
Self-assertion vs. multi-fusion in the field of disaster management R&D: the case of Korea

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Abstract: This study examined how the role of research and development (R&D) can be improved in the field of disaster management in Korea by comparing self-assertion and multi-fusion approaches. Literature review was the major methodology utilised. Using five variables, namely public institutions, the industry or the business sector, college laboratories, mass media, and international R&D, the two approaches were analysed, and in the process, the pentagon model was established. The study's key position is that Korea has to transform its current self-assertion approach to a multi-fusion approach in the near future by understanding and improving its R&D culture, and thus, integrate expert knowledge into the R&D system.

Keywords: R&D culture; integrated approach; public institutions; industry; mass media.

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1 Introduction

Many international researchers have studied disaster management in terms of how research and development (R&D) has improved the field using diverse perspectives. In Korea, a micro-perspective continues to be implemented. For example, the National Disaster Management Research Institute (NDMRI) has uploaded 515 research documents

on its website at the beginning of 2017, of which more than 95% were carried out following a single perspective, either from a civil engineer or an architect (NDMRI, 2017). Similarly, the website of Koreanstudies Information Service System (KISS) has 567 research articles on fire emergency and its management at the end of 2016, but 546 articles (96.3%) were also produced following a single perspective, either a firefighter or a public administrator (KISS, 2016). In disaster management, micro-perspective means looking through the lens of an individual expert or sector or a small-scale study. This perspective does not consider many of the other aspects or the views of other sectors, such as political, economic, and social, as a whole.

Moreover, Korean researchers have given little attention to analysing disaster management via a macro-perspective, as evidenced by the examples given for NDMRI and KISS with only about 5% and 3.7%, respectively, by multiple perspectives. Macro-perspective is about analysing the role of disaster management R&D on a large-scale, considering various sectors or aspects, such as political, economic, and social including a nation's culture and professional expertise.

A popular thought in advanced nations is that disaster management R&D should be done via macro-perspective mainly because a disaster is not linear but multidimensional [Noran, (2014), pp.1034–1037]. Korea seems to have been stuck to micro-perspective in its disaster management R&D, creating a distinctive gap between advanced nations and Korea. These observations have strongly motivated the author to examine the role of Korean disaster management R&D via a national or macro-perspective. Thus, this research question is formulated: “In what ways has Korean disaster management R&D progressed?”

If Korea continues to rely on a micro-perspective or a single discipline, the impact or benefits of its disaster management will not be as effective. To illustrate, if firefighting R&D continues to focus only on the discipline of firefighting science without considering the psychological aspect, then the firefighters' psychological wellbeing may not be given much attention by R&D. Another example is in the case of civil engineering R&D being focused on using civil engineering perspective alone; doing so may fail to cover and solve flood-related problems including the danger of hazardous materials present in flood water, among others. In the case of infectious diseases, not only medical researchers but also other stakeholders should have participation in R&D or at the very least be informed of developments including former patients and their families, parents and their children, soldiers, tourists, and other more vulnerable sectors of society, knowing that infectious diseases could spread fast on certain occasions. This is why quick and sharp action is critical.

The purpose of this article is to delve into ways to positively change the role of disaster management R&D in Korea by evaluating two approaches: self-assertion and multi-fusion. In the former, stakeholders work on their R&D following their own R&D perspective. In the latter, they integrate their peers' and other stakeholders' viewpoints into their R&D results. Note that self-assertion approach is not the same as the micro-perspective as the former is of a larger category; however, it is closely related.

The literature review and relevant explanations that follow systematically analysed self-assertion and multi-fusion approaches in the field of disaster management via five variables, namely public instructions, industry, college laboratories, mass media, and international R&D. Their interrelationship and importance define or establish the pentagon model in this study, as it relates to disaster management. This study maintains that Korea presently implements a self-assertion approach, and as such, needs to change

it into a multi-fusion approach in disaster management R&D, thereby working towards improving the nation's R&D culture and knowledge diversity.

2 Literature review

The main purpose of research is to invent something new, whereas development is to improve the result of a research [Johnson, (2000), pp.3–5]. Some R&D models or approaches are related to innovation itself, but others are focused on the aspect of R&D management or strategy. Many specific models are available, such as open innovation model, statistical model, factor model, business model, and cost-benefit model [Minniti and Venturini, (2017), pp.316–317]. In general, these dynamic R&D models or approaches have been suggested for innovation or productivity growth. However, these models are not fixed but change or evolve due to related risk, time influence, and other challenges [Schuhmacher et al., (2016), pp.2–4].

