

Article

Improvement Measure of Integrated Disaster Management System Considering Disaster Damage Characteristics: Focusing on the Republic of Korea

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Abstract: Recently, the Republic of Korea has experienced natural disasters, such as typhoons and heavy rainfall, as well as social accidents, such as large-scale accidents and infectious diseases, which are continuously occurring. Despite repeated disasters, problems such as inefficient early response and overlapping command systems occur continuously. In this study, we analyzed the characteristics of disaster management systems by foreign countries, and the status of the damages by disasters for the past 10 years in the Republic of Korea, to suggest possible measures to improve the Republic of Korea's integrated disaster management system. When a disaster occurs in the Republic of Korea, the Si/Gun/Gu Disaster Safety Measure Headquarters, under the command of the local governments, become the responsible agencies for disaster response while the central government supervises and controls the overall disaster support and disaster management. To improve the current disaster management system, we propose to incorporate all disaster types rather than dividing them by type into natural disasters and social disasters. To improve the disaster response and disaster management system, we propose to restructure the current administrative organization, revise the disaster-related laws, and overcome problems, such as inter-ministerial interconnectivity and overlapping regulation.

Keywords: disaster management system; natural disaster; social disaster; improvement measure; the Republic of Korea

1. Introduction

Recently, because of an increase in local typhoons and heavy rainfall resulting from climate change and rapid economic growth driven by urban and industrial development of the Republic of Korea, disaster aspects are becoming more complicated, diversified, and large-scale. Since these changing aspects of disaster require a rapid disaster response, an effective government disaster management system is emphasized.

According to foreign studies on disaster management, it has been often reported that abnormal weather phenomena occur frequently due to the influence of climate change and national development plans, and that the possible occurrence of a disaster that incurs colossal damage is on the rise [1–4]. Hundreds of natural disasters occur globally yearly, and since 1980, such disasters have claimed approximately two million people's lives and caused \$300 billion in damages [5,6]. It requires the

collection, confirmation, and management of disaster-related data to establish a policy or system for disaster control [7]. Data mining and analysis technology must be integrated for an effective management of disaster-related data to collect and update data about various kinds of disasters from news and the scale of damages on a real-time basis. The subsequently accumulated data serve as the framework of a database for disaster management depending on the disaster type [8,9].

In the Republic of Korea, various disasters, including Typhoon Rusa, Typhoon Maemi, the Daegu subway fire accident, the Taean oil spill accident, the Mt. Umyeon landslide, the sunken Sewol ferry accident, and the Middle East Respiratory Syndrome (MERS) epidemic outbreak, have caused the loss of many people as well as severe property damage. The occurrence of these large-scale disasters fueled an opportunity to build and complement governmental agencies. The principal responsible agency has changed from being the National Emergency Management Agency to the Ministry of Public Safety and Security and was again reorganized into the Ministry of the Interior and Safety. Disaster management is a term used in different countries and in different languages, but is generally divided into step-by-step activities: prevention, preparedness, response, and recovery [10–14].

As disasters are beyond the capacity of individuals to manage, they require the government's intervention to establish and manage a disaster management system [14,15]. Many theories, including the disaster incubation theory, normal accidents theory, and high reliability theory, have been proposed, and many studies have been established to facilitate understanding of the characteristics of disasters. Many studies have been conducted to define the socially vulnerable people at disaster sites by economic, physical, and environmental conditions [14,16,17]. The occurrence of large-scale disasters has fueled an opportunity to recognize the importance of national-specific disaster management systems and has provided an important turning point for organizational restructuring and law revision to ensure effective disaster management. In the United States, disaster management began in the 1960s because of the occurrence of large-scale natural disasters such as hurricanes, the 9/11 terrorist attacks in 2001, and Hurricane Katrina in 2005, which served as momentum to establish the current disaster management system [18,19]. In Japan, the Disaster Relief Act was enacted after the Nankai earthquake in 1946. After the Great Hanshin-Awaji Earthquake in 1995, the role of the Cabinet Office was expanded to integrate disaster management. When the Great East Japan Earthquake occurred in 2011, a combined disaster of earthquakes, tsunamis, and a nuclear plant accident provided an opportunity to enact the 'Basic Law on Great Earthquake Reconstruction' and establish the current disaster management system [20,21]. The Republic of Korea enacted its disaster management law after the collapse of the Samping Department Store in 1995, launched the National Emergency Management Agency in the wake of Typhoon Maemi and the Daegu subway fires in 2003, and enacted the 'Basic Act on Disaster and Safety Management'. After the sunken Sewol ferry accident in 2014, the Ministry of Public Safety and Security was launched to respond to natural and social disasters in an integrated manner and was again reorganized into the Ministry of the Interior and Safety in 2017 to establish the current disaster management system.

While the Republic of Korea experienced the sunken Sewol ferry accident in 2014 and the MERS epidemic outbreak in 2015, many problems were revealed, including a lack of an effective early response to cope with a large-scale disaster, the absence of a clear definition on the responsible agency for disaster management, and an ineffective disaster response system with too much focus on administrative organizations [22,23]. For disaster management, a quick collection and distribution of disaster-related information also play a critical role in minimizing damages and alleviating risks [24]. In the Republic of Korea, a disaster evacuation guide app that taps into smartphone GPSs for the collection of disaster information has been applied in recent years to ensure a prompt disaster response and a quick distribution of disaster information [25–28]. However, despite such advanced disaster management technology, legal and institutional entanglements actually cause confusion in disaster responses [29–32]. In this study, we propose measures to improve the Republic of Korea's integrated disaster management system by considering disaster management and the status of damages by disasters.

As study methods, we examined the respective characteristics of disaster management systems of Japan, Germany, the U.S., and the U.K. and conducted a survey on damage levels and problems caused by disasters occurring for the past 10 years in the Republic of Korea to identify measures to improve the disaster management system.

This study was conducted to identify the problems of the current disaster management system in the Republic of Korea and propose measures to improve the integrated disaster management system by considering the status of damages from past disasters.

2. Domestic and Overseas Disaster Management Systems

2.1. The United States

In the case of disaster management in the United States, the Federal Emergency Management Agency (FEMA), established in 1979, plays a pivotal role in operating an integrated management of natural disasters and man-made disasters. The FEMA was incorporated into the Department of Homeland Security (DHS) in 2003 under the ‘Stanford Act’ but performs the same main functions. The FEMA operates the National Response Framework and the National Incident Management System and is responsible for the prevention, preparedness, response, and recovery of disasters [33,34]. The organizational chart of the disaster management system of the U.S. FEMA is shown in Figure 1.

