can be done through the establishment of national committees or platforms on DRR that include the participation of national scientific and technical bodies and that report to high levels of government [8]. The role of these platforms can be to share and recognize the practices that exist on the local level regarding science-based decision making in the context of DRR, to conduct periodic assessments of the progress of DRR science and technology, to improve data standards and develop holistic risk models, and to organize regional science and technology conferences [11]. Such well-functioning coordination mechanisms can accelerate the use of science and technology in DRR by removing key barriers to their adoption [8]. However, without strong and thoughtful leadership by managers who stay on in the position for a long time, such platforms do not sustain and declined in effectiveness.

2.2. Coproduction of knowledge

Lack of knowledge is not the key challenge, but nevertheless, knowledge may not be transferred to practitioners and policy makers, especially at the local level. There are currently large social, structural, and functional barriers to knowledge sharing and implementation [18]. Increased losses to disaster are also a consequence of the unsatisfactory transformation of existing knowledge, i.e., the conversion of theoretical research findings into concrete action in practical disaster management [19]. The key barriers are a lack of resources for the application of knowledge in practice and a lack of incentives for decision makers to continue gaining knowledge to support improved, evidence-based decision making in policy and practice [18] as well as changes in socio-economic-political priorities.

In addition, more context-sensitive knowledge production is necessary that integrates local knowledge and understanding of local priorities and perceptions; provision of improved, target-oriented methods of communication; and trans-disciplinary approaches to research [18]. The social sciences can play a significant role through their consideration of the social context within which these events occur, as well as giving estimates for the likelihood of a variety of impacts in different scenarios, all of which require diverse types of data, including qualitative data [8,20].

Generating actionable scientific knowledge is possible through collaborative partnerships among scientists, policy makers, and practitioners [13,17], such as a development of joint production of assessments by experts and decision makers with better integration of different viewpoints [17,21]. It is necessary to shift from the traditional single, objective methodology to multiple, objective solutions in science, design, policy, and multi-scalar processes [22].

2.3. Role of academia

It is not clear to what degree practitioners have absorbed scholarly evidence. However, there is much research showing that the diffusion of research knowledge into practice is often incomplete or garbled. The gap between academic study and policy practice is widening [23]. Policymaking requires the delivery of the right information at the right time to the right people, and these tasks are not generally considered to fall under academia's role. However, it is now expected that the research community will attempt to report, share, and disseminate their research findings in a way that maximizes the likelihood of its use as active contributions to policy development [7]. In particular, in knowledge transfer, it is expected that the findings are concrete, the amount of evidence is high, the statistical methods are easy to understand, and there are clear practical implications. In particular, it is crucial that the practical implications be straightforward [23].

Traditionally, the research community has had an excessive focus on conducting research. This led to the belief that outreach and dissemination are someone else's task. However, local scientists, consultants, applications specialists, development practitioners, and journalists can all play a crucial role as intermediaries who bridge the gaps between expert and practitioner [8]. It is also crucial for researchers to develop the skill to understand the needs of policy makers and practitioners through building trust, opening channels of communication, creating a sense of a joint future, providing information, and designing incentives for co-operation [7], while learning how to communicate and transfer scientific practices and their research findings to practitioners and governments so that they maximize the use of technology and knowledge in policy practice. National committees and platforms should actively promote communication of actionable knowledge through many different processes and media, including briefs, drama, songs, storytelling at public events.

Table 1
Selection of 30 DRR innovations.

30 innovations for DRR							
Products				Approaches			
1	GIS and remote sensing	9	Seismic micro zonation	1	Community-based disaster risk reduction/management	9	Terminologies of resilience and vulnerability (R&V)
2	Drones	10	Earthquake early warning for high speed train	2	Hyogo Framework for Action	10	Post disaster needs assessment
3	Social Networking services (SNS)	11	Doppler radar	3	Hazard mapping	11	Transnational initiative on resilient cities
4	Concrete and steel: building material and infrastructure	12	Disaster resilient material	4	National Platforms for Disaster Risk Reduction	12	Mobile payment: a tool for accessing distribution/funds after a disaster
5	Disaster risk insurance	13	Rainwater harvesting	5	Safe schools and hospitals	13	A dollar for DRR saves seven dollars in disaster response/recovery
6	Disaster prevention radio (Bosai musen) and telemetry system	14	Electricity resistant survey	6	Assessments and index approach: vulnerability assessment, resilient index, sustainability	14	Traditional practices and evacuation behaviors
7	School cum cyclone shelter			7	Crowdsourcing	15	Indigenous DRR technology
8	Seismic code			8	Sphere standard	16	River engineering