In particular, since the year 2000, many global models or approaches, such as poverty reduction, income inequality, energy efficiency, and supply chains and value chains, have been advocated in the field of R&D. Among them, the issue of national security in R&D has been heavily emphasised [NSTC, (2016), pp.1–13]. In general, national security means more than homeland defence or military power in each nation. The field of national R&D also continues to work on cutting-edge research and technology to protect national security. In doing so, related R&D stakeholders seek to address new challenges (ex. asymmetric threat), threats to stability (ex. climate change), and other crises (ex. the outbreak of pandemic diseases).

The field of disaster management covers all types of hazards, not only natural disasters but also man-made emergencies. Its lifecycle consists of four phases, namely disaster prevention/mitigation, preparedness, response, and recovery [Ainuddin et al., (2015), pp.69–73]. Accordingly, the field of disaster management has developed diverse models and approaches over time. Among them, several fundamental models have been suggested by the USA Federal Emergency Management Agency (FEMA) and then are being widely used in the international community. Such models include integrated emergency management system, comprehensive emergency management, coordination and collaboration, flexible model, risk-driven model, progressive approach, and professionalism (EMI, 2013).

At the beginning of the 21st century, many US colleges including the University of North Texas, Oklahoma State University, Georgian Washington University, and Georgia State University have started to classify the subject of disaster management as a regular academic discipline. Simultaneously, diverse researchers in other countries began to follow the USA's example. Based on disaster management models and approaches, which were developed by FEMA authorities in the 20th century, those researchers examined many issues in their countries. They have made efforts to study how FEMA's disaster management principles are to be efficiently applied to various disasters in their national contexts [Faulkner, (2001), pp.135–140]. Accordingly, while utilising case studies, they have introduced many characteristics of national disaster management, such as comprehensiveness, integration, and networking.

Disaster management R&D influences all phases of the disaster management lifecycle. It helps stakeholders monitor potential hazard, detect disaster, and devise better

ways of dealing with disasters [Cutter, (2003), pp.443–444; GDIN, (1997), pp.58–62]. Moreover, the integration of R&D into disaster management has been studied recently by many accredited researchers. In so doing, some researchers have looked into the differences among normal science, structural science, and real-time research as they related to disaster management models and approaches. In addition, other researchers have discussed the importance of crowd-sourcing, probabilistic innovation, the integration of information into disaster management, and others [Alamdard et al., (2016), pp.72–77; Callaghan, (2016), pp.239–242].

Particularly in the 21st century, disaster-prone nations and advanced nations have made efforts to deal with diverse disasters locally or globally via the integration of R&D into disaster management, such as the development of H1N1 vaccines in the USA, the invention of quakeproof housings in Japan, and the establishment of early warning system on earthquakes with tsunamis in New Zealand and Indonesia, among others. Because disasters may occur regardless of national boundary, R&D activities in such nations have been carried out with the cooperation of national researchers [Bodin and Nohrstedt, (2016), pp.184–185]. In this context, cooperative R&D models or networking R&D approaches have been supported strongly.

Moreover, the integration of R&D into disaster management may facilitate the management of knowledge assets. Knowledge management plays a certain role in the integration of R&D into disaster management. For instance, stakeholders will have access to external knowledge, evaluate R&D performance, and thus, share useful information, using R&D data efficiently. Knowledge management then becomes an analysis and communication tool for stakeholders [Drongelen et al., (1996), pp.228–229; Frederiksen et al., (2004), pp.820–827]. By managing knowledge, stakeholders may overcome some serious challenges and barriers around disaster management more quickly and efficiently because of available knowledge. This may also result to more innovation, and thus, have and maintain competitive advantage in the field of disaster management. Accordingly, stakeholders become satisfied with not only the process, but also the outcome of disaster management.

Among the many roles of knowledge management in the field of disaster management R&D, two are clearly supported. First, knowledge management plays a role in meeting customers' demand under quality management [Ansari et al., (2009), pp.78–80]. Basically, the role of knowledge management is oriented towards continuous improvement, and this allows an organisation to protect itself against diverse risks, while managing related knowledge based on flexible routines and procedures. Also, quality management means that the quality systems in place in an organisation are appropriate and efficient. In doing so, knowledge management may address various customers' demand on disaster management or its R&D by providing beneficial features or advantages for them. Namely, knowledge management is to newly figure out extraordinary or hidden trends and relationships for those customers.

