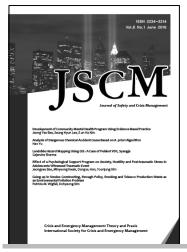

J. Saf. Crisis Manag. Vol.9 No.2, Dec. 2019. pp.1-13
pISSN 2234-2214 / eISSN 2671-5732
http://doi.org/10.14251/jscm.2019.2.1

Journal of Safety and Crisis Management

Drawing Improvement Measures of a Smart Disaster Monitoring Management System in an Integrated Manner through Analyzing Overseas Cases

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A B S T R A C T

Disaster situation management is critical for reducing vulnerability in disaster and safety management areas, fostering safety awareness and improving response capabilities in the event of a disaster. Accordingly, National Disaster Management Research Institute of Korea has been running a smart disaster monitoring management system (SDMMS) to manage disasters in an integrated manner. However, the system has faced some limitations in disaster information collection in accordance with disaster management phases. Overseas cases have shown some implications regarding the system. Thus it is necessary to find out measures to improve the system. This study has intended to draw improvement measures of the SDMMS through analyzing overseas cases. To meet the purpose, this study has developed a case analysis framework composed of two major categories such as both information gathering and construction system, As a result, this study has found following improvement measures: 1) SDMMS needs to expand its functions to managing disaster and safety information holistically; 2) SDMMS needs to adopt an integrated approach in collecting disaster information; and 3) SDMMS needs to be available at all disaster management phases.

Key words: Smart Disaster Monitoring Management System, SDMMS, PDC, Sahana, compare analysis

Introduction

Backgrounds and Research Objectives

The nation experienced major disasters such as the Sewol ferry incident in 2014, MERS in 2015 and the earthquake in Pohang in 2017, resulting in very severe national losses. Recently, not only natural disasters, but also social disasters and complex disasters are frequent, and their damage is also super-wide, and the scope of the disaster has expanded beyond the region to inter-state damage. Therefore, the importance of disaster management is becoming more important. Accordingly, the National Disaster Management Research Institute developed a smart disaster situation management system to efficiently manage disasters(Choi, 2013).

The SDMMS, however, was found to be underutilized due to the limitations of the system's accessibility. The initial purpose of the SDMMS is to make it available to the public as well as local governments and related agencies. However, it is not available in many local governments because they are currently using systems

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Received: Nov. 13, 2019 / Revised: Dec. 02, 2019 / Accepted: Dec. 04, 2019
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that are self-established by local governments or cannot afford to introduce SDMMSs. It also has limited access to the system, since it cannot be shared by multiple agencies in a format that only issues IDs to the requesting agencies. Therefore, the central government should establish an integrated disaster management system and distribute it to local governments to enhance their disaster management capabilities.

It also showed that SDMMSs are not highly utilized due to lack of real disaster information. SDMMS was expected to be utilized throughout the entire phase of actual disaster management as a GIS-based convergence of disaster and safety information. However, there were criticisms that the information provided by the SDMMS was not available for effective use due to lack of public relations and guidance and lack of practical disaster information(Dong-Ah Science, 2016). In other words, it is difficult to expect integrated disaster management, an initial research goal. Therefore, the nation's integrated and comprehensive disaster management system should be established through the improvement of the current system's problems.

However, it is difficult to draw improvement measures as the integrated disaster management system in Korea is the only one. Discussions on disaster management are under way around the world as disasters are not just domestic but global phenomena, so that many countries have been are also establishing disaster management systems for efficient disaster management.

The purpose of this study is to find out the problems of the disaster situation management system and to draw improvement measures of the SDMMS. To meet this goal, this study analyzes overseas cases based on assessment criteria for the utilization of the information system and disaster management, being discussed as a problem of smart disaster situation management system. Analysis of problems of SDMMS through prior study shows that the system lacks disaster information resources with utilization of disaster management and integrated information collection system. Therefore, the SDMMS, which is currently in operation, was performed comparative analysis with overseas disaster management systems based on the assessment of the information system and the usability of disaster management. Therefore, problems were drawn based on the judgment of the smart disaster situation management system currently in operation and the usability of disaster management and compared and analyzed with overseas disaster situation management systems.

Literature Review

Scope of Disaster

The concept of disaster was to refer to massive natural disasters such as floods and earthquakes. In modern society, the results of large-scale man-made disasters surpassed those of natural disasters due to the development of science and technology caused by industrialization and urbanization. Therefore, it is used as a concept that covers not only natural disasters but also artificial ones(Lee, *et. al.,* 2006).