3. Innovations in disaster risk reduction

Innovations are not required to be entirely new or radical in nature [24]. They drive growth and help address social challenges [25] and can contribute to the mitigation of climate change, advancement of sustainable development, and the promotion of social cohesion [26]. To tackle those issues, innovations should be cost effective and should save lives, reduce losses, and ensure effective recovery and rehabilitation [12]. Thus, innovations can take such different forms as products, processes, concepts, methods, approaches, services, and mindsets [9,12,23,24,26].

In DRR fields, many innovations have been implemented and proven their usefulness and effectiveness. To further promote DRR innovations, the types of DRR innovations that are most effective and useful for improving current DRR capacities must be understood. To collect information on the most effective and useful innovations, a survey was conducted among representatives of academia, practitioners, the private sector, and government. Use of the results can help support the development of localized innovations that will reduce future disaster risk, providing more effective and prompter responses and building disaster-resilient societies.

3.1. Methodology

First, disaster experts and researchers from five universities and one NGO gathered to discuss and select DRR innovations that they considered to be effective and useful. After a series of discussions and meetings, these were reduced to a short list of 30 (14 products and 16 approaches) (Table 1). Using these 30 innovations, a survey was conducted to identify what DRR innovations are considered most effective among specialists based on their experience of them.

This does not imply that there are only 30 DRR innovations; obviously, more exist. As opinions may differ regarding this list, at the end of the survey, the participants were also asked to add innovations that they considered as or more effective as those listed.

The survey had two main questions, obtaining data on what three innovations the participants considered most effective and adding DRR innovations the participants considered effective, in addition to the 30 innovations listed. The survey form was disseminated from December 2018 to January 2019 through networks such as the Association of Pacific Rim Universities, the Integrated Research on Disaster Risk, the Asian Disaster Response and Reduction Network, the contacts of the researchers, universities, and NGOs.

3.2. Overall analysis

In total, 228 answers were received from universities and research institutes (145), government (30), NGOs (24), international and regional organizations (16), the private sector (6), and others (7) (Fig. 1). There was a significant gap in the proportion of answers received: 60% were from universities or research institutes.

The top-10 innovations selected included five products (remote sensing and GIS, disaster risk insurance, Social Networking Service (SNS), drones, and disaster-resilient material) and six approaches (CBDRR, hazard mapping, assessments, index approach [these two were tied], national platforms, and indigenous DRR technology) (Table 2).

Among innovations, high-tech products may come to mind first. However, the results indicate that products and approaches can both have great impacts on reducing disaster risks. It is extremely important to use approaches together with products as a framework and guiding principle for the application and implementation of products and to analyze issues using the tools of the social sciences aspects: developing new thinking on risk, vulnerability and poverty, the risk process, and the role of humans in the accumulation of risk [8]. Both products and approaches bring multiplier

Fig. 1. Votes by group.

Table 2
Top-10 innovations (A: approaches, P: products).

	Innovations
1	Community-Based Disaster Risk Reduction (CBDRR) (A)
2	Hazard mapping (A)
3	Remote sensing and GIS (P)
4	Assessments and index approach: vulnerability assessment, resilient index, sustainability (A)
5	Disaster risk insurance (P)
6	National platforms for Disaster Risk Reduction (A)
7	Social Networking Service (SNS) (P)
8	Drones (P)
8	Disaster resilient material (P)
10	Indigenous DRR technology (A)
10	Crowdsourcing (A)

effects to current DRR capacity. Without novel approaches, novel products cannot maximize their effectiveness.

Products often require larger budgets or more sophisticated technology to adopt, operate, and maintain. Additionally, some products are still new and used only at limited sites. Additional time may be necessary for the effectiveness and value of these products to be fully understood. To obtain budgets for application, strong support from the authorities and decision makers is necessary. The government must be convinced to invest funds into DRR. For that purpose, it is crucial to build links between the government and those that develop these technologies, particularly academia and the private sector. For instance, national platforms for DRR (ranked sixth) can provide opportunities for all stakeholders to meet and share information and knowledge on DRR and discuss increases in national DRR capacity at once.