Second, knowledge management plays a role in sustaining disaster management R&D in the long-term. On the basis of continual improvement efforts, knowledge management continues to improve the quality, services, and products of disaster management R&D. Without this sustainability, disaster management R&D would not be preserved and would not serve its purpose [Arain, (2015), pp.235–23]. To elaborate, knowledge management provides appropriate and useful information for R&D decision makers. Accordingly, decision makers will be able to cooperate with various researchers, while coordinating

and addressing thorny issues. Therefore, knowledge management may facilitate the success of disaster management R&D by empowering all R&D stakeholders.

Similarly, intelligent quality management as a component of knowledge management is aimed at improving learning skills or knowledge by ensuring repeated or consistent quality management implementation, as the results of disaster management R&D are collected and analysed, serving as the overall system controller. In so doing, intelligent quality management receives, adapts, transmits, and utilises rich data and information through diverse sub-channels by correcting errors and uncertainties on disaster management R&D. At the same time, social and knowledge processes as knowledge management tools are exploited for more knowledge and innovative ideas in the R&D field [Khobreh et al., (2012), pp.283–284].

Some practical examples are available on knowledge management in disaster management research projects. In Japan in 1996, Nonaka and Takeuchi suggested the SECI model for knowledge creation by referring to four ways of the knowledge process, namely socialisation, externalisation, combination, and internalisation (Frost, 2012). Although the SECI model was not exactly a practical example, the fundamentals of the theory and potential for application are quite promising. In European states, the Eurofound as a policy agency has practised cross-boundary collaboration or knowledge sharing for the success of related projects. In fact, multidisciplinary or different perspectives (or the high extent of diversity) exist among nations regarding disaster management research projects, and thus, these cause a big challenge against knowledge management such as the aspect of complexity. To this point, the Eurofound has flexibly relied on each nation's legal frameworks, the European industrial relations dictionary, and others for knowledge sharing (Schmidt-Abbey, 2011). In addition, many companies in the USA have used knowledge management software via their business continuity planning, such as World Bank (information technology transformation), Southern Co. (information technology aids for post-Katrina recovery), Dow Jones (making newspaper headlines on content management), Shuffle Master (building a portal), and Pratt & Whitney (transmitting information to customers) (Baseline, 2007).

Disaster management R&D has many characteristics. The majority of disaster management issues require the application of R&D as well as the use of basic management principles. In another aspect, the majority of R&D solutions are applicable to the field of disaster management, at least to some extent. In addition, R&D application has to be addressed through an operational procedure, which is the grass root level [Committee on Emergency Management, (1982), pp.1–3]. Thus, the scope of disaster management R&D is wider than what is expected and includes not only scientific knowledge but also management of information.

In the international community, many researchers have discussed how to contribute to the field of disaster management by including emergency operation planning, hazard mitigation, and other operations, or by utilising appropriate R&D. In particular, via diverse perspectives, several R&D areas have been heavily investigated, such as nuclear effect, hazardous chemicals, public health, environmental problems, and information development [Becerra-Fernandez et al., (2008), pp.4–7; Dinh and Chu, (2006), pp.290–292].

Following the international trend, some Korean researchers have begun to examine how R&D has to deal with disasters. They have utilised their own perspectives or micro-level perspectives on the role of disaster management R&D [Han et al., (2012),

pp.187–188; Lee et al., (2009), pp.637–639]. Almost no attention has been given to research on how the whole range of disaster management R&D in Korea has to handle related activities. In this context, it is valuable to delve into the role of disaster management R&D via a national viewpoint.

Disaster management R&D has been surrounded by a national culture. A professional culture has influenced many important aspects of national disaster management R&D via a macro-viewpoint. Although details on disaster management R&D have been decided by individual criteria, the whole direction of related R&D has been strengthened by a grand culture such as value, ideology, the concept of technology, or else. In other words, the ultimate decision on disaster management R&D has been made by a national culture [Brettel and Cleven, (2011), pp.254–259; Perry and Green, (1982), pp.313–316].

When a specific disaster management R&D is attuned to the appropriate culture, it will play a crucial role in managing disasters long-term. Otherwise, R&D would vanish in a short time, although it is potentially revolutionary. To promote R&D in the field of disaster management, it is necessary to understand, and then, improve related R&D culture around disaster management, such as political, economic, and social aspects [Applegate, 2008; Marincioni, (2007), pp.469–471].