Article 3 subparagraph 1 of the Framework Act on Disaster and Safety Management defines disasters as those that can harm or damage people's lives, bodies, property and the nation. Natural disasters are natural phenomena such as typhoons, floods, heavy rains, strong winds, wind waves, cold waves, lightning, drought, heat waves, earthquakes, yellow dust, tidal current, tide, volcanic activity, and the crash of natural space bodies. Social disasters are damages caused by fires, collapses, explosions, and traffic accidents (including aviation accidents and maritime accidents), chemical and environmental accidents. The national infrastructure system (energy, telecommunications, transportation, finance, medical and water supply) paralysis, spread of infectious diseases and livestock diseases, and damage caused by fine dust are also classified as social disasters.

Recently, the occurrence of social and compound disasters, as well as natural disasters, is frequent and the damage is extremely extensive. Across the region, disaster damage is also on the rise. Examples include damage caused by ultrafine dust from China, discharge of radioactive water from the accident at Japan's Fukushima nuclear power plant, and damage from sea pollution. In 2010, volcanic ash from the eruption of Iceland's Eyjafjallajokull caused aviation chaos across Europe. These various types of disasters are causing ultra-wide damage beyond the nation.

Disaster Management System and Disaster Information Sharing

Article 3 of the Framework Act on Disaster and Safety Management defines disaster management as all activities to prevent, prepare, respond to and recover from disasters. This includes all aspects to prevent and prepare for a disaster and to identify the response activities and damages after the disaster and restore them to their normal state.

Disaster management has a mutually cyclical nature, not a mu-

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tually isolated process. The results and content of the activities in the disaster management process affect the following activities: And the results, effort and experience of the final recovery activities can be refluxed to the preventative stage, improving long-term disaster management capabilities. Effective disaster management can be achieved only when the stage of disaster management is managed in an integrated management system. Due to the total nature of such disaster management, efforts are also needed to equip necessary activity systems, such as coordination and control of central, regional and related agencies participating in disaster management(Lee, 2013).

Disaster occurs in local units. That is why local governments should respond first. But only at the central government level, we take the initiative in disaster management. Each local government conducts disaster management in a different way, and the forms of disaster-related organizations are different. As a result, it is said that the damage was huge whenever a disaster occurred. Such problems call for improvement in the disaster management system(Yoon, 2017).

Under these circumstances, the establishment of an integrated management system for disaster management is considered essential. Currently, each local government has failed to operate or even establish a separate disaster management system. It has limitations that the system is not standardized or that a large amount of disaster-related data is not available. At the central government level, it is necessary to establish an integrated disaster management system and distribute it to local governments to enhance their disaster management capabilities. By operating an integrated disaster situation management system in accordance with the actual conditions of each agency, disaster management can be carried out in accordance with local characteristics when various and compound disasters occur. Unstructured and unsystematic information such as disaster-related manuals, regulations, experience, and situational awareness should be considered. It should also identify disaster safety information required for related tasks, such as policymaking, and support effective response and prompt decision-making in the event of a disaster. To this end, the government should develop and distribute systems that are integrated and can apply local government regional characteristics.

Compound Disaster Management

In addition to natural disasters, social disasters and Compound disasters such as the sinking of the Sewol ferry, paralysis of national infrastructure, Kangwon wildfires, and ASF are occurring frequently and in various types.

Our society is undergoing social and environmental changes such as climate change, urbanization, industrialization, and population density increase. Large-scale disasters where various risk factors are interconnected are frequent. In particular, the number of compound disasters is increasing, with single disasters expanding into various types of disasters(Current Daily, 2017). The compound disaster has an overall impact on society and the damage is astronomical. It may have an international impact beyond a single region or country(Current Daily, 2017).

In particular, Korea has a large number of facilities, including state infrastructure, energy-related facilities, and livestock and meat farming facilities, in the land where urbanization rates are high and narrow. That is why it is highly likely that one disaster will escalate into several disasters. Therefore, the government should be able to effectively prepare for and respond to not only natural disasters and social disasters, but also to compound disasters that occur continuously and simultaneously. To this end, the government needs to establish and upgrade a disaster management system.

Disaster Information Gathering System

Systematization of the collection, management and analysis process of disaster and safety information is important in disaster management. SDMMS is a big data platform and needs systematic management of mass information. In order for information to be managed systematically, improvements in the information gathering system must be made first. However, the current disaster task is carried out individually by various agencies, and thus lacks connectivity, making it difficult to establish an integrated system of information gathering. For example, in a central and local government disaster status control center operated to minimize the damage situation in a disaster, sufficient disaster situation information should be gathered so that the progress of the disaster and the damage situation can be predicted. However, due to the lack of connectivity in disaster work, information is gathered sporadically and insufficiently, making it difficult to support systematic disaster information management. Therefore, the integrated gathering system of disaster and safety information should be established through work links between relevant agencies to achieve the systematic system of disaster information. So, through prior research and review, we would like to check if SDMMS constitute such information gathering systems.