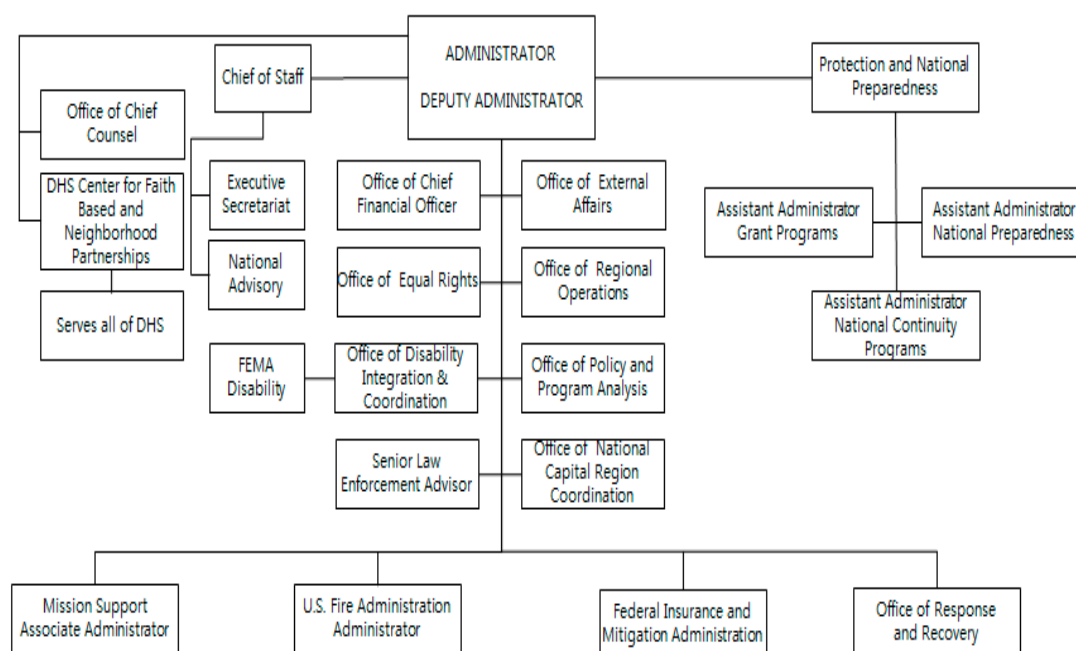


Figure 1. Organizational chart of the U.S. the Federal Emergency Management Agency (FEMA; <https://www.fema.gov/>).

The U.S. disaster management system incorporates vertical relationships between federal, state, and local governments and the FEMA responds to disasters effectively by integrating all responsibilities and obligations for all disasters [19,35–37]. If we look at early response to disasters, local governments respond with nearby local autonomous communities, state governments, and volunteer agencies, but if the scale of a disaster is beyond a local government’s capacity, the state and federal government will intervene in disaster relief. At the request of state governments, various types of support including search, rescue, electric power, food, water, shelter, etc., can be mobilized by the federal government.

2.2. Japan

In the case of disaster management in Japan, the Central Disaster Management Council (CDMC) was established in 1962 to formulate the basic measures for disaster management. Since enactment of the 'Basic Law on Disaster Preparedness', the CDMC has been chaired by the Prime Minister of the Cabinet Office, a central agency responsible for disaster management, to implement the procedures of disaster prevention, preparedness, response, and recovery [38]. The heads of municipalities or prefectures serve as the heads of their respective disaster response headquarters; the central government establishes the emergency response headquarters headed by the minister responsible for disaster prevention; the Prime Minister serves as the head of the Emergency Disaster Response Headquarters to prepare for disaster. The organizational chart of the CDMC is shown in Figure 2 [39].

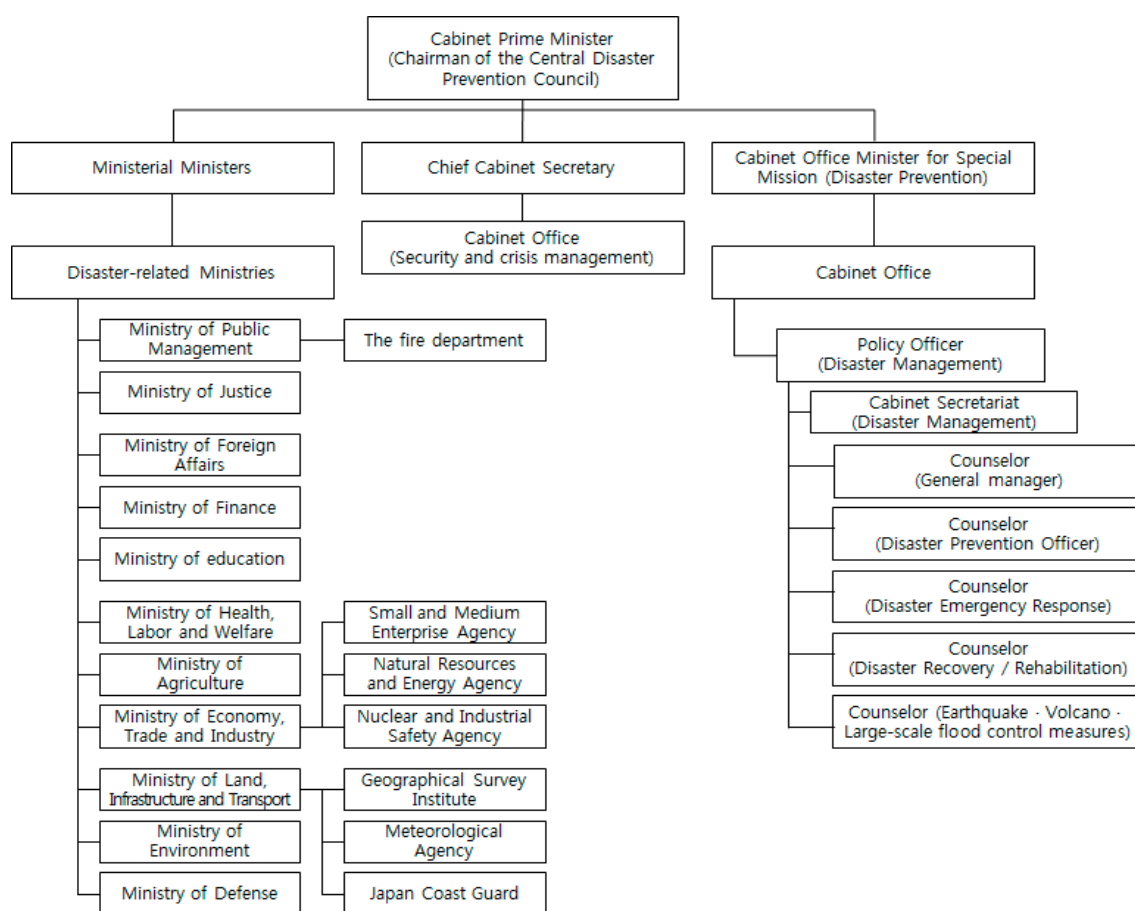


Figure 2. Organizational chart of Japan's Central Disaster Management Council (<http://www.cao.go.jp>).

In the event of a disaster, municipality governments are responsible for the initial response, while prefecture governments will provide assistance for the smooth implementation of disaster response. The central government will play the role of providing overall assistance as well as supervising disaster response. For the prevention and recovery of disasters, municipalities, prefectures, and the central government will jointly perform their responsibilities. Additionally, local governments revised their local disaster prevention plans to strengthen the linkage between municipalities and prefectures and identify human and material resources in their areas, including public and private organizations as well as residents, which will be applied by the early response system in the event of a disaster [40].