In dealing with a disaster, many stakeholders hunger for the best practices and cutting-edge R&D. To provide a holistic picture of a disaster and its management, the field of disaster management R&D has to depend on integrated or multi-fusion approach against unknown disaster impacts [Featherstone et al., (2012), pp.110–111].

For example, it takes not only many experts' domain knowledge but also statistical techniques to make a hazard zone map. In R&D, the impact of factors such as wind, wave, and storm, is carefully investigated, and then, related ranking is assigned according to its own weight. Without considering every R&D parameter, a hazard zone map will not be successfully produced [Srivastava, (2009), pp.68–69]. A hazard zone map established without utilising an integrated approach will not serve its purpose well.

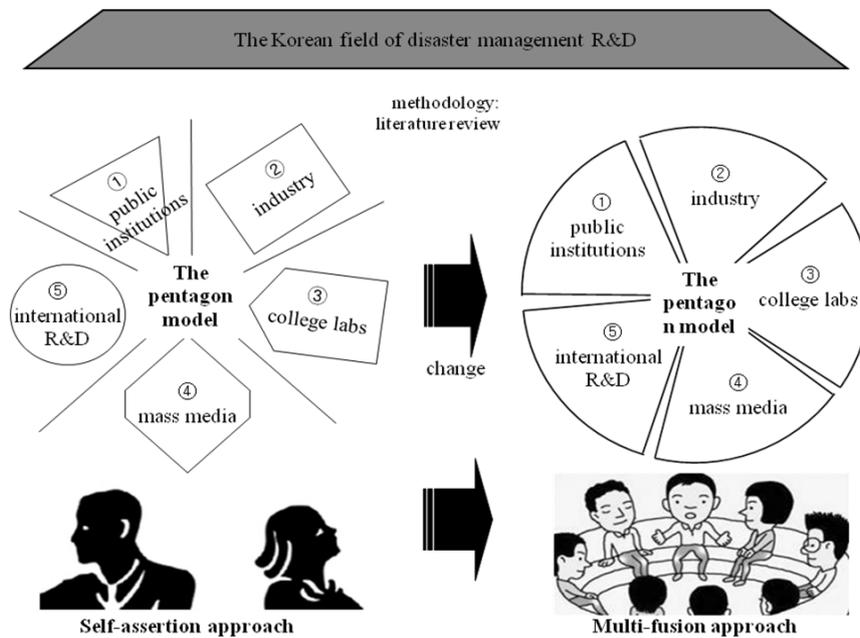
3 Analytical framework

Disaster management R&D has provided crucial innovative or economic opportunities for enhancing the field of disaster management. By creating new R&D via a series of experiments or changing the nature of existing R&D, disaster management R&D has offered chances of rebuilding disaster management planning and operation. Also, disaster management R&D has facilitated many stakeholders to effectively fight against various disasters. The role of disaster management R&D has been frequently proven in many countries, including Korea [Jansen, (2003), pp.53–55; Kesavan and Swaminathan, (2007), pp.744–745; Reddick, (2011), pp.54–56; Tveiten et al., (2012), pp.1962–1964].

R&D is an important aspect of disaster management. Some of its outcomes have contributed to controlling the severity of many disasters; however, more need to be accomplished. One example is cloud seeding. Although it is now being used by a number of countries from Asia to Europe, its effectiveness is not yet statistically proven by local and global R&D (StudyBlue, 2017). Man-made emergencies, including terrorism, are considered more controllable in some regions than natural disasters are, but the former are more difficult to predict than the latter [Gad-el-Hak, (2008), pp.40–41].

Given the above, this paper identified two approaches for the field of disaster management R&D in Korea: self-assertion and multi-fusion. In the self-assertion approach, stakeholders in the field of disaster management work on their R&D by relying mainly on their own perspectives, asserting their individual achievement or capabilities, without reflecting on other perspectives. In the multi-fusion approach, stakeholders carry out their R&D duties by considering diverse perspectives, resulting to integrated results (Figure 1).

Figure 1 Analytical framework



To systematically analyse the two approaches in Korea, five major elements were chosen as comparative variables:

- 1 public institutions
- 2 industry or the business sector
- 3 college laboratories
- 4 mass media
- 5 international R&D.

These five elements are considered the major stakeholders in the field of disaster management R&D and they represent the five sides that make up a pentagon, and so this is called the pentagon model. The model recognises that these five stakeholders are critical to disaster management R&D. The absence of one makes the pentagon model non-existent.