The SDMMS will receive observation information through weather, streams, CCTVs, sensors and on-site information through mobile images and satellite images managed by various ministries from public organizations and the private sector. In addition, a" social

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big board" has been built inside the system, which reports on site tweets from all users. However, the SDMMS has failed to implement the initial research goal of commercializing the public as well as establishing customized platforms for consumers due to limitations in accessibility, such as issuing and allowing government-affiliated organizations to use their IDs upon request. In addition, the social big board can analyze disaster information such as time and location of disaster occurrence in the system, but the specific function of identifying real-time field responses and Tweets motives is not realized at all. However, SDMMS currently have access limitations in a format that can only be issued when a government-affiliated agency requests an ID. Therefore, the initial research objective of commercialization for the public as well as the establishment of custom platform for consumers is not being implemented(Consumer Economy, 2016). Therefore, its utilization is not consistent with the initial research goal, as it is currently used only to obtain information from the National Safety Sensitivity Survey's monthly report, which is published by the Ministry of Public Safety and Security. In other words, there are fewer actual users of the system and no user-specific disaster information gathering system, so only limited information is gathered from limited agencies. Due to the limitations of gathering disaster information, it is difficult to establish diverse and highly utilized information resources. Therefore, effective disaster management should be carried out by establishing a practical information gathering system for disasters through improvement of the cooperative system of information provision by each user.

Disaster Information Resource Management

Analyzing disaster phenomena to predict progress and damage is the core of disaster management, and to this end, many systems introduce information processing technologies such as big data and analyze them by converging large amounts of information. SDMMS are also using big data platforms to handle large amounts of information. However, if this large amount of information is not managed, the actual utilization of the information is low, whereas the large amount of information deployed is large, resulting in a surge in traffic, which makes the system less efficient(Jeong, *et. al.,* 2016). Therefore, information should be managed in terms of the availability of disaster management. In other words, the government should support the convergence analysis of disaster phenomena by supplementing the highly utilized disaster information and their attribute information at each phase of actual disaster management. Therefore, we would like to review the preceding research to see if SDMMS are building such disaster information resources.

The disaster and safety information covered by the SDMMS include natural disasters, social disasters, infrastructure information, evacuation and rescue information and social media information by type of disaster. In addition, properties by each disaster and safety information includes national spatial information, related agency information, professional simulation, smart big board analysis information, text and video, and more details are shown in <Table 1> (Choi, 2013).

However, the current system does not reflect many disasters, and properties information by disaster is also poor, which has little real impact on disaster management. As an example, when the earthquake hit Gyeongju in September 2016, and the typhoon ‘Chaba’ that swept through Busan, Ulsan and South Gyeongsang Province in October, local government officials criticized that they could not effectively utilize the information provided by SDMMSs due to lack of practical disaster information (Dong-Ah Sience, 2016). Due to the poor quality of disaster information resources of smart disaster situation management system, it is difficult to expect the use of integrated disaster situation management, an initial research goal.

Therefore, it should fully reflect disaster and related information, such as natural disasters and social disasters, that are insufficient to increase the usability of SDMMS. In addition, the establishment of a functional continuity and resilience system in the disaster management system should facilitate interaction for each phase of disaster management functions, and thus seek to enhance and synthesize the disaster management system(Moon, 2019).

In summary, the establishment of an integrated collection system

<Table 1> SDMMS properties by disaster and safety information

National spatial information	Waterlogging, Topography, Elevation, Soil map, River basin diagram
Related agency information	Rainfall, Temperature, Wind speed, Tides, Water level, Traffic, Landslides.
Professional simulation	Waterlogging forecast, Rapid gradient indication, High altitude, Tsunami prediction, Typhoon path
Smart big board analysis information	Hazard alarms (Risk, Boundary, Warning), KML mapping
Text	SNS(tweet), Disaster report, Site information (Text, Location information)
Video	CCTV, Satellite images(Chunlian), Radar images, Site information(photo, video)

※ Source : NDMI(2015).

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of disaster information and supplementation in terms of the availability of disaster management are important for disaster management. Therefore, it is deemed that this can be used as the basis for assessing the disaster management system. Through prior research, we identified the problems of the current SDMMS in terms of two evaluation criteria. The results showed that the current system's gathering system of disaster information and the status of disaster information construction are very insufficient, and they do not affect disaster management. Therefore, it is necessary to draw a direction for improvement of SDMMSs through these problems. However, the existing research does not currently produce a paper that has been drawn through the smart disaster situation management system, and there is a lack of a paper that has been analyzed in terms of improving utilization.

Comparative Analysis of Overseas Cases

Currently, it is difficult to draw up an assessment and improvement direction as there are not many integrated disaster management systems in Korea. However, discussions on disaster management are under way around the world as disasters are not just domestic but global phenomena. Therefore, overseas countries are also establishing disaster management systems for efficient disaster management(Yoon, 2011). Therefore, we need to draw improvement direction by comparing information gathering system and information construction, which are discussed as a problem of SDMMS, with overseas system based on evaluation criteria.