2.3. Germany

For disaster management, Germany established the Federal Office of Civil Protection and Disaster Assistance (BBK) in 2004 and is operating an integrated crisis prevention system for an effective

management of disaster control by federal and state governments. The BBK abides by the regulations of a state government’s disaster protection law enacted in accordance with the federal government’s “Civil Protection Act”, and the German Federal Agency for Technical Relief (Bundesanstalt Technisches Hilfswerk: THW) assigns and supervises relief work. An integrated crisis prevention system to respond to a comprehensive crisis situation is operated by the German disaster management system consisting of the Federal Office of Civil Protection and Disaster Assistance (in the second administration vice minister’s office under the under the Federal Interior Ministry), the German Federal Agency for Technical Relief (THW), the Federal Office of Civil Protection and Disaster Assistance (BBK), etc., (Figure 3).

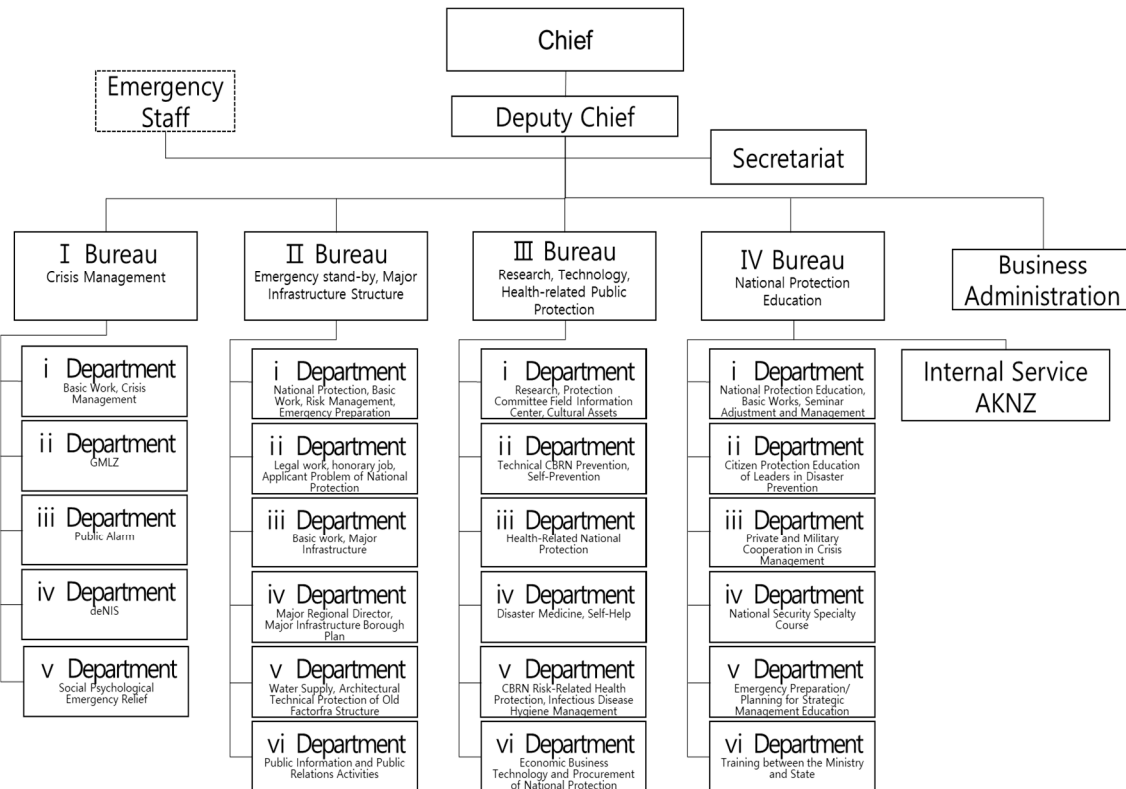


Figure 3. Organization chart of Germany’s disaster management organization under the Federal Interior Ministry.

Germany’s disaster response system comprises four directorates under the Second State Secretary under the Federal Interior Ministry. Among them, the Federal Office of Civil Protection and Disaster Assistance plays the most critical role and consists of a total of six divisions: Division KM 1 serves as the coordination center and addresses national crisis management works, Division KM 2 is responsible for NATO and EU-related works, Division KM 3 is the Federal Agency for Technical Relief and is also responsible for international support, Division KM 4 (responsible for reporting on the critical infrastructure), Division KM 5 (responsible for weapons and explosives legislation (National Weapons Register) and for safety legislation), and Division KM 6 (responsible for communications, command, and control).

2.4. The United Kingdom

In the case of the UK’s crisis management system, the Civil Contingencies Secretariat (CCS), which was created under the Cabinet Office in 2001, establishes and operates an integrated crisis management system that includes disaster response systems and civil defense in one unit. The CCS, which uses a result-oriented integrated disaster concept in accordance with the Civil Contingencies Act

(2004), is responsible for military security based on civil defense and also responds to various kinds of threats regardless of causes and types. The integrated disaster management system of the CCS consists mainly of preparation, response, and recovery systems, geographically divided into local and central government units. The organizational chart of the integrated disaster management system of the CCS of the UK Cabinet Office is shown in Figure 4.

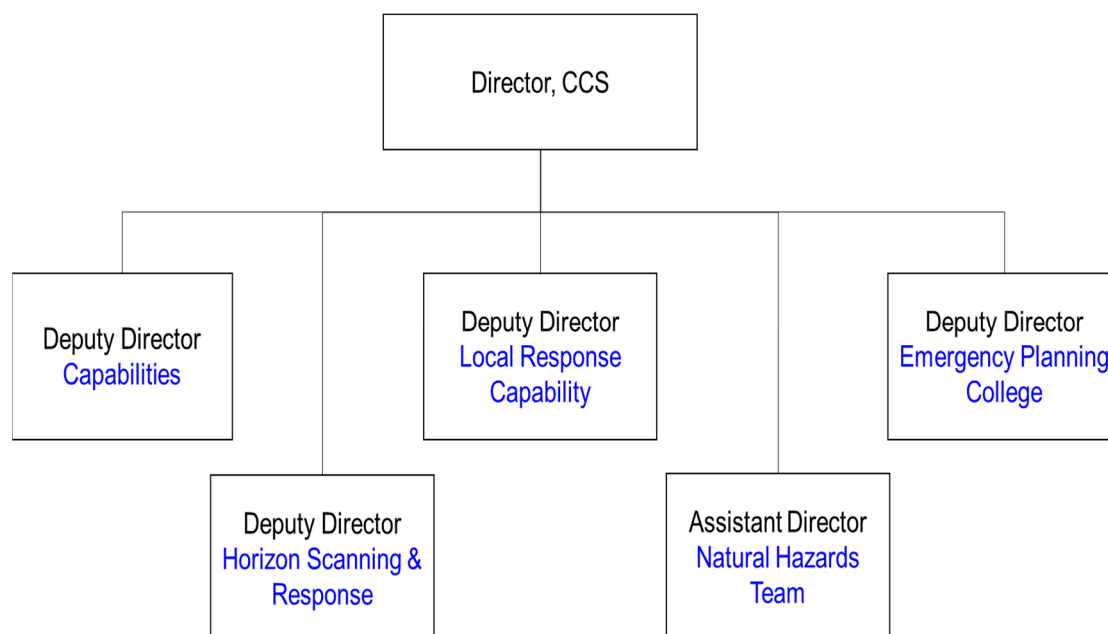


Figure 4. Organizational chart of the Civil Contingencies Secretariat (CCS) of the United Kingdom.