Respondents clearly voted for the innovations that were familiar to them, that they knew the effectiveness of, and that they had already used. Some items on the list are not well known and have been adopted only over very limited areas. For instance, electricity resistance survey, which is used to identify groundwater zones, their geometry, variation in salinity and direction of water movement, in relation to droughts received no votes (Fig. 2). This may be because its focus is restricted to drought and the technology is not widely known or used, although it could become extremely effective for drought. It is crucial to disseminate information on such innovations and share case studies using them and show what kind of impacts they could have.

Community-based disaster risk reduction or risk management (CBDRR/RM) received the most votes in this survey. Tanwattana [27] credits CBDRR/RM with completely changing the mindset of the top-down approach in DRR to a bottom-up approach. It was once believed that the government has the greatest responsibility in disaster management, including DRR, but this approach strongly encourages community participation at each point, including planning, implementation, monitoring, and giving ownership to the community. Using this approach, further innovations have been developed: community zoning, data collection to support community disaster planning, installation of community staff gauges for water level, floating storage, elevated chicken coops, and emergency elevated walkways [27].

Although CBDRR is highly recommended, in many cases, governments and communities that do not fully understand its value or their responsibility to implement it still exist. Lassa et al. [28] determined that voices and inputs from the communities are still not reflected in many planning documents funded by the government and international donors, although communities may be involved in the assessment. CBDRR requires collective coproduction by communities and the government, and it is insufficient for them to simply work together. A key of CBDRR implementation is the complementarity of community initiatives [29].

Changing the mindsets of communities will take time; however, people often attempt to make large changes over a very short period. This approach does not often lead to success. It is important to understand that nurturing community is not a simple endeavor; however, without patient cooperative work, the chance of success is very small [28]. It should not be forgotten that CBDRR is still new to communities and even to governments [27].

3.3. Comparison by group

This section assesses the results by group, for those groups with larger numbers of respondents: university or research institute, government, and NGOs. There was a gap in the total number of the answers for each group, so the percentages of the total votes for each innovation among total votes in each group were used for comparison (Fig. 3).

To calculate the percentages, the total number of votes was used. For instance, all participants were asked to select the three innovations that they considered most effective and useful, so the total number of votes was expected to be three times of the total number of the respondents. Thus, the total number of the responses from representatives of universities and research institutes was 145, so the total number of votes was 435 (145 × 3).

The innovation that received the most votes among the three groups was CBDRR (Table 3). CBDRR, Geographic Information System (GIS), and hazard mapping were ranked among the top five for each of the three groups. More approaches (such as CBDRR, hazard mapping, assessment and index approach, national platform, and indigenous DRR technology) were ranked in the top five more than products (such as GIS, drones, and social networking services).

There are innovations that found a place among the top five for each group that were not among the top five for other groups: disaster risk insurance, assessments and the index approach, a national platform for DRR, SNS, drones, and indigenous DRR technology.

1) _Universities and research institutes:_ Assessments and the index approach was the fifth highest rated by representatives of universities and research institutes. This approach is a crucial base for research for those who perform scientific analyses and studies of all aspects and areas of