<Table 2> summarizes the contents and implications of preceding study. Considering the implications, it is important to establish an integrated disaster information gathering system and supplement disaster information resources management in terms of the usability of disaster management. However, the SDMMS's gathering system and resources management of disaster information are insufficient. Therefore, it is necessary to draw an improvement measures from these problems.

The Differentiation of Preceding Studies

Through literature review, the implications and differences in research were drawn. One of the limitations of literature review is the lack of capacity to draw empirical problems of the disaster management system. Previous studies grasp problems in the information gathering system and information construction to improve the management system at the national level. However, since this is a macro-level analysis, it is necessary to draw problems from a empirical system at a micro-level. Thus, the differentiation of this research is empirically to examine the disaster information gathering system and the status of information construction in smart disaster management systems and to draw problems.

Currently, it is difficult to draw an assessment and improvement direction as there are not many integrated disaster management systems in Korea. Therefore, it is difficult to evaluate SDMMSs and draw improvement directions. However, Yoon(2011) drew the implications of Korea's disaster management system through qualitative comparisons with overseas disaster management systems. However, this is nothing more than a simple comparison of each system, which has limitations in deriving specific improvement directions for the system. Thus, the differentiation of this study is based on the comparative analysis of specific information in each system, using the problems that have been drawn through literature review as the basis for evaluation.

<Table 2> Deduction of implications through consideration of literature review

Content	Author	Main research content	Implications
Disaster information gathering system	Kho, *et. al.*(2018)	In big data, information resource management is very important. Therefore, systematic management in the process of gathering, managing and analyzing of information is required	Big data based on the need for systematic management of large amounts of information
	Kang, *et. al.*(2006)	In the construction of the disaster information system, the absence of work linkage was drawn as a problem of disaster management due to difficulties in systematic information management	The need for an integrated disaster gathering system through the establishment of a link between disaster operations
Disaster information resource management	Kim, *et. al.*(2015)	When disaster information is gathered in a centralized manner, there are limitations to data gathering due to system reliability and availability issues	Need to manage information resources of disaster information to improve the availability of the system
	Jeong, *et. al.*(2016)	In the management of large amounts of information, unnecessary data need to be processed by separating the actual data, which can increase the system's operational efficiency	Information utilization needs to be identified in terms of each phase of disaster management
Comparative analysis of overseas cases	Yoon(2011)	The implications of Korea's disaster management system were drawn by comparing IT-based disaster management systems overseas	Comparison between SDMMS and overseas' systems is required

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Analysis Framework

The analysis criteria were prepared based on the problems of the current SDMMS derived through Theoretical components and Precedent Study. Through comparative analysis of SDMMS and overseas disaster situation management system, improvement direction is derived. The comparative analysis criteria derived are as follows.

First, the disaster situation management system needs to receive disaster and safety information from related agencies and ordinary citizens and present them in a single system to effectively manage the disaster situation. However, the SDMMS collection of disaster-related information is very limited and disaster cooperation systems are not being established either. Studies on the nation's disaster management system also pointed out that decentralized response among various ministries and agencies by type of disaster takes place. It also points out that the lack of close cooperation makes it difficult to provide systematic support in the situation of disaster response and does not provide rapid information delivery(Huh, 2014). Therefore, we would like to compare the sources of disaster and safety information. Through comparison, the collection system by information can be identified and the disaster cooperation system can be improved.

Second, the disaster situation management system should provide information on situation management and decision support for the entire process of disaster management ranging from prevention, preparedness, response and recovery. The current SDMMS, however, is focused on prevention and preparedness, making it impossible to support situation management for the response and recovery process. Therefore, it is required to distinguish and compare whether or not functions are supported in each stage of prevention, preparedness, response, and recovery for disaster and safety information covered by the current system. Through comparison, the level of functions for each information can be identified and insufficient support functions can be improved for each information and disaster management stage.

By comparing the scope of collection of disaster and safety information and the application of each stage of disaster management, improvement directions for integrated disaster situation management can be derived. Therefore, the analysis framework as shown in the table below can be applied.

Based on the analysis criteria in <Table 3> above, SDMMS of the National Institute of Disaster and Safety is compared and the overseas disaster situation management system is analyzed. Based on disaster and safety information (observation information, information by disaster type, infrastructure information, evacuation and rescue information, and social media information). A comparative analysis was made to see if the data building and response system of each stage of disaster management is well-equipped and if disaster-related information can be processed and displayed by receiving it from public institutions, private institutions and the public.

Comparative Analysis of Overseas Disaster Management Systems

Comparable systems are open platforms, not government-level disaster management systems. The reason why we compare and analyze with open platforms is that not many of the national disaster situation management systems overseas are managed at an integrated and comprehensive level. Even if it existed, it was not easy to analyze because it had limited accessibility. Therefore, we are going to analyze the open platform disaster situation management system abroad and draw up a direction for improvement of Smart Disaster Situation Management System.