In the case of the UK disaster management system, preparation, response, and recovery are performed by local governments, and all disaster situations are managed without the intervention of the central government. As the central government unit, the CCS under the Cabinet Office is responsible for coordinating emergency response efforts of central government agencies to maintain the uniformity and consistency of disaster management policies of the central government. The UK government also classifies disasters by types and designates a governmental department considered the most appropriate to a particular disaster type as the respective responsible agency to address preparation, response to, and recovery.

2.5. The Republic of Korea

For disaster management, the Republic of Korea launched the National Emergency Management Agency in 2004 in the wake of the Daegu subway accident in 2003, which was incorporated into the Ministry of Public Safety and Security in 2014 and again into the Ministry of the Interior and Safety in July 2017. Since the enactment of the 'Basic Law on Disaster and Safety Management', the Ministry of the Interior and Safety has established an integrated disaster response system by incorporating disaster management institutions under the wing of the National Disaster and Safety Status Control Center. The organizational chart of the National Disaster and Safety Status Control Center under the Ministry of the Interior and Safety is shown in Figure 5.

In the Republic of Korea, the head of the National Disaster and Safety Status Control Center (the Minister of the Interior and Safety) is at the core of the disaster management system and has the general command to control all disaster responses and operate the Si/Gun/Gu Disaster Safety Measure Headquarters to respond to disasters. In the case of early response to a disaster, the City/Gun/Gu Disaster Safety Measure Headquarters will conduct an emergency response and the central government, after being reported on the occurrence of disasters, will embark on a systematic disaster response

in accordance with the 'National Crisis Management Guidelines'. Additionally, all decisions on prevention, preparedness, response, and recovery in the wake of disaster occurrence will be made through the Si/Gun/Gu Disaster Safety Measure Headquarters under the command of the central government [41].

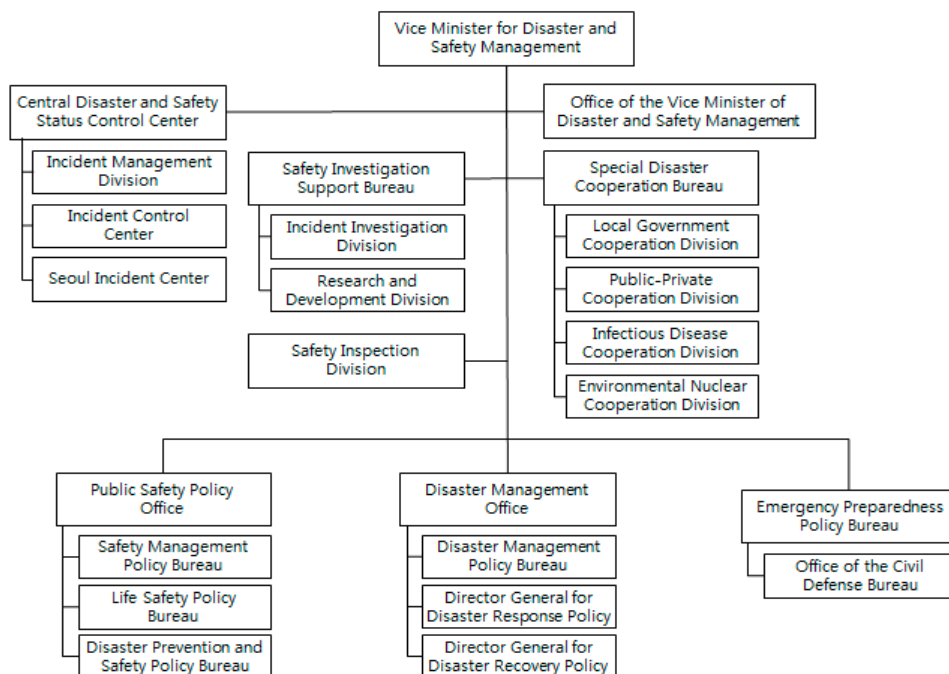


Figure 5. Organizational chart of Central Disaster Safety Relief Headquarters under the Ministry of the Interior and Safety in the Republic of Korea (<http://www.mois.go.kr>).

If we look at the domestic and overseas national disaster management systems investigated by this study, it is identical for local governments to initiate the response to a disaster at an early stage. However, local governments of Japan, Germany, the U.S., and the U.K. are responsible for continuous disaster management, while their central governments support them by providing materials and personnel required to curb disasters. In contrast, local governments in the Republic of Korea intervene in the central government to report the overall progress of disaster management and to respond to disasters.

The overseas cases in this study do not represent the disaster management system of every country or cannot be used as guidelines. However, the above-mentioned countries were selected as the subjects of a comparative analysis due to limited availability of data about overseas disaster management systems and also because these countries have established their current disaster management systems after undergoing various disasters over a lengthy period.

3. Disaster Management System and the Status of Damages by Disaster Type in the Republic of Korea

3.1. Disaster Management System by Disaster Type

In the Republic of Korea, disaster is defined as an event that can cause damage to people's life, body, and property and to the nation in accordance with the 'Basic Act on Disaster and Safety Management'. In the event of a disaster, the Ministry of the Interior and Safety, centering on the National Disaster and Safety Status Control Center, will establish the Central Accident Practice Headquarters, depending on the type of disasters, and operate the Si/Gun/Gu Safety Measure Headquarters, constituting a vertical administrative organization that manages situation control, administrative assistance, rescue emergency, emergency assistance, volunteer works, etc., for disaster relief (Figure 6).

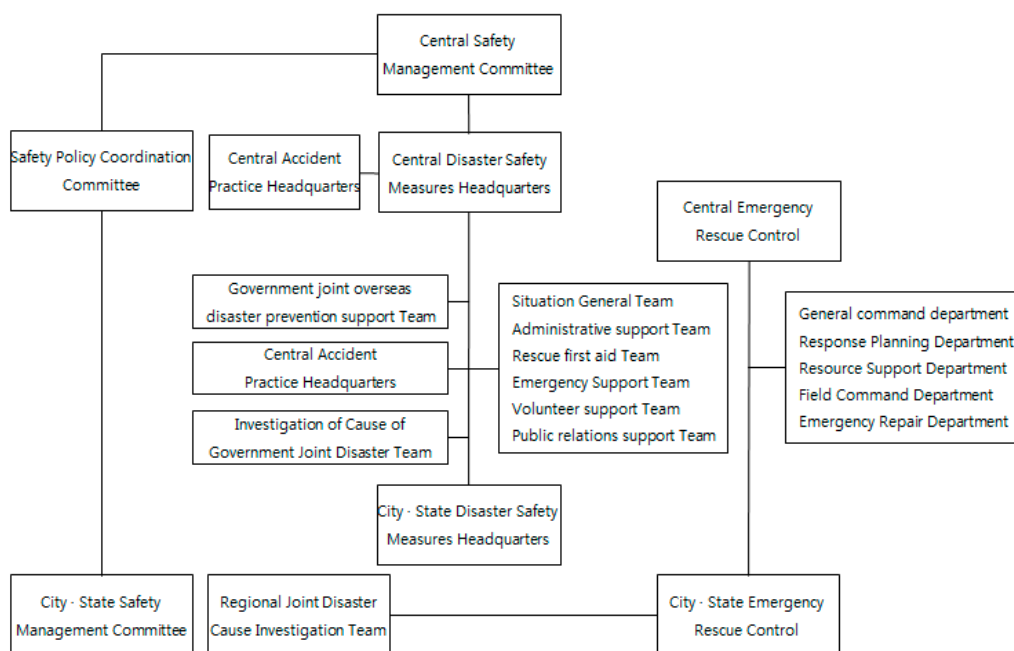


Figure 6. Organizational chart of the National Disaster and Safety Status Control Center under the Ministry of the Interior and Safety in the Republic of Korea (National Disaster and Safety Status Control Center (2011) Safety Management Plan in the Republic of Korea (2015–2019)).

