Review Article

Priority Analysis of Remote Sensing and Geospatial Information Techniques to Water-Related Disaster Damage Reduction for Inter-Korean Cooperation

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The social and economic harm to North Korea caused by water-related disasters is increasing with the increase in the disasters worldwide. Despite the improvement of inter-Korean relations in recent years, the issue of water-related disasters, which can directly affect the lives of people, has not been discussed. With consideration of inter-Korean relations, a government-wide technical plan should be established to reduce the damage caused by water-related disasters. Therefore, the purpose of this study was to identify remote sensing and GIS techniques that could be useful in reducing the damage caused by water-related disasters while considering inter-Korean relations and the disasters that occur in North Korea. To this end, based on the definitions of disasters in South and North Korea, water-related disasters that occurred during a 17-year period from 2001 to 2017 in North Korea were first summarized and reclassified into six types: typhoons, downpours, floods, landslides, heavy snowfalls, and droughts. In addition, remote sensing- and GIS-based techniques in South Korea that could be applied to water-related disasters in North Korea were investigated and reclassified according to applicability to the six disaster types. The results showed that remote sensing and other monitoring techniques using spatial information, GIS-based database construction, and integrated water-related disaster management have high priorities. Especially, the use of radar images, such as C band images, has proven essential. Moreover, case studies were analyzed within remote sensing- and GIS-based techniques that could be applicable to the water-related disasters that occur frequently in North Korea. Water disaster satellites with high-resolution C band synthetic aperture radar are scheduled to be launched by South Korea. These results provide basic data to support techniques and establish countermeasures to reduce the damage from water-related disasters in North Korea in the medium to long term.

1. Introduction

After the first Inter-Korean Summit that took place on April 27, 2018, additional summits were held to discuss inter-Korean issues. These summits mainly discussed economic and cultural exchanges. However, natural disasters are important because North and South Korea are geographically close and can affect each other. Furthermore, for the first time, North Korea–United States summits were held in Singapore on June 12, 2018, and February 27–28, 2019, and issues related to North Korea were discussed internationally. During discussions at the summit, the United States and North Korea agreed to resolve a variety of issues, including complete denuclearization, a peace regime, normalization of United States–North Korea relations, and the repatriation of a corpse from the Korean War. However, as with the inter-Korean summit, no issues pertaining to North Korea's safety from natural disasters have been discussed, despite the severe current situation with regard to natural disasters in North Korea.

Water-related disasters are increasing in North Korea as unusual climate problems emerge worldwide. Correspondingly, disaster safety problems are receiving more attention [1]. According to the 2018 Global Risk Index, North Korea

has the 41st highest risk index among 191 countries [2]. In comparison, South Korea ranked relatively low at 166th. For geographical reasons, the occurrence of disasters at the inter-Korean border directly affects the entire Korean Peninsula, especially South Korea, because the water systems flow into South Korea. For example, in September 2009, six South Koreans were killed by the discharge of the Hwanggang Dam upstream on the Imjin River. Therefore, to reduce the damage caused by water-related disasters in North Korea, it is necessary to develop technical measures at the national level.

In this study, the frequency of water-related disasters in North Korea to identify applicable techniques was analyzed to ensure safety through inter-Korean cooperation. This plan reflects recent changes in North Korea's diplomatic relations in terms of humanitarian issues, which may foster responses to water-related disasters. Based on statistics regarding water-related disasters in North Korea, this study investigated the applicability of science and technology employed in South Korea, which has similar geographic characteristics, and established priorities for techniques that could support inter-Korean cooperation. To this end, the trend of water-related disasters in North Korea is first summarized and analyzed. Then, forms of science and technology used to respond to water-related disasters in South Korea are surveyed, and a ranking of the types of science and technology that would be applicable to North Korea is determined. Finally, case studies of remote sensing data of water-related disasters are analyzed. As a result of these processes, science and technology could be employed to reduce the damage caused by the disasters.

Due to the secretive nature of North Korea, data on the damage caused by disasters are difficult to obtain. Therefore, this study summarized data on the occurrence of water-related disasters in North Korea based on information released by the international community and data published by the North Korean government during a 17-year period from 2001 to 2017. The water-related disasters were categorized into six types based on the definitions of disasters in North and South Korea and the current status in North Korea. Through this process, water-related disaster-related techniques used in South Korea were investigated and classified into whether they could reduce damage from disasters occurring in North Korea. South Korean techniques for water-related disaster damage reduction could be applied to adjacent areas of North Korea. Against this backdrop, the use of remote sensing technique is essential. In addition, the priorities among South Korean techniques were evaluated by considering the water-related disasters that occur in North Korea; focus group interviews were conducted to assess the technical aspects and impacts of disasters. Through this effort, the techniques most applicable to the problems resulting from water-related disasters all over North Korea were evaluated. Based on the evaluation results, the priorities of various techniques for application were calculated in North Korea through quadrant analysis. Finally, an additional analysis of application of these techniques was conducted for water-related disasters, which continue to cause significant damage in North Korea.