<Table 3> Framework of comparative analysis

By collection scope and management step / Disaster and safety information	Information collection			Disaster management steps
	Govern-ment	Private	Citizen	Prevention ▽ Recovery
• Observation information			○	
• Disaster information				
• Infrastructure information		○		
• Evacuation and rescue information				
• Social media information	○			

Prevention: Preparation: Response: Recovery:

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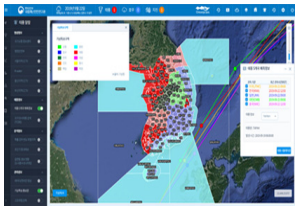
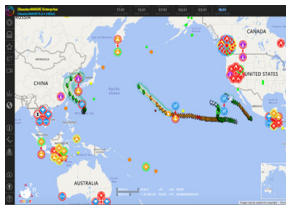
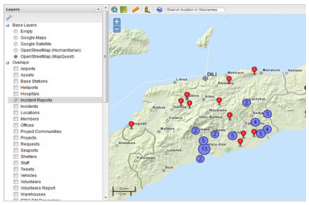
General Points and Characteristics of the Disaster Management System in the Countries to be Compared

It is important to understand the general details of each country's disaster situation management system before trying to figure out what level the SDMMS is. The comparative analysis targets PDC(Pacific Disaster Center) of the United States and Sahana Eden(Emergency Development ENvironment) of Sri Lanka all serve as systems to help disaster management in countries. They will first look at the differences in general matters of the system, such as information sharing system, information collection method, and disaster and safety information.

Originally, the SDMMS was planned to be publicly distributed to all users. However, it is currently required to obtain and use ID when requested by related agencies. It is a situation in which it cannot function as an open platform. The system displays disaster and safety information provided by satellite images, CCTVs and unmanned helicopters based on GIS and real-time video streaming. The range of contents covered is concentrated on earthquakes, typhoons and rainfall in the case of natural disasters, and only the air pollution index and the living environment index in the case of social disasters. It provides safety information on health facilities, public safety facilities and evacuation facilities. Other information includes traffic observations, history of past disasters, and information on tweets.

The U.S. PDC is developed and managed by the State University of Hawaii. It is an open platform that can be used anywhere in

<Table 4> Comparative analysis of general matters of disaster situation management system

Division		SDMMS(Korea)	PDC(USA)	Sahana Eden(SriLanka)
System screen				
Information sharing system		Closed type	Open type	Open type
GIS-based		○	○	○
Leverage big data		○	○	○
Use SNS		○	○	○
Observation information		○	○	×
Natural disaster	Earthquake/Tsunami	○	○	○
	Tropical cyclone	○	○	△
	Volcano	×	○	×
	Avalanche	△	○	×
	Thunderstroke	×	○	×
	Rainfall/Flood	○	○	×
	Other	• Heat wave • Cold wave	• Drought • Abnormal temperatures • Waves • Storms	×
Social disaster	Fire	×	○	×
	Biomedical hazards	×	○	×
	Air pollution	○	×	×
	Other	• Living environment index	×	×
Infrastructure / Safety information		• History of past disaster occurrence • Health facility • Public safety facility • Evacuation facility • Gas station • CCTV	• Nuclear power plant • Railroad • Road • Submarine communication cable • Dam • Drainage system	• Volunteer / Disaster management practitioners location • Relief goods inventory and transportation vehicles • Wireless communication equipment • Shelter
Other		• Traffic information • Traffic incident information	• Population • Lines of longitude and latitude • Detail coast line	×

Application:○ / Partial application:△ / Not applied:×

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the world. The PDC collects weather and satellite images from organizations such as NASA and NOAA and exposes information through the Internet and mobile disaster alert applications based on GIS. PDCs are divided into several platforms, depending on the type of user. There are 'Disaster Alert' available to all users, 'Emops' available to disaster managers and humanitarian assistance practitioners, 'VinAware' and 'DMRS' available to limited users on regional and institutional platforms. The scope of content covered by the "Disaster Alert," available to all users, covers disasters such as earthquakes, tidal waves, tropical cyclone, volcanoes, avalanches, landslides, lightning, rainfall, floods, droughts and storms in the case of natural disasters. In the case of social disasters, it deals with forest fires, biological and medical risks, etc. It provides safety information on nuclear power plants, railways, roads, dams and drainage systems. Other information includes population, latitude, and detailed shorelines.