The Republic of Korea has established an integrated disaster management system centering on the National Disaster and Safety Status Control Center in the event of disasters but will manage them by classifying disasters into natural disasters and social disasters. In accordance with the ‘Basic Act on Disaster and Safety Management’, natural disasters are caused by natural phenomena including typhoons, floods, heavy rain, strong winds, wind wave, tsunamis, heavy snow, lightning, drought, earthquakes, yellow dust, tidal currents, tides, volcanic activities, collision and collision of natural space objects such as asteroids and meteoroids, or comparable incidents. In contrast, social disasters are defined as damages beyond the magnitude designated by Presidential Decree that are caused by fire, collapse, explosion, traffic accidents (including air and marine accidents); chemical, biological, and radiological accidents; environmental pollution accidents, etc.; the paralysis of national infrastructure, including energy, telecommunications, transportation, finance, medical care, and water supply; as the damages caused by infectious diseases in accordance with the ‘Act on the Prevention and Management of Infectious Diseases’, and as the spread of livestock infectious diseases in accordance with the ‘Act on the Prevention of Livestock Infectious Diseases’.

The Republic of Korea classifies natural and social disasters into six and 26 types, respectively, according to the disaster classification system and disaster types, and implements the disaster management system of prevention, preparedness, response, and recovery to develop response and management strategies appropriate to each type of disaster (Table 1). The Ministry of the Interior and Safety also publishes an annual report on disasters that occur in the Republic of Korea. The status of damages caused by natural disasters in terms of human losses, damage cost, and recovery cost can be found in the ‘Statistical Yearbook of Natural Disaster’, while those caused by social disasters can be found in the ‘Statistical Yearbook of Social Disaster’.

Table 1. Types of Natural Disasters and Social Disasters in the Republic Korea.

Class.	Count	Disaster Types
Natural Disaster	6	typhoon, heavy rainfall, heavy snowfall, extreme wind, wind wave, heat wave
Social Disaster	26	forest fires, toxic chemical spills, large-scale water pollution, large-scale marine pollution, utility tunnel disaster, dam collapse, subway large-scale accident, large-scale high-speed train accident, large-scale fire at multi-use buildings, radioactive spills from adjacent countries, marine vessel accident, large scale human accident at workplace, large-scale collapse of multi-use buildings, correctional facilities' disasters and accidents, livestock diseases, infectious diseases, telecommunications, financial computing, nuclear safety, power, crude oil supply, health care, drinking water, land cargo transportation, GPS signal disturbance, space radio disaster

3.2. Human Losses by Disaster Types

The Republic of Korea implements disaster management by classifying disasters into natural and social disasters and publishes the reports on the status of damages by disasters. In this study, we analyzed the human losses of each year caused by natural and social disasters 2006–2015 by using the data of the '2015 Yearbook of Natural Disaster' and '2015 Yearbook of Social Disaster' (Table 2) [42,43]. The 'Yearbook of Natural Disaster' and the 'Yearbook of Social Disaster', which are statistical data used as national policy data, are released by a central government agency after collecting data about disaster damages reported by local governments.

Table 2. Yearly human losses by disaster type in the Republic of Korea (2006–2015).

		(Unit: People)										
Class	Year	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	Sum
	Natural Disaster		63	17	11	13	14	84	31	18	3	11
Social Disaster		5	6	54	224	85	3	5	12	411	67	872

The total human losses by disasters during the period was estimated at 1137 people, and among them, natural disasters accounted for 23% or 265 people, while social disasters accounted for 77% or 872 people, which was almost three times higher than natural disasters. In the case of the yearly proportion of human losses during the period, 2006 and 2011 accounted for 24% and 32%, respectively, both of which accounted for approximately 50%. In the case of social disasters, 2009 and 2014 accounted for 26% and 27%, respectively, both of which accounted for approximately 50%.

If we classify the total human losses of 265 people caused by natural disasters into types, heavy rainfall accounted for 68%, followed by heat waves (18%) and typhoons (14%). Among the total human losses of 872 people caused by social disasters, the marine vessel accident accounted for 47%, followed by infectious diseases (35%) and large-scale fires at multi-use buildings (15%; Figure 7). If we look at the yearly average of the statistical years, typhoons claimed the lives of four people yearly; heavy rainfall incurred a death toll of 18 people; heat waves incurred a death toll of nine people. It was confirmed that typhoons and heavy rainfall as well as heat waves caused severe human losses.

In the case of social disasters, human losses continued to occur yearly, including the H1N1 outbreak in 2009, the sunken Sewol ferry accident in 2014, and the infection disease (MERS) outbreak in 2015, in addition to large-scale forest fires and large-scale fires at multi-use buildings. Even if we excluded large-scale disasters, we could deduce that more human losses were caused by social disasters than by natural disasters. Until recently, it was perceived that natural disasters were the main causes of human losses, but the statistical results of this study showed that human losses caused by social disasters are more severe than by natural disasters.

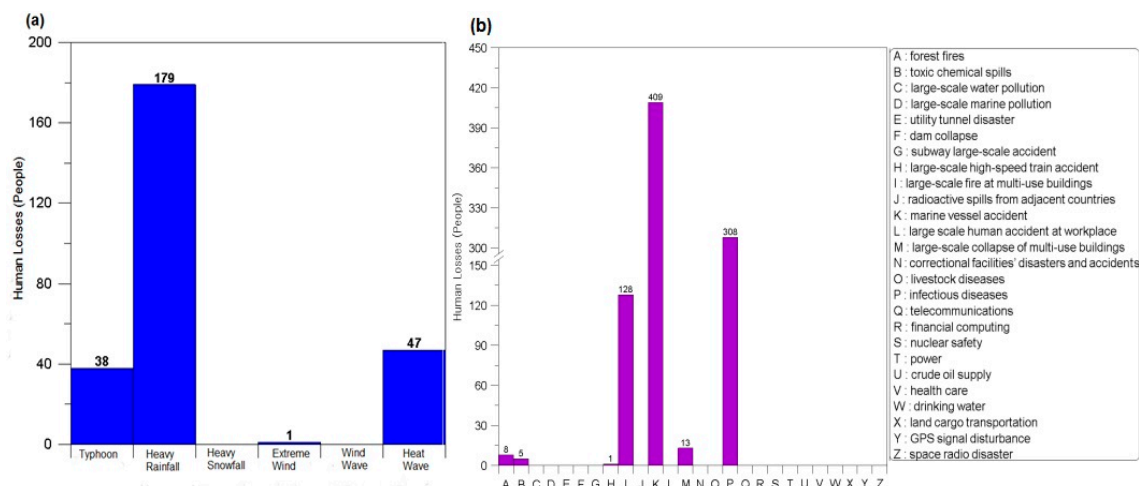


Figure 7. Human losses by disaster type in the Republic of Korea (2006–2015): (a) natural disasters and (b) social disasters.