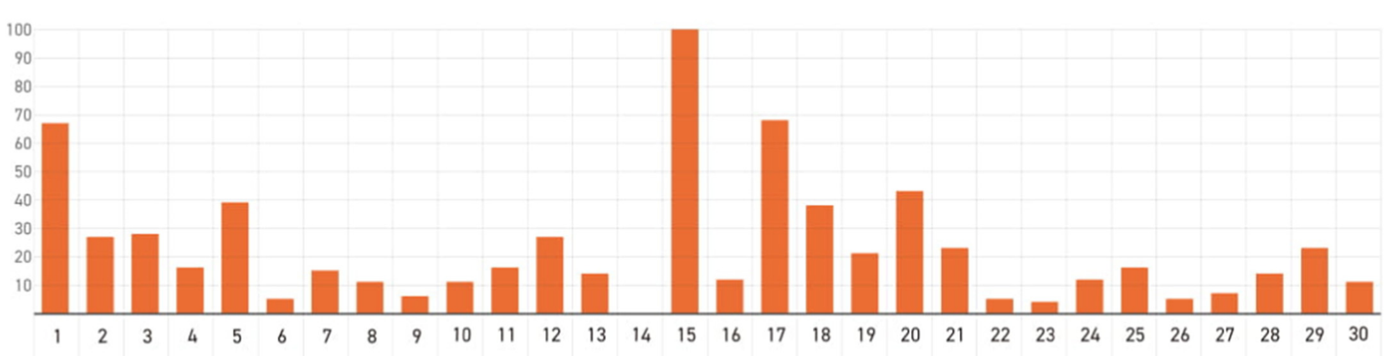

Fig. 2. Overall result of the survey (number of the votes gained). Total number of votes: 684 (228 answers × 3–each participant was asked to select the three innovations they considered to be most effective).

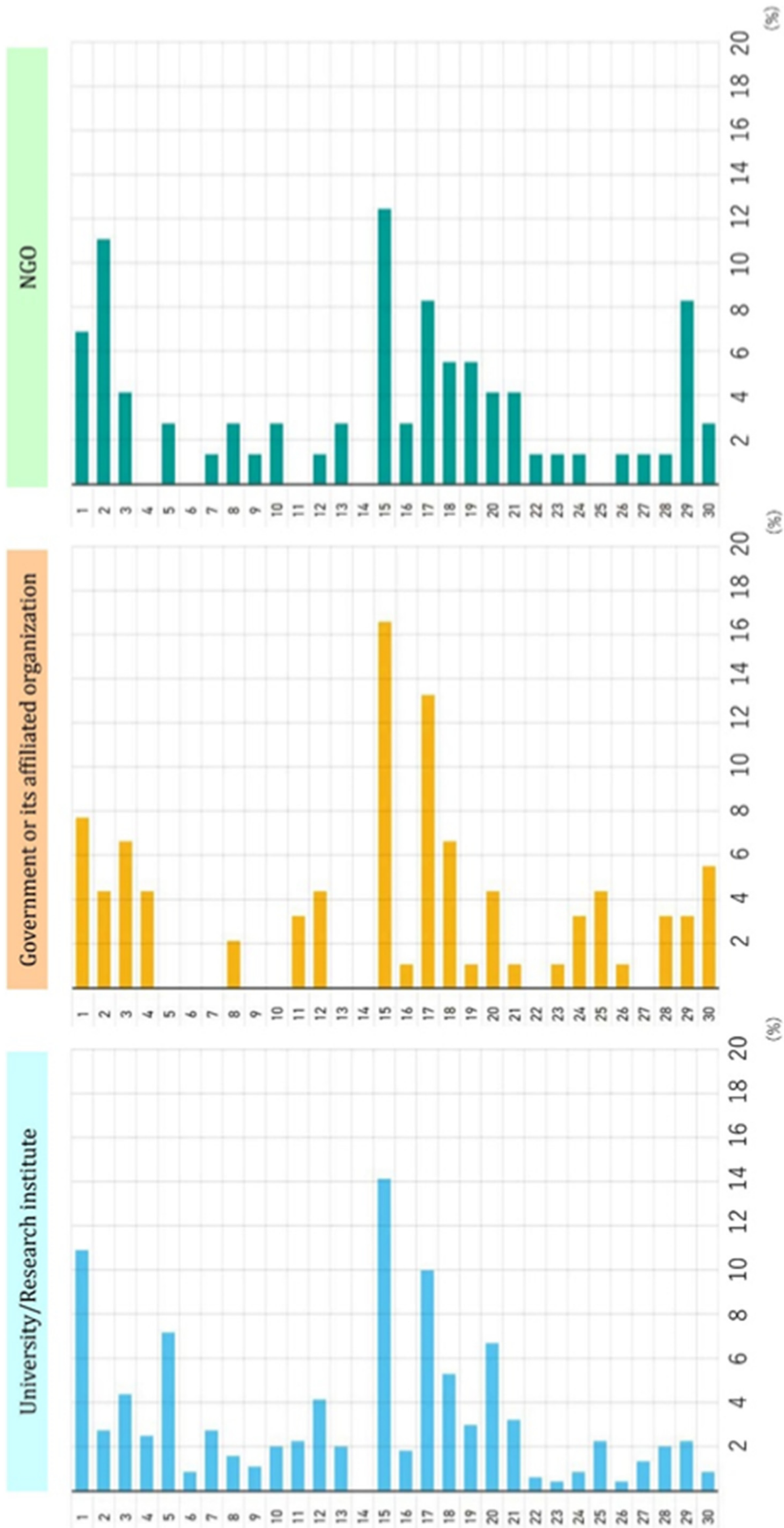

Fig. 3. Survey results for the three groups.