Sri Lanka's Sahana Eden is run by the Lanka Software Foundation, a non-governmental organization. It is used as part of the official portal of Sri Lanka's main government agency, the National Operations Center. Sahana's information sharing system is an open platform and open-source software. Governments, disaster management practitioners and citizens alike can efficiently register and track rescue requests and coordinate response agencies and resources. In the end, it provides solutions to reduce the impact of disasters on the local community. The range of content covered by Sahana includes earthquakes and tidal waves in the case of natural disasters, and provides safety information on the location of volunteers, disaster managers and emergency response agencies, relief goods inventory and transportation vehicles.

Therefore, the general points of each country's disaster situation management system discussed so far can be compared as follows.

Comparing the general points and features, we can see that SDMMS provide contents biased against natural disasters, such as typhoons and earthquakes. In particular, there are very few contents related to social disasters such as frequent fires and livestock infection. Most of the various infrastructure information only provides information linked to natural disasters such as typhoons, earthquakes and heavy rains. The PDC deals with social disasters against fires, biological and medical risks. It also provides various infrastructure information, population and other information such as detailed coastlines. Because it provides information on the national infrastructure, such as nuclear power plants, railways, and communication cables, measures can be taken against facilities that should be protected in the event of a disaster and those that would be a risk component. Sahana Eden focuses on disaster management, mainly earthquakes, tsunamis and typhoons. In particular, it provides information on the location of volunteers and disaster management practitioners, inventory of relief goods, transportation vehicle information and shelter. This can be seen as providing disaster management information ranging from disaster preparedness to response and recovery.

After comparing SDMMS with overseas systems, this study found out that contents related to social disasters that can be expanded into composite disasters in SDMMS should be expanded significantly. It is also expected that the government will need to expand content and manage disaster situations, ranging from prevention and preparedness to the entire process of disaster management.

Comparison on the Utilization of the Disaster Management Systems

In order to understand the usability of SDMMSs, collection system of each disaster and safety information and the utilization level of each disaster management phase are to be measured. We also compare the SDMMS with overseas cases to draw improvement measures of SDMMS.

First of all, SDMMSs will receive radar images and satellite images from the Korea Meteorological Administration for observation information and display weather observation information such as rain, wind and temperature information by monitoring stations. Further, by establishing integrated sensor management function of SDMMS, the water level observation information of each monitoring station is displayed by linking AWS and water level sensors. In the case of infrastructure information, major infrastructure location information and video information by CCTV location of local governments are displayed through the connection of NDMS disaster information co-use system by the Ministry of Public Safety and Security and through CCTV video information by local governments. These meteorological and infrastructure information are used as information on conditions around the site in the event of a disaster. Therefore, meteorological and infrastructure information is used to draw the vulnerability through the hazard analysis and can be used in the preventive phase of disaster management.

Disasters information is provided through the connection of disaster information co-use system, disaster site sensor information, real-time video information and information link of relevant agencies. Such disaster information is presented as past disaster occurrence history, disaster forecast index, and disaster risk area, and there is not enough information to predict real-time progress of the disaster. In addition, disaster information enhances disaster response capabilities through overlapping observation information, infrastructure information and attribute information by type of disaster. However,

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since each observation and infrastructure information is provided by the monitoring stations and by the location of CCTV in the form of point data, it is difficult to analyze the risk of a disaster through overlapping analysis due to problems in connection between information in the event of a disaster. Therefore, disaster information can be utilized in the preventive and preparedness stages, but there is a limit to it in the response phase because of the lack of connection between disaster information and its effects, which makes it difficult to predict disasters.

Evacuation and rescue information are provided through the connection of the disaster information joint utilization system, and information such as health centers, public safety facilities and evacuation facilities are displayed. This evacuation and rescue information display evacuation and rescue facility's location in the form of point data. Therefore, real-time emergency response, life saving, medical and rescue activities required in the response and recovery phase of disaster management are difficult. In addition, since the SDMMS is a closed platform, it is not possible for all users to verify these evacuation and rescue information. Therefore, this information is currently being used only by the government and related agencies to identify and coordinate facilities. Therefore, evacuation and rescue information can be utilized in the preventive and preparedness phases of the disaster management, and information and functions are insufficient to be utilized in the response phase.

Social media information is provided on-site status such as SMS, photos and videos through Twitter from all users. In addition, the SNS information provided is expressed as point data on GIS, which enables an analysis of the progress of the disaster. Therefore, such social media information enables the prediction of disaster and damage situations, and therefore social media information is utilized throughout the whole stage of disaster management to support decision-making.

The U.S. PDC gathers information such as radar images and satellite images from agencies such as NASA and NOAA for observation information. In addition, real-time weather conditions are predicted through climate modeling agencies such as GFS (Global Forecast System) and NCEP (National Center for Environmental Prediction) to display various observations, including wind, precipitation, and sea level temperature, through photographic and imaging information. The infrastructure is provided with information such as nuclear power plants, railways, roads and undersea communication cables through the information system of each facility. Infrastructure information is expressed in the form of point data and has property information such as status of each location, operator, owner, and supplier. These observations and infrastructure information enable analysis of the extent of the effects and risks of a disaster. Therefore, observation and infrastructure information can be utilized in the preventive, preparedness and response phases of the disaster management.