In this model, each element's inclusion is justified by relevant and extensive literature review. The first three elements have always played significant roles in national disaster management in terms of R&D efforts from public and academic institutions as well as R&D undertakings and funding from the business sector [NSF, (2012), pp.1–4]. In addition, the influence of mass media towards the direction of national disaster management R&D has been sharply increased in the 21st century with the support of information and communication technology. Similarly, international R&D has directly or indirectly influenced science and technology policy in Korea (Stepp et al., (2012), pp.42–54). It is believed that these five have satisfactorily reflected every important aspect of the two approaches in Korea and play a major role in disaster management R&D in Korea.

Each variable under the pentagon model does not act alone; they interact with one another under a complex and dynamic environment. There are also various interdependencies among them (Pade-Khene et al., 2013). Public institutions played a major role in keeping or managing the relationship with private institutions in Korea until the 20th century [Nalla and Hwang, (2006), pp.483–486]. In the 21st century, private institutions, such as industry, colleges, and mass media have steadily increased their influence or power regarding their relationship with public institutions via the spirit of democracy, the use of information technology, or references to foreign cases. Also, international R&D institutions have recently begun to interact with the Korean field of disaster management R&D. In short, the specific role of each variable has been defined throughout the manuscript under the interrelationship with the other variables.

Under self-assertion approach, stakeholders assert their own R&D perspectives and knowledge individually. Similarly, each of them has exclusive viewpoints on R&D efforts. Among the five elements, only international R&D sees the big picture of the multi-fusion approach. In general, however, self-assertion approach is quite dissymmetrical.

On the other hand, each stakeholder has to fuse the others' R&D perspectives via the multi-fusion approach. Multi-fusion approach is symmetrical and holistic, unlike that of the self-assertion approach.

Moreover, significant guidelines on R&D or disaster management are being utilised. When conflicts exist among the principles, guidelines, and other related issues, the best approach to address future concerns is chosen during the process of decision making and then interpreted. An example is the aspect of comprehensiveness of R&D in disaster management, or the integration between disaster management and R&D.

Additionally, when studying the limitations of the self-assertion approach, Korean literature was primarily cited by this study. Note that almost no rigorous international literature has fully discussed the Korean self-assertion approach, primarily because the topic has a limited scope. In providing the alternative being the multi-fusion approach, international literature was used as reference. Many international researchers have directly or indirectly advocated the multi-fusion approach for the goal of disaster management [Pearson and Clair, (1998), pp.59–63].

By relying on literature review, the paper will attempt to answer two questions. Will the review of the defects or limitations of self-assertion approach confirm that Korea's disaster management R&D suffers from this approach? What alternatives are available, eventually leading to a multi-fusion approach for Korea's disaster management R&D?

4 Defects of the self-assertion approach

4.1 Public institutions

Two public institutions have played major roles in working on firefighting R&D under the Ministry of the Interior and Safety (MOIS or formerly known as the Ministry of Public Safety and Security); they are the Korea Institute of Fire Industry and Technology (KFI) and the National Fire Service Academy (NFSA). These two have recently tried to expand their R&D activities against diverse fires, but the majority of their researchers are still those who are taking a major in firefighting science or firefighting engineering.

The Korea Coast Guard Research Center (KCGRC), which works on maritime-related activities including R&D, used to be under the Ministry of Oceans and Fisheries. However, the Korea coast guard completely failed to manage the sinking of ferry Sewol on April 16, 2014, where only 172 were rescued out of 476 people. KCGRC is now under Ministry of Oceans and Fisheries (or under the MPSS from 2014 to 2017), expanding its R&D capacity to search and rescue and the prevention of collision, spillage of hazardous materials, and others (KCGRC, 2018).

Under MOIS, NDMRI is supposed to work on the whole disaster management R&D except firefighting and maritime accident-prevention R&D. The National Institute for Disaster Prevention changed its official name to National Disaster Management Institute (NDMI or currently known as the NDMRI) at the end of 2011 for the purpose of working on diverse R&D. However, researchers at NDMRI are not composed of diverse group professionals; all of them are civil engineers. Furthermore, they have focused on researching on flood brought about by typhoon (MOIS, 2018).

Although KFI, NFSA, KCGRC, and NDMRI have recently tried to diversify disaster management R&D, their R&D efforts are focused on three categories only, namely firefighting, maritime accident, and civil engineering. In addition, only a few professionals have been allowed to regularly work in the said institutions, and most are on contractual basis. Hence, R&D efforts in these four public institutions fall under self-assertion approach.