As the incidence of water-related disasters has increased, monitoring techniques using various types of data have been developed around the world, including in Korea. In particular, remote sensing technique is essential in low-access areas such as North Korea as it makes periodic monitoring of large areas possible. As shown in previous research, various types of disasters are currently being monitored using satellite images. In addition, various spatial analyses are performed based on monitoring data, allowing for the establishment of integrated water-related disaster management. Especially for water-related disasters, the use of SAR satellite imagery with clear water reflectivity is known to be very effective [3, 4].

This study sought to clarify which South Korean disaster damage reduction techniques using remote sensing and spatial information could be used for reducing damage in North Korea. The study first summarized the current situation of water-related disasters in North Korea through a review of the literature, websites, and related reports [5]. The status of water-related disasters in North Korea was aggregated by year and cause. Then, damage reduction techniques for water-related disasters used in South Korea were investigated and their applicability to North Korea was evaluated. Third, the methodologies and data (remote sensing and GIS data) used in South Korea were organized and analyzed. Fourth, the use of C band synthetic aperture radar satellites by South Korea, which can directly monitor North Korean water-related disasters in the future, was presented. Finally, the study summarized the approaches to reduce the damage in North Korea. The detailed workflow is shown in Figure 1.

2. Data and Methodology

2.1. Investigation of Natural Disasters Occurring in North Korea. To identify applicable techniques based on the occurrence of disasters in North Korea, North Korea's natural disaster occurrence data were collected. Due to the isolationist policy of the North Korean government, comprehensive published statistical data on natural disasters in North Korea are difficult to gather. Therefore, this study was based mainly on newspapers and press releases, which represent the official media of North Korea. In addition, data on North Korea published by disaster-related international organizations were reviewed to improve the credibility of the dataset. An interim report published by the International Federation of Red Cross and Red Crescent Societies (IFRC) provided information about North Korea's response to and recovery from natural disasters. In addition, data published in South Korea were compared and analyzed to minimize missing data. This process led to a summary of data on the frequency of natural disasters in North Korea as previously investigated [5].

By comparing data from various sources, systematic investigation and summarization of the status of disasters in North Korea were conducted [5]. Due to insufficient data on recent occurrences, the survey period was set as January 2001 to December 2017 (Table 1). Based on data from a previous study of disasters in North Korea [6], additional investigations and reviews were conducted and the results reclassified using the classification system presented in this
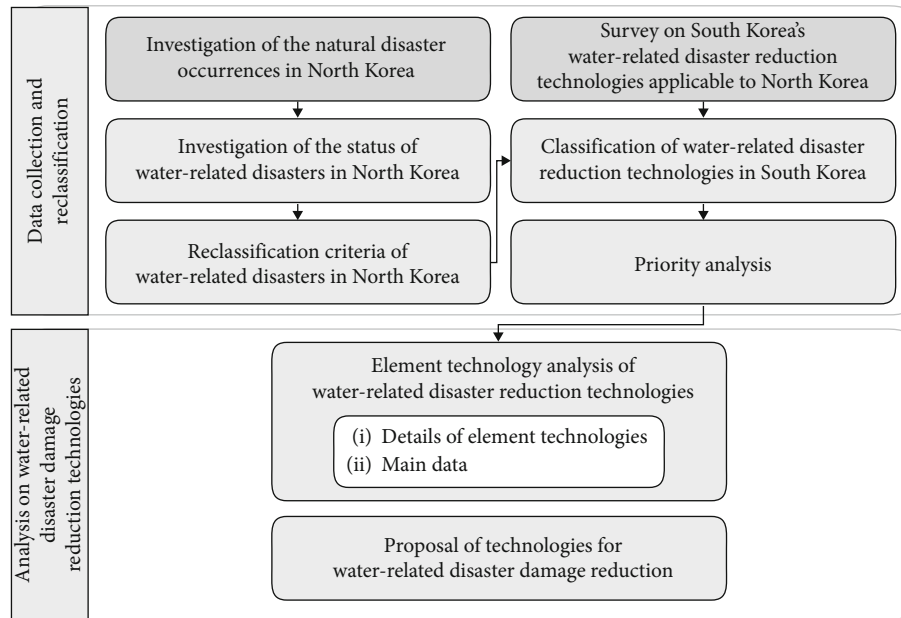
Figure 1: Detailed workflow for this study.

Table 1: Water-related disaster occurrence rates in North Korea between 2001 and 2017 [5].