3.3. Damage Costs and Recovery Costs by Disaster Type

In case of damages caused by disasters, the damages caused by natural disasters are assessed by estimating damage costs and recovery costs, while the damages by social disasters are evaluated using damage costs. Considering that damages from natural disasters are caused by natural phenomena, the estimation of damage costs combines the damages inflicted on buildings with the costs required to restore the damaged buildings to the original condition. In contrast, the estimation of damages by social disaster includes only damage costs. We analyzed the amount of damage costs and recovery costs caused by natural and social disasters, respectively, 2006–2015 (Table 3).

Table 3. Damage and recovery costs by year in the Republic of Korea depending on the disaster year (2006–2015).

		(Unit: Thousand Dollars (\$ = 1200 won))										
Year		2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	Sum
Class												
Natural Disaster	Damage	161,917	20,983	5308	24,900	35,567	66,183	90,767	14,333	15,000	2650	437,608
	Recover	304,250	40,808	12,308	64,458	59,608	137,833	171,100	32,217	42,258	3175	868,017
Social Disaster		100	17	556,458	183	163,000	100	25,117	10,617	4425	7875	767,892

The total damage and recovery costs resulting from natural and social disasters amounted to 2,173,517 thousand dollars in total; the damage costs caused by natural disasters accounted for 437,608 thousand dollars or 21% of the total; the recovery costs were estimated at 868,017 thousand dollars or 42%; and the damage costs caused by social disasters were estimated at 767,892 thousand dollars or 37%. If we looked at the damage costs from natural disasters by year, 2006 accounted for 37%, followed by 2012 (21%) and 2011 (15%). In the case of recovery costs, 2006 accounted for 35%, followed by 2012 (20%) and 2011 (16%), three of which accounted for more than 50% of the total damage and recovery costs during the period. In the case of damages from social disasters, 2008 and 2010 accounted for 72% and 21%, respectively, both of which accounted for approximately 90% of the total for the period.

The total damage costs caused by natural disasters were estimated at 437,608 thousand dollars, and if we classified them into type, typhoons and heavy rain accounted for 30% and 63% of the total, respectively; the total amount of recovery costs was estimated at 868,017 thousand dollars, and typhoons and heavy rain accounted for 29% and 69% of the total, respectively. Given this, an overwhelming majority of the damage and recovery costs result from typhoons and heavy rain. The total amount of damage costs caused by social disasters was estimated at 767,892 thousand dollars,

and if we classified them into types, land transportation and animal diseases accounted for 74% and 22%, respectively, both of which exceeded 90% (Figure 8). If we compared the damage costs caused by natural disasters with recovery costs, the recovery costs by typhoons and heavy rainfall required more than twice as much as the damage costs; the recovery costs by heavy snowfall, extreme winds, and wind waves were approximately two times as much as the damage costs. If we looked at the damage costs by social disasters, the unionized truck drivers' strikes in 2008, the outbreaks of foot and mouth diseases, and AI virus in 2010 accounted for most of the total. The large-scale fires at multi-use buildings accounted for only 3% of the total but continuously occurred over many years.

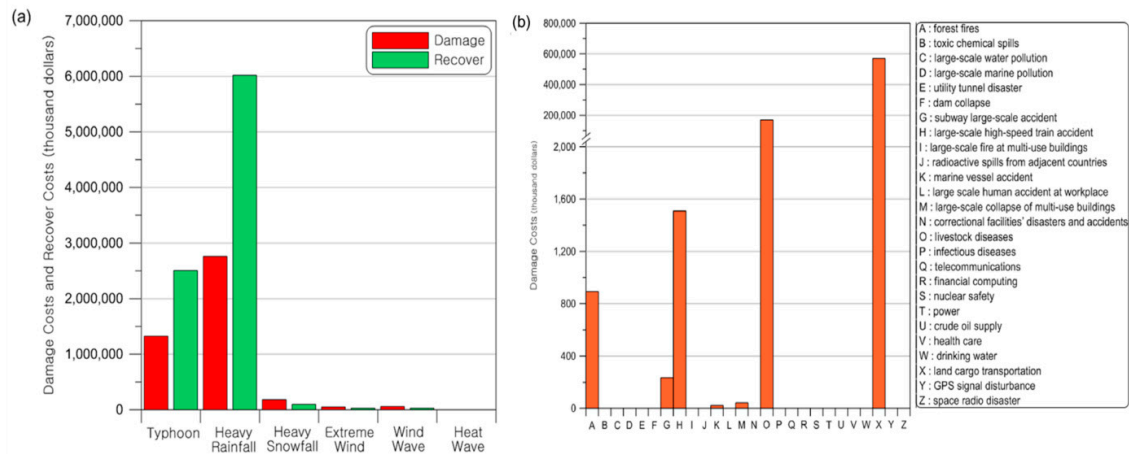


Figure 8. Damage and recovery costs by disaster type in the Republic of Korea: (a) natural disasters and (b) social disasters (1\$ = 1200 won).

4. Improvement Measures for the Integrated Disaster System Considering Disaster Types

4.1. Challenges of the Current Disaster Management System

This study investigated and analyzed the disaster management systems of the United States, Japan, Germany, the United Kingdom, and the Republic of Korea, and the status of damages caused by different disaster types 2006–2015 in the Republic of Korea. The most significant differences between the Republic of Korea and the advanced countries in terms of disaster systems were the principal agency of early response in the event of disasters and the disaster management types. In the case of the United States, Japan, Germany, and the United Kingdom, initial response to a disaster is implemented by local governments to ensure a prompt response in the event of a disaster, which may later be followed by the central government's support activities for response and recovery.

In the Republic of Korea, the Si/Gun/Gu Disaster Safety Measure Headquarters conduct an emergency response as part of an early response, and the central government, after being informed of the occurrence of a disaster, will assume the role of the principal agency of disaster response management through an integrated disaster management system ranging from early response to recovery (Table 4). However, the vertical disaster management system of the central government often requires a lengthy time to collect reports on disaster situations and assess the scale of damages in the early stages of a disaster, and the change in the principal agency from local governments to the central government will make a prompt response to disaster more difficult.

Table 4. Comparison of disaster management systems by country.

Country	Natural Disaster Law	Disaster Management Organization	Disaster Response for Executive Institution
United States of America	Stanford Law	Federal Emergency Management Agency	Local Government after Central Government (support)
Japan	Disaster Control Measures Basic Law	Cabinet Office	Local Government after Central Government (support)
Germany	Civil Protection Act	Federal Interior Ministry	Local Government after Central Government (support)
United Kingdom	Civil Contingencies Act	Civil Contingencies Secretariat	Local Government after Central Government (support)
Korea	Disaster and Safety Management Basic Law	Ministry of the Interior and Safety	Local Government and Central Government

As the national disaster management system revealed the problem of overlapping roles of the central and local governments, we proposed that the roles of the central and local governments must be improved in legal, organizational, and financial aspects [44,45]. Given that future disasters are much more likely to have a complex nature and cause damages beyond the control of a local government and threaten the security of the nation, we proposed that the concept of a national disaster management policy must be re-established [46].