4.2 Industry

Four great rivers run in Korea – the Han River, the Geum River, the Yeongsan River, and the Nakdong River. Although they are the major sources of water, they have also caused serious flooding during typhoon season. With the support of previous administrations, many civil engineering R&D companies were allowed to research on the four great rivers to find ways to prevent flooding in the region.

When President Lee Myung-Bak was elected in 2008, civil engineering R&D groups raised the flood risk around the four great rivers, and then, suggested the urgent need to reshape them under the name of ‘green new deal’ policy. However, the public with the support of foreign assessors (including German researchers) did not agree to this suggestion, and instead, they clamoured for the President and civil engineering R&D companies to take action and work toward projects that could enhance the water flow of various small streams. Accordingly, a number of disputes and tension were observed between civil engineers and other professionals regarding whether the civil engineering R&D industry should restore four great rivers.

In addition, the particular civil engineering R&D group working on the project was not oriented on disaster management, and allegedly, they were more concerned about potential financial gains from this engagement. To make matters worse, flooding has not been dramatically decreased, and the impact of drought to the environment has in fact increased even after the completion of the USD 20-billion development (Min, 2015). Therefore, the assistance of civil engineering R&D industry has clearly failed to divert flood risks in Korea, and sound restoration of the ecosystem around the four major rivers was also not achieved.

In this regard, the actions from the people involved in civil engineering R&D were clearly based on the self-assertion approach. Majority of the Koreans actually did not support the development; only those who were involved in the civil engineering R&D and the president have claimed positive effects of the development. Allegedly, the president's allies in the civil engineering R&D have benefited financially from this development.

4.3 College laboratories

The history of modern disaster management study in Korea is quite short, about only longer than a decade. Colleges maintain their own R&D laboratory as a key academic major in the field of disaster management, such as firefighting R&D, marine R&D, civil engineering R&D, meteorological R&D, and public administration laboratories. This shows that the classification of disaster management R&D studies in colleges has been segmented, individualised, or at times, even confusing.

Despite the fact that an increasing number of researchers in college laboratories have recently recognised that disaster management R&D is not a singular but an interdisciplinary study, very few have approached related R&D via the interdisciplinary perspective [Choi et al., (2010), pp.806–808]. There were those who have conducted academic seminars under the name or pretext of interdisciplinary study, but these seminars were unsatisfactory. Each researcher presented his or her own R&D results without substantially including or connecting to other R&D knowledge related to disaster management.

The preceding data indicate that college laboratories employ a self-assertion approach on R&D. Each college chooses to concentrate on R&D for their specific disciplines without considering the potential value and impact of other disciplines. Furthermore, the fact that those researchers have not attempted to collaborate with other R&D majors also indicates their use of the self-assertion approach [Rijinsoever et al., (2015), pp.1104–1105].

4.4 Mass media

The Korean Broadcasting System (KBS) has played a key role in disseminating disaster management information, including related R&D in Korea. Although it is true that KBS has distributed crucial R&D information to the public before, during, and after a disaster, the number of interviewees has been significantly limited. That is, only a number of experts have been interviewed regularly by KBS despite various hazards that have occurred and that could have been mitigated with inputs from other stakeholders.

Moreover, there are times when KBS disseminates uncertified disaster management R&D information to the public. For example, when there was a series of typhoons in

2012–2014, such as typhoons Sanva, Volaven, and Denbin in 2012, Leepi in 2013, and Halong 2014, KBS maintained that it was necessary for apartment owners to tape windows or to spray water to newspapers on windows to prevent them from breaking. Although some R&D experts pointed out its uselessness, KBS insisted on spreading its effectiveness (KBS, 2015).

Considering that KBS repeated its interviews with only a number of R&D experts about all kinds of hazards for the past five years, the content of related R&D is limited, denoting the use of self-assertion approach. Similarly, the fact that KBS insisted on using tapes or wet newspapers on windows during typhoon indicates its lack of integration of advanced R&D information to broadcast contents, thus again, falling under the self-assertion approach.

4.5 International R&D

Owing to various researchers' efforts, a wealth of cutting-edge R&D documentation on disaster management is available in the international market. However, it has not been easy for Korea to select which international R&D is more appropriate for disaster management in its region because many have not been proven or tested in Korea yet. Also, it is true that very few Korean researchers are willing to participate in international joint R&D because of legal, financial, and linguistic issues, among other barriers.