Table 3
Top-five innovations by three major groups.

	University/Research institute	Government	NGO
1	CBDRR (A)	CBDRR (A)	CBDRR (A)
2	GIS and remote sensing (P)	Hazard mapping (A)	Drones (P)
3	Hazard mapping (A)	GIS (P)	Hazard mapping (A) Indigenous DRR technology (A)
4	Disaster risk insurance (P)	National platform (A) SNS (P)	
5	Assessments and index approach (A)		GIS (P)

DRR; thus, this approach is often used by researchers and is understood by them to be very effective.

There are a number of researches conducted regarding the effectiveness on disaster risk insurance. Therefore, for academia, disaster risk insurance could be familiar and considered something useful for DRR, however, other groups may not have been convinced yet by its effectiveness. Such information and evidence on the effectiveness of insurance should be shared and understood widely by other groups.

2) *Governments:* A national platform for DRR was the fourth highest rated by representatives of government. This refers to a platform for multi-stakeholder collaboration at national level; it is thus to be expected that the government would be familiar with it. It was strongly promoted in the HFA and the SFDRR. It has proven relatively effective in its use by governments, which are the ones implementing the platform in most cases.

   SNS is already considered an effective tool of information sharing publically. It could be also a useful tool for government to understand the damage situation and the immediate needs for relief assistance. It is extremely important for government to access such information as early as possible to provide emergency assistance.
3) *NGOs:* Indigenous DRR technology was rated third highest by representatives of NGOs, which, particularly national and local ones, appreciate local culture, wisdom, technique, and materials. They are often familiar with indigenous technology, which is often unique and developed with reference to their unique culture and environment. Their experience at the local level allows NGOs to understand the effectiveness of such technologies quite well.

The innovations listed below exhibit a more than 5% gap in the voting rates among the groups.

1) *Indigenous DRR technology*: 8.3% of NGO representatives voted for this approach, but only 3.3% of government representatives, and 2.3% of representatives of universities and research institutes did likewise. As noted above, this approach is more commonly taken by NGOs. The gap in use of this approach between NGOs and others may imply a communication or knowledge gap between them. Most likely, this innovative approach and its effectiveness have not been well understood by either the government and or universities and research institutes and will not be until they grasp DRR efforts at the local level.
2) *Disaster risk insurance*: 7.1% of representatives of universities and research institutes, but only 2.8% of NGO and 0% of government representatives supported this. The SFDRR emphasizes the importance of promoting mechanisms for disaster risk transfer and insurance, risk sharing and retention, and financial protection. The cost-effectiveness of risk transfer and insurance for disaster risk management has been widely discussed. It is thought that insurance is not necessarily the most cost-effective option for governments [30]. Especially in wealthy countries government insurance hardly exists at the national level except the Unities States, Canada and Australia [31]. However, for small, low-income and highly exposed countries that have over stretched tax bases, sovereign insurance may become an important cornerstone for tackling the effects of natural disasters [32,33]. It is also particularly suitable for financing the immediate post-disaster needs that follow low frequency, high impact events [34,35], but not for high-frequency, low-impact events [30]. The effectiveness of this method will differ in national and local contexts, including the specific history and impact of disasters in the particular place, the government and its public financial situation, and other DRR measures being used [36]. Further research and discussion on risk insurance and transfer is necessary as a better option for reducing future disaster risks and supporting response and recovery works in the affected countries and governments.
3) *Drones*: 11.1% of NGO, 4.4% of government, and 2.8% of university and research institute representatives voted for drones. Drones are often used and can assist disaster risk management at any stage of disaster management: before, during, or after a disaster. They can greatly contribute to monitoring, forecast, and early warning systems; disaster information sharing; situational awareness, logistics, and evacuation; and standalone communication systems, search and rescue missions, and damage assessment [37]. There may be a gap between NGOs and governments in understanding the effectiveness of drones or in the experience of using them. Alternatively, it could simply be that the government officials who participated in this survey had not had experience of using drones in live disaster-management situations. NGO representatives may have had more opportunities to see drones in operation and the effectiveness of their use in various occasions, primarily in disaster response. For the use of drones, a certain level of budget, technology, and human resources is necessary. NGOs with experience with drones may be good partners to gain necessary information and discuss the use of drones. There are also many countries and areas that have already adopted drones in their DRR measures; therefore, many case studies and papers already exist for reference and study.