Disaster information is gathered through each disaster warning and prediction center and the National Meteorological Agency. The disaster information in this system is not simply presented as location data at the site of the disaster, but also exposes new disaster information through the convergence of high-level analysis systems, such as real-time progress analysis of the disaster, potential disaster probability analysis, and disaster damage analysis. This disaster information enables prediction of the progress of the disaster and analysis of the effects of the disaster. Therefore, disaster information can be utilized throughout the entire phase of disaster management to help make decisions and to establish highly predictive and analytical information.

Observation information in Sri Lanka's Sahana is provided by the National Weather Service with weather observation information such as rainfall, cloud amount and current weather. This information is expressed in the form of point or face data. Such observation information can be used as information about the conditions around the site in the event of a disaster. In addition, disaster information exposes the location of recent earthquakes as point data, and the location where sea levels have risen by more than 2 meters in the form of face data. This observation and disaster information can be presented on the basis of GIS to provide visual identification in the event of a disaster. However, the lack of attribute information contained in each information can only be used in preventive phase of disaster management.

Infrastructure is provided information such as airports and ports through e-documents on Sahana's homepage, and SNS by public institutions, private institutions, NGO field managers and the public. Evacuation and rescue information is also provided relief organizations, relief projects, volunteers and information on the inventory and assets of relief goods by all users through e-documents on Sahana's homepage and through SNS. These infrastructure, evacuation, and rescue information are displayed in form of point data based on GIS and have property information such as location, contact number, and activity area of each information. Through this information, related agencies, disaster site personnel, missing persons and volunteers can identify real-time disaster and safety information. This can reduce the scope of damage from disasters by efficiently adjusting rescue requests and resources. Thus, infrastructure and evacuation and rescue information can be utilized throughout the whole phase of disaster management.

Social media information is provided site situation information such as disaster occurrence, rescue request and rescue resource request in real time by Twitter from all users. The SNS information provided makes it easier for field personnel and volunteers to assist

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in the rescue. In addition, such SNS information can be presented in form of point data based on GIS to visually identify the disaster progress. Thus, social media information can be used throughout the whole phase of disaster management.

<Table 5> compared the utilization of each disaster management system to the analysis criteria and provided a visual indication of the gathering system and utilization of each disaster management system.

As a result of the analysis, most of the information in the SDMMS was provided in connection with the NDMS disaster information co-use system of the Ministry of Public Safety and Security, and other existing information was provided through public institutions, private institutions and local governments. Thus, the information provided by the public is limited to social media information, which has also been found to be underutilized due to uncertainties in information such as real-time response checking and inability to identify the motivation for tweeting. In addition, information from SDMMSs, excluding social media information, could be found to be in the preventive and response phase of the disaster management.

As the U.S. PDC only deals with observation, infrastructure, and disaster information, the diversity of information was small, while the contents of each information were sufficient, and information establishment by disaster, observation, and infrastructure was organized. In addition, it is easy to visually identify disasters by expressing information through photographic and imaging information, and it is highly analytical because of the variety of attribute information that each information contains. Thus, almost all information can be utilized throughout the whole phase of disaster management.

Sri Lanka's Sahana was able to provide information from all users except observation and disaster information. In addition, as the information is provided through SNS and e-documents, real-time disaster situations and rescue resources can be identified and assisted in disaster response and recovery. Therefore, Sahana can be utilized in the all phase of disaster management unlike the SDMMS and PDC, among which it can be actively used in the response and recovery phase, effectively losing in case of a disaster and reducing the scope.

Discussion

Through a comparative analysis of general matters and usability of SDMMS and overseas disaster management system, the following improvement directions were drawn.

First, it is deemed essential to establish an integrated gathering system of disaster and safety information. SDMMS cannot provided with on-site information such as rescue requests and disaster occurrence situations because information gathered is limited. However, in the case of Sri Lanka's Sahana, this information gathering system is very systematic and integrated, so that rescue and field information can be effectively provided in the event of a disaster. Therefore, it is necessary to improve information gathering methods by users, such as e-documentation on the system, development of real-time disaster site alerts and rescue request apps. Through the improvement of the information gathering system, it is deemed that highly utilized information will be established to enhance the efficiency of disaster management.