As an example, the website of the US Emergency Management Institute (EMI) contains diverse disaster management R&D information available to the international community. By becoming a member, anyone can have free access to the website and its contents including R&D information (EMI, 2015). However, because the contents are written or recorded in English, only a few researchers in Korea have been able to utilise related R&D information.

Despite rich and cutting-edge disaster management R&D data, not only Korea, but also some countries still apply the self-assertion approach. Majority of Korean researchers continue to rely on this approach despite knowledge of existing and well-organised disaster management R&D (e.g., via the EMI website) because of many factors, such as reliance on a particular discipline alone and language barriers. For these reasons, international disaster management R&D has not attracted much attention from Korean researchers.

5 Alternative: the multi-fusion approach

5.1 Public institutions

Traditional ways of managing disaster management R&D have to be adjusted, as disasters become more and more complicated. When the European Union (EU) provides assistance to a nation hit by a disaster, it fully utilises interdisciplinary R&D. For example, when the EU works on health R&D or anti-seismic technology, it forms a multinational expert team. At the same time, it works on all aspects of related R&D [Boin and Rhinard, (2007), pp.81–82; Broer and Pickersgill, (2015), pp.59–60]. This approach, being integrated, is what public institutions in Korea need to follow or emulate.

Since 2004, a number of unfortunate events have surrounded disaster management R&D in Korea, such as the case of ferry Sewol sinking in 2014 and the subsequent failure

in disaster management. The people of Korea, have since then, demanded more from public institutions and encouraged them to take solid actions towards integrated disaster management R&D. This has to be the new normal or culture of the nation.

By following a social culture, KFI, NFSA, KCGRC, and NDMRI have to diversify their human resources. Firefighters, ocean researchers, and civil engineers have to let go of their individual interests, and participate in recruiting or building a network of diverse R&D professionals. In addition, new employees have to dramatically expand their research into all aspects of disaster management like in the case of the EU.

5.2 *Industry*

According to the National Security Strategy of the UK, diverse researchers' knowledge should be gathered to solve civil engineering R&D issues in the field of disaster management. When the field of civil engineering R&D accumulates related information, it will clearly create a resilient construction environment and policies [Bosher and Dainty, (2011), pp.8–13]. To implement a multi-fusion approach in Korea, its field of civil engineering R&D has to learn valuable lessons from the UK.

A basic problem on the R&D done on the four great rivers was related to the nepotistic relation between the field of civil engineering R&D in the industry and that of the president. Back then, with political support, the field of civil engineering R&D alone dared to work on the development, without incorporating other researchers' or stakeholders' knowledge. Consequently, the lack of diverse knowledge in R&D contributed to spending a huge amount of tax in vain.

The industrial or business sector disaster management R&D must pay attention to eliminating implementation of projects without consultations from identified stakeholders. Stakeholders should be vigilant to ensure legitimate transactions and that there is no unnecessary political pressure [Forsberg et al., (2015), pp.23–25].

5.3 *College laboratories*

In a study in Finland, significant differences were found among students in medical college laboratories with regard to their practical performance and theoretical knowledge. Students with integrated R&D curriculum were more satisfied with their R&D result, and thus, empirically considered their R&D result as a cutting-edge technology, compared with students without it [Niemi-Murola et al., (2007), pp.823–826]. To promote the multi-fusion approach, college laboratories in Korea have to seriously consider the case of Finland.

Rather than maintaining their own R&D to be a key academic major in the field of disaster management, researchers in college laboratories have to recognise the real status of their R&D in the field of disaster management. Additionally, they need to acknowledge that disaster management R&D is an interdisciplinary study, and that one of its goals is to change or improve related culture. Without this recognition and change, the confusion on and limitation of disaster management R&D following a self-assertion approach will continue.

Researchers and curriculum specialists of college laboratories are advised to look into the example of Finland and work towards the improvement of their R&D programs. The objective is towards having interdisciplinary or integrated disaster management R&D courses for use in academic programs, seminars, and other similar undertakings.

5.4 Mass media

When an earthquake hit Azerbaijan on November 25, 2000, the mass media were unable to spread critical anti-seismic R&D information to the public. Rather, the mass media, including TV channels, unfortunately spread panic and fear to the residents in Baku, resulting to more adverse psychological impact [Seid-Aliyeva, (2006), pp.81–82]. For this reason, Korea needs to avoid the same mistake from recurring, making it even more important to promote a multi-fusion approach.