As fundamental problems of the past disaster damages, a lax safety management at a prevention level, a failed early response at the field site, and an operational defect of the disaster response system. To solve such problems, we proposed the clear establishment of roles between the central government and the related departments and the establishment of an integrated disaster response support system [47,48].

According to “Framework Act on the Management of Disasters and Safety”, a disaster is defined as a natural disaster or a social accident that actually causes or is likely to cause any harm to the lives, bodies, and property of citizens and the state [49]. However, the law does not provide clear criteria for the level scales or damages to define it as a disaster.

Additionally, there are no clear definitions on the scale and severity of damages that may require the shifting of the authorities to be reported on from the Si/Gun/Gu Disaster Safety Measure Headquarters to the central government.

If we look at the disaster management types by country, the Republic of Korea classifies disasters into six natural disaster types and 26 social disaster types, while the United States, Japan, Germany, and the United Kingdom have integrated disaster management systems that do not classify disasters into different types. In the Republic of Korea, the human losses caused by natural disasters 2006–2015 were estimated at 244 people, while the total human losses caused by social disasters were estimated at 872 people, totaling 1116 people. The damage costs caused by natural disasters were estimated at 437,608 thousand dollars, while the damage costs by social disasters amounted to 767,892 thousand dollars, totaling 1,205,500 thousand dollars, and the recovery costs were estimated at 868,017 thousand dollars (Figure 9).

In the event of disasters, human losses, damage costs, and recovery costs arise with natural and social disasters. Although the Republic of Korea’s disaster management has the division of disaster types, the same procedures of prevention, preparedness, response, and recovery are applied regardless of disaster types. If we look at the status of major disasters in the past, they were classified into natural and social disasters based on the classification system, but they distinguished only the causes of damages (Table 5). Recent disasters have been caused by typhoons, heavy rainfall, accidents, etc., and the subsequent damages have resulted from multiple causes. Thus, it is judged that the Republic of Korea needs an integrated disaster management system that incorporates different types of disaster management, rather than classifying disasters into type, to reduce the occurrence of disasters and respond more effectively.

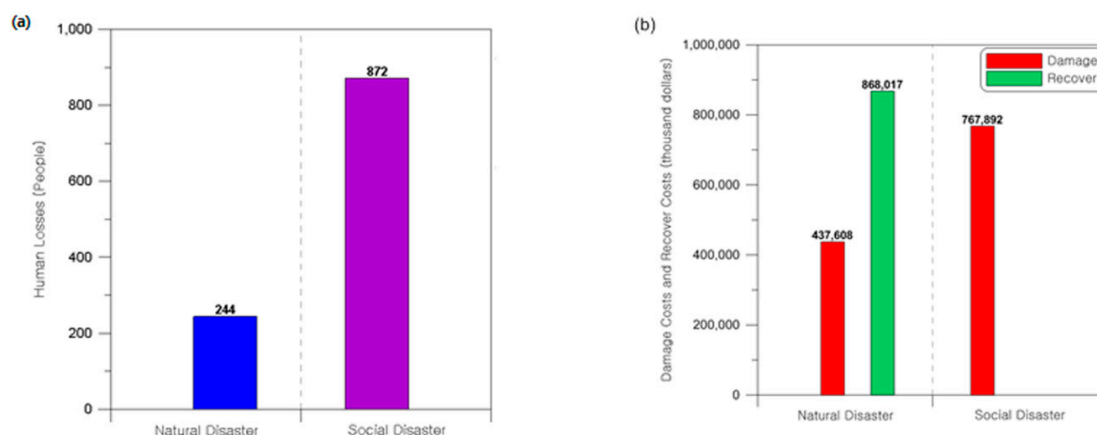


Figure 9. Damages by natural and social disasters in the Republic of Korea (2006–2015): (a) human losses and (b) damage and recovery costs (1\$ = 1200 won).

Table 5. Status of major disasters 2006–2015.

Date	Disaster Classification	Details
2006.07.	Natural Disaster	Typhoon Ewinari
2006.10.	Social Disaster	29-Car Crash on <i>Seohae</i> Grand Bridge
2007.12.	Social Disaster	Oil Spill from Crashed Oil Tanker, Taean
2008.01.	Social Disaster	Fire at Cold Storage Warehouse, Incheon City
2008.02.	Social Disaster	Arson at <i>Sungnyemun</i>
2009.03.	Social Disaster	H1N1 Virus
2009.03.	Social Disaster	Water Discharge from <i>Hwangang</i> Dam, North Korea
2010.09.	Natural Disaster	Typhoon Kompasu
2010.09.	Natural Disaster	Flood in Gwanghwamun Square, Seoul City
2010.09.	Social Disaster	Distributed Denial of Service Attack (DDOS)
2010.12.	Social Disaster	Foot and Mouth Disease
2011.07.	Natural Disaster	Landslide in Chuncheon City
2011.08.	Natural Disaster	Typhoon Muifa
2011.08.	Natural Disaster	Landslide on Mt. Umyeon
2011.09.	Social Disaster	Massive Power Outage
2012.08.	Natural Disaster	Typhoons Bolaven and Tembin
2012.09.	Social Disaster	Gas Leakage in Gumi City
2013.03.	Social Disaster	Urban Wild Fire in Pohang
2014.02.	Social Disaster	Collapse of Mauna Ocean Resort Gymnasium Roof, Gyeongju City
2014.04.	Social Disaster	Sunken Sewol Ferry Accident
2015.02.	Social Disaster	106-Car Crash on Yeongjong Grand Bridge
2015.05.	Social Disaster	Middle East Respiratory Syndrome Outbreak (MERS)

4.2. Improvement Measures for the Integrated Disaster Management System in the Republic of Korea

The Republic of Korea has learned lessons from past disasters and has continued to improve and complement its disaster management system to establish the current integrated disaster management system. However, recent disasters, including the flood at the Gwanghwamun Square, the Mt. Umyeon landslide, the sunken Sewol ferry accident, and the MERS outbreak, have raised several problems in terms of early response and the formulation of countermeasures [22,30,50–52]. Thus, this study proposes improvement measures for the current integrated disaster management system of the Republic of Korea in consideration of the disaster management systems of developed countries and the status of damages from past disasters in the Republic of Korea (2016–2015).

First, we proposed to change the principal agency of disaster response from the central government to local governments in the event of a disaster. If a disaster occurs, the Si/Gun/Gu Disaster Safety Measure Headquarters centering on local governments will implement a primary disaster response, but if the scale of the disaster exceeds the authorities of local governments, the central government will intervene to conduct a general disaster assistance and disaster response. The local governments in the

Republic of Korea consist of 17 local governments with two special cities, one special autonomous island, six metropolitan cities and eight provinces to respond to disasters occurring in each region (Figure 10a). To ensure a disaster management system led by local governments, we proposed to provide continuous disaster response exercises, to establish a disaster management systems, and to expand the related capacities, for example, by expanding the number of people responsible for disaster management.