Second, it is deemed urgent to expand disaster and safety information and attributes information for each information. SDMMSs cannot respond to social disasters and complex disasters due to the lack of such disaster and safety information. In addition, the current system only provides information that is biased toward natural disasters such as earthquakes and typhoons. In other words, there is no information available to manage various social disasters and complex disasters in the current system, and it will be difficult to respond quickly to actual disasters. Overseas disaster management systems provide information on social disasters such as fires, biological and medical risks, as well as information on various infra-

<Table 5> A Comparative analysis on the utilization of disaster management system

By Collection Scope and Management Step / Disaster and Safety Information	SDMMS (Korea)				PDC (USA)				Sahana Eden (SriLanka)			
	Information Collection			Disaster Management Steps	Information collection			Disaster Management Steps	Information collection			Disaster Management Steps
	G	P	C		G	P	C		G	P	C	
Observation Information	○	○			○	○			○	○		
Disaster Information	○	○			○	○			○	○		
Infrastructure Information	○	○			○	○			○	○	○	
Evacuation and Rescue Information	○	○							○	○	○	
Social Media Information	○	○	○						○	○	○	

Prevention : Preparation : Response : Recovery :
G : Goverment P : Private C : Citizen

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structure, evacuation and restoration. This information supports effective awareness and response to disasters. However, as many types of disasters are not included in overseas systems, it is difficult to cope with a complex disaster. But there are many restrictions in dealing with all disasters. Therefore, we first need to add disasters such as fires, infectious diseases, infectious disease in domestic animals and fine dust as defined Framework Act on Disaster and Safety Management. In addition, existing information such as typhoons and earthquakes should be enhanced to recognize and respond to disaster situations. If the systematic information gathering and deployment system for each disaster is established later on, can effectively respond to multiple types of disasters simultaneously.

Third, it is deemed essential to systematize information for each disaster so that it can be utilized at all phase of disaster management. Various information, such as analysis information, past information, observation information, infrastructure information, and disaster information, should be established systematically. And It is necessary to expand disaster and safety information that reaches the entire process of response and recovery besides prevention and preparedness of disasters. In addition, effective visualisation ways are needed for information display. This will help the decision maker quickly identify the situation and make decisions in the event of a disaster, thereby helping to minimize the damage. Therefore, it is deemed that the systematic management of the information of each disaster through the expansion of information and improvement of the function of expressing and it will be efficiently utilized in all phases of disaster management.

In addition, a unified system should be applied to local governments and related agencies to support primary disaster response to suit local characteristics. This allows local governments and related agencies to respond effectively and timely in the entire process of disaster management. When a disaster management system is later distributed, it will be necessary to develop a technology that can incorporate content that suits the characteristics of the agency.

Conclusion

In addition to natural disasters, social disasters and Compound disasters such as the sinking of the Sewol ferry, paralysis of national infrastructure, Kangwon wildfires, and ASF are occurring frequently and in various types.

Our society is undergoing social and environmental changes such as climate change, urbanization, industrialization, and population density increase. Large-scale disasters where various risk factors are interconnected are frequent. In particular, the number of compound disasters is increasing, with single disasters expanding into various types of disasters(Current Daily, 2017). In particular, Korea has a large number of facilities, including state infrastructure, energy-related facilities, and livestock and meat farming facilities, in the land where urbanization rates are high and narrow. That is why it is highly likely that one disaster will escalate into several disasters. Therefore, the government should be able to effectively prepare for and respond to not only natural disasters and social disasters, but also to compound disasters that occur continuously and simultaneously. To this end, the government needs to establish and upgrade a disaster management system.

This study derived improvement measures of SDMMS through analyzing overseas system cases. The disaster and safety information of domestic and overseas systems were compared by dividing them by the level of disaster management and the scope of information collection. The comprehensive comparison of the collection and management of disaster information was made and the improvement direction was derived for integrated disaster situation management.

Contents on frequent disasters such as fires, infectious diseases, livestock epidemics and fine dust should be expanded first and existing information should be enhanced to recognize and respond to disaster situations. In the future, the information sharing system for each disaster shall be established, and disaster-related data and various facility information shall be displayed in accordance with the disaster situation. Eventually, we can respond effectively to multiple types of disasters at the same time. In addition, various information, such as historical data, observation information, infrastructure information, and public information, should be established systematically. It is also expected that the government will need to expand content and manage disaster situations, ranging from prevention and preparedness to the entire process of disaster management.

In order to come up with a more systematic analysis standard in conducting this study, it should have been aimed at comparing the disaster situation management system of government agencies outside the country. However, the data collection was limited because the system was not being disclosed for security reasons. If these problems are overcome, they will be of great help in drawing up ways to compare and improve the disaster management system. Still, the study carries great significance in the current situation, where various and compound disasters are frequent. This can be meaningful in that the system has strong poetic character to expand contents of social disasters and compound disasters, and to expand contents of each stage of disasters. It can be meaningful in that it is the beginning of a study on the expansion of contents in

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social and compound disasters of the disaster situation management system and the expansion of contents in each stage of the disaster. It is deemed necessary to continuously study the development direction of the disaster management system and the expansion of contents in the future.

Acknowledgement

This study was conducted as a major project of the National Disaster Management Research Institute (NDMI-PR-2019-03-04).

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