To improve the limited contents of disaster management R&D, KBS must diversify its usual list of interviewees or resource experts. If KBS will keep on interviewing only a limited number of experts, the dynamic aspect of R&D will not be addressed and known to the public at all. In particular, KBS has to interview various professionals who analyse new knowledge on disaster management R&D. If done so, ways on dealing with all kinds of disaster will be more efficiently relayed to the public.

To filter misleading R&D information, KBS has to extensively research about related information via internet and foreign media and consult with diverse stakeholders. For example, the US federal government clearly stated that window taping or similar activities could not prevent apartment windows from breaking [FEMA, 2004, pp.69–71]. Considering that the above information has been available on the internet, it is possible to suspect that there may have been a monetary motive between KBS and perhaps tape-manufacturing companies. To adopt the multi-fusion approach, the mass media need to improve on fact-checking and on related economic motivation.

5.5 International R&D

After a devastating earthquake hit Haiti on January 12, 2010, the role of international relief, including international R&D, was significantly disputed. When analysing that the aid of international R&D was delayed owing to the breakdown of the international airport, Haiti should have more proactively approached the technological issues such as the establishment of a robust airport, the structure of runway, and others in advance [Benjamin et al., (2011), pp.316–317]. Korea has to take more proactive action towards international R&D, following the multi-fusion approach.

The field of disaster management R&D in Korea needs to study which international R&D is more suitable for the case of Korea. To do so, Korea has to set up pre-disaster plans on international R&D. Without planning, it would be impossible for the field of Korean R&D to know the pros or cons of international joint R&D.

For practical reasons and with globalisation, learning and understanding the English language is a key to international communications as well as participation in international disaster management R&D forums. With this knowledge, Korean researchers will be able to benefit from a multitude of resources on international disaster management R&D.

6 Conclusions

This study analysed two identified approaches, namely self-assertion and multi-fusion, in relation to disaster management R&D improvement. In their comparison, five variables under the pentagon model were used, specifically public institutions, industry, college laboratories, mass media, and international R&D. The key finding is that the field of Korean disaster management R&D must transform from a segmented-exclusive or self-assertion approach into a holistic-inclusive or multi-fusion approach by addressing critical political, economic, and social issues.

The details on necessary actions or solutions in this study are put forward for Korean disaster management R&D to evaluate and implement, to benefit all stakeholders. Doing so is expected to position the nation into the right direction towards integrated disaster management R&D.

When public institutions, industry, and college labs, working as a triad or having a three-way relationship, turn their single-disciplinary R&D into multi-disciplinary R&D with the support of mass media and international R&D, the productivity and quality of Korean disaster management R&D will be strengthened. As such, NDMRI may start employing not only civil engineers but also other professionals, when delving into the issue of flood accompanied by typhoon. As an example for the corporate setting, the Global Loss Control Center of Samsung may look into diversifying its R&D investment given that its focus R&D has been mainly from the perspective of firefighters.

In addition, the Ulsan National Institute of Science and Technology may improve its engineering perspective by including political, economic, social, or cultural perspectives into the process of its R&D. In short, the institution needs to invite diverse professionals during its R&D planning, organising, or evaluation unlike its current practices. If YTN (also known as Your True Network), a TV station, discusses the issue of multi-fusion, its viewer rating is likely to increase, and thus, contribute to improving emergency awareness in Korea. The EMI may also contact the Korean representative of International Association of Emergency Managers to talk about international disaster management R&D.

In a similar token, it is necessary for emergency managers to rapidly adopt the transition from self-assertion approach to multi-fusion approach so that they are oriented to deal with complicated issues as part of routine work. Without multi-fusion, they are not likely to fully carry out their roles and responsibilities in the field. By utilising multi-fusion, emergency managers may become more flexible and resourceful in getting appropriate solutions. Further, the function of multi-fusion is superior to that of self-assertion or to those of others because the approach can better reflect the nature of disaster management, such as nonlinear aspect, comprehensiveness, and connectedness.

Additionally, this study highlighted the need for a macro-perspective coupled with an integrated approach, as opposed to a micro-perspective with a segmented approach. The former is ideal for disaster management R&D that is nationally sound and that may be internationally applicable as well.

Future studies may focus on examples of integrated disaster management R&D outcomes that have mitigated, if not eliminated, adverse disaster impacts such as human loss, psychological distress, and economic damages. Similarly, researchers may apply multi-fusion approach, the pentagon model, and other related models to their specific case studies.

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