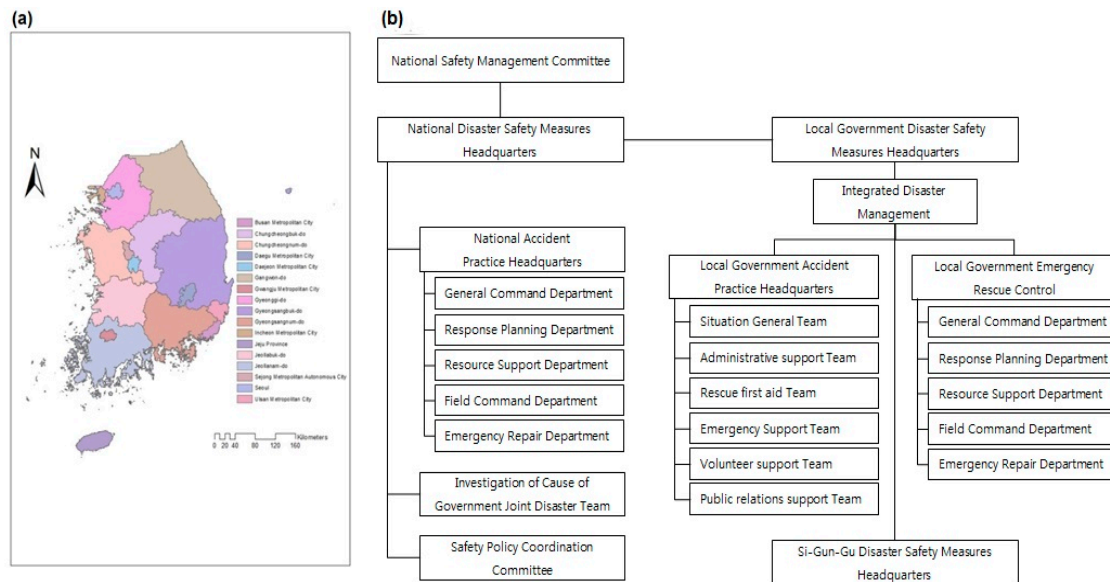


Figure 10. Improvement measures for the Republic of Korea's Integrated Disaster Management System. (a) Restructuring of disaster management organizations in 17 local governments and (b) the organizational chart of disaster management organization under the Ministry of the Interior and Safety.

Second, we proposed establishing an integrated disaster management system by incorporating all disaster types rather than classifying disaster management into natural disasters and social disasters. Currently, the disaster management procedures in the Republic of Korea consist of four steps: prevention, preparedness, response, and recovery. These procedures can be applied to natural and social disasters. If we had appropriately responded to and prepared for recent disasters, such as urban flooding, landslides, foot-and-mouth disease, and the MERS outbreak, we could have reduced damages and minimized the risk of disaster occurrence. Thus, we proposed establishing an integrated disaster management system that incorporates all disaster types instead of classifying disasters by types.

Third, to improve the integrated disaster management system of the Republic of Korea, we proposed to resolve some problems, including the restructuring of the administrative organization currently focused on the central government, the revision of disaster-related laws, a lack of inter-departmental interconnectivity, and overlapping regulations. Organizational restructuring should be implemented to ensure early response to disasters by local governments and control by the central government and to resolve some problems of the currently dispersed organization system in terms of data sharing, overlapping reporting, and omissions. We also proposed to provide clear definitions of the scale and damages that can be classified as disasters. These problems have been consistently raised in past disasters in the Republic of Korea, including large-scale power outages, the sunken Sewol ferry accident, and the MERS outbreak.

Thus, this study analyzed the disaster management systems of developed countries and the status of damages by past disasters in the Republic of Korea to propose improvement measures for the integrated disaster management system. Figure 10b shows improvement measures for the Republic of Korea's integrated disaster management system in consideration of the above research results.

5. Conclusions

To propose measures to improve the Republic of Korea's disaster management system, we investigated and analyzed advanced countries' disaster management systems, as well as damages caused by disasters occurring 2006–2015. The domestic and overseas disaster management systems have continued to restructure their organizations responsible for prevention of, preparedness for, response to, and recovery from a disaster.

In the Republic of Korea's disaster management system, when a disaster occurs, early response is performed by local governments before it reports to the central government. After the report, the central government will be responsible for an overall response to and recovery from the disaster. However, the recent disasters that wreaked serious havoc on the Republic of Korea, such as the flood in Gwanghwamun Square, Foot and Mouth disease outbreak, the sunken Sewol ferry accident, and MERS outbreak raised the issues of a lax safety management, a failed early response, and an overlapping role of departments responsible for disaster response. These problems of the existing disaster management system played the role of compounding damages, and if safety management and early response had been conducted successfully, it could have curbed the disaster earlier and reduced damages.

Thus, we proposed to make a clear definition of agencies responsible for disaster management to ensure a rapid and effective early response and also to designate those agencies that will continue with response and recovery.

In the Republic of Korea, disasters are classified mainly into natural disasters such as typhoon, heavy rain and strong wind, and social disasters such as fires, infectious diseases, and major accidents. In the case of damages by disaster type, natural disasters are showing a decreasing tendency in the amount of damages. In contrast, social disasters cause colossal damage once every four to five years. Despite these differences in their trends, the same disaster management system is applied regardless of disaster type, and the recent disaster-related damages involve complex (multiple) aspects. Thus, we proposed that the Republic of Korea government establish an integrated disaster management system to ensure the safety of the people by protecting them from natural and social disasters.

The integrated disaster management system makes it possible to encourage all related departments to cooperate based on a central or local government and to develop a clear definition of the roles of each department. Additionally, the time to establish the National Disaster and Safety Status Control Center and to operate each department can be clearly defined, which allows for a quick early response, and an effective communication channel can be secured. The improvement of such disaster management system can solve problems such as overlapping roles of the related departments and ambiguous time to operate the related departments and for early responses.

To revise the responsible agency for disaster management in the Republic of Korea as local governments and establish a disaster management system that integrates all disaster types, we proposed to resolve some problems, such as restructuring of the existing administrative organization, the revision of disaster-related laws, interdepartmental interconnectivity, and overlapping regulations, in an organic manner. Additionally, we proposed to establish clear definitions on the scale and damages that can be classified as a disaster. Thus, this study conducted an analysis to identify improvement measures for the integrated disaster management system of the Republic of Korea, and the study results are seen below.

1. The responsible agencies for disaster management in the event of a disaster must be changed from the central government to local governments so that the Si/Gun/Gu Disaster Safety Measure Headquarters can conduct a primary response to a disaster, while the central government performs general disaster assistance and disaster response only in the case of a large-scale accident beyond the authorities of local governments.
2. We proposed establishing an integrated disaster management system instead of classifying disaster management into types of natural and social disasters. Additionally, quantitative definitions of scales or damage levels must be presented.

- To improve the Republic of Korea's integrated disaster management system, we proposed to resolve some problems, including the restructuring of administrative organizations currently based on the central government, the revision of disaster-related laws, inter-departmental interconnectivity, and overlapping regulations.

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