3.4. Additional innovations

In addition to the 30 innovations selected in the original list, the survey prompted participants to suggest additional innovations that were not at first included (Table 4). Artificial intelligence (AI) was a common response. It is necessary to investigate how AI could strengthen DRR capacity and reduce disaster risks, such as for early warning and evacuation modeling, and to make changes in the current state of DRR. There were also a number of suggestions to include the innovations for climate-related disasters, both products and approaches. Furthermore, innovations that use mobile devices were also widely suggested. However, these suggestions vary from technical products to educational and awareness-raising materials, as well as action, policy, and funds for particular purposes. It will be important to continue to identify DRR innovations and share acquired information with practitioners and policy makers.

Table 4
Suggested innovations.

Products	Approaches
Drought resistant crops	Impact based forecasting
Communication technologies	CCA and DRR
Mobile application based on smart water solution	Shaking table demonstration
AI technology	Ecosystem-based adaptations and DRR
Sanitation technology during emergency	Religious organization involvement
Susceptibility mapping for a changing climate	Regional and national response mechanism
Early warning by emergency phone ringing/Disaster alerts through mobile phone	Nowcasting
Digital management information system	Land-use regulation
Virtual Reality in DRR education	DRR fund
Solar energy used for response such as mobile water treatment	Go Bag
	Forecast based financing
	Weather-based agriculture

4. Conclusion

The need in DRR for the increased use of innovation and new technology has never been greater, however, there is a tremendous gap in the interface of science, technology, and policymaking. One prominent difference between HFA and SFDRR is that the latter emphasized the application of science and technology much more heavily than the HFA [14]. The SFDRR recommends that the two be linked more emphatically, that innovative approaches be developed, and that they be used in practice. There is an urgent need of a platform and opportunity to enhance communication among various stakeholders and increase an opportunity to learn how science and technology could increase support for DRR work, especially among practitioners and governments. To reduce the gap, this paper identified three key issues: networking, coproduction of knowledge, and the role of academia.

The results of the survey clearly show that innovations are not required to be completely new or high-tech products, but approaches and frameworks can lead to changes and to influences on people's thinking and behavior. It is necessary to take both innovative products and approaches into account in DRR strategies when working to develop them further and make them more effective and useful. CBDRR received the most votes among the 30 innovations chosen. This is a widely acknowledged and implemented approach, but it should not be forgotten that CBDRR is still a relatively new approach, even among governments. The innovations that representatives of universities and research institutes, NGOs, government, and the private sector think most effective differ slightly from each other. It is crucial for these groups to share their experience of these innovations with other stakeholders and to promote and support their application in practice. In the case of further examination of effective innovation considered by group, it is necessary to increase the number of responses, especially among NGOs, government, and the private sector.

To strengthen the use of science and technology in policy making and to increase the application of innovative DRR measures in practice, it is crucial to do the following:

- ➢ Increase coproduction between researchers and practitioners. It is insufficient for these groups to simply work together or collaborate ambiguously if strong policy making based on scientific evidence is to emerge;
- ➢ Continue sharing case studies of innovations. Academia should take a further step here and study how to communicate their research and its results;
- ➢ Strengthen communication and dialog among stakeholders, using effective platforms such as the national platforms for DRR;
- ➢ Understand that innovations can go beyond only high-tech products to include approaches as excellent innovations to be adopted. Without such innovative approaches, the products cannot maximize its effectiveness;
- ➢ Conduct further study, especially on the potential of using AI, communication tools, and innovations related to climate disaster that improve current DRR strategies and capacities.

Declaration of Competing Interest

The authors declare that they have no Conflict of Interest.

This paper, authored by Rajib Shaw and Takako Izumi was handled by Akhilesh Surjan, a Section Editor on the Journal with expertise in Investing in Disaster Risk Reduction for Resilience. Progress in Disaster Science Journal would like to assure readers that neither Rajib or Takako took any decision on the Publishing of this paper in the Journal. The paper was submitted to Akhilesh who handled the peer review process.

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