	Typhoon	Downpour	Flood	Landslide	Heavy snowfall	Drought	Total of water-related disasters
2001	1	2	1	2	2	2	10
2002	5	3	1	1	0	0	10
2003	0	1	0	1	0	0	2
2004	1	5	2	1	0	0	9
2005	2	4	1	1	0	0	8
2006	1	3	2	2	0	0	8
2007	2	2	1	0	0	0	5
2008	2	1	1	0	0	0	4
2009	0	1	0	1	0	0	2
2010	3	4	4	0	0	0	11
2011	4	5	2	1	2	1	15
2012	3	5	5	2	0	1	16
2013	0	1	1	1	0	0	3
2014	0	0	0	0	0	1	1
2015	1	2	2	0	0	1	6
2016	1	2	1	2	0	0	6
2017	0	0	0	3	0	1	4
Total	26	41	24	18	4	7	120

study. North Korea is a very secretive country; as a result, it is difficult to acquire quantitative data on North Korea. Our results were obtained by reviewing previous research on natural disasters [5, 6], focusing on water-related disasters.

According to the integrated data [5, 6], 114 earthquakes occurred in North Korea, and more than one third of all natural disaster occurrences were caused by earthquakes. However, the magnitudes of the earthquakes were relatively low compared to the number of occurrences, so the damage was not significant. The earthquakes that occurred, most of

which were artificially induced, generally ranged in magnitude from 2.0 to 4.0. Natural disasters related to water are important among the results in [5, 6] because although earthquakes are reported frequently, the degree of damage is not directly proportional [5]. Other natural disasters, such as heat waves, are less frequent, which indicates that the most damaging natural disasters are water-related. According to Figure 2, where the number of natural disasters is compared, it can be seen that the occurrence of water-related disasters are relatively higher than other natural disasters. In addition
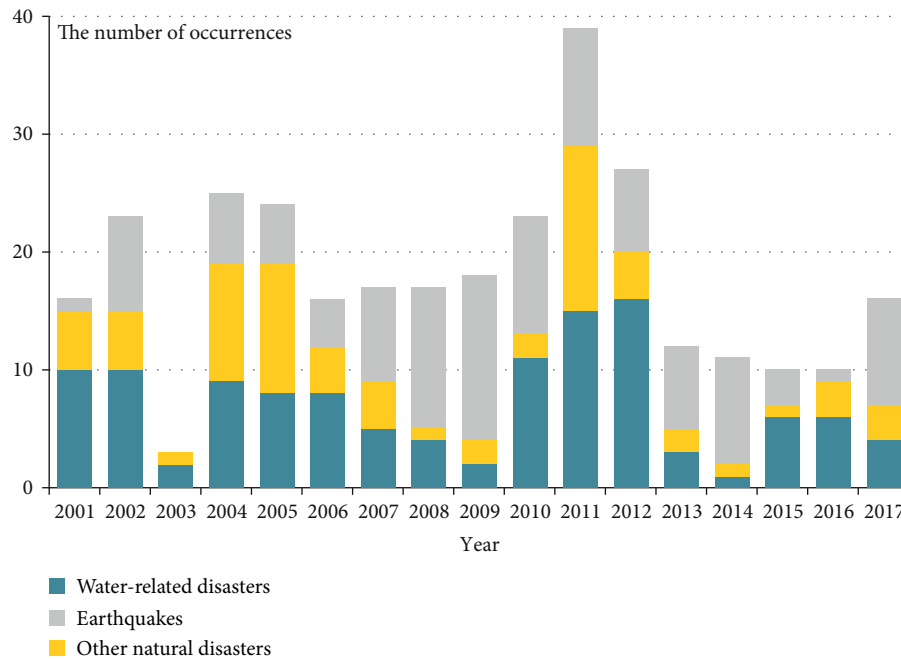
FIGURE 2: The number of natural disasters of water-related disasters, landslides, and other natural disasters.

to the frequency of occurrence, the actual damage from water-related disasters is higher than others [6, 7]; other disasters include cold wave, heat wave, and sandy dust.

Therefore, this study analyzed disasters that have a great impact on people due to the actual damage caused [6, 8]. This study classified water-related disasters into six categories according to the classification systems of South and North Korea: typhoons, downpours, floods, landslides, heavy snowfalls, and droughts.

Among the types of water-related disaster classified in this study, the disasters, including typhoons, strong winds, downpours, and floods, were relatively frequent and also resulted in large losses of life and property. The cumulative frequency of downpour in North Korea for the 17 years was highest after an earthquake. Thirteen downpours, about 30 percent of the total, were occurred together due to typhoons [6]. The occurrence of downpours was associated with floods, landslides, and tsunamis, which caused greater and wider damage. According to a report by a UN coordinator currently residing in North Korea, 231 people died and 212,000 were adversely affected by downpours in North Pyongan Province and South Pyongan Province in 2012 [9]. In 2013, the following year, 189 people died and 800,000 people were affected in the area. In 2014, the region suffered 18 months of drought. In 2015, Typhoon Goni caused severe damage in South Hwanghae Province, North and South Hamgyong Province, and the city of Naseon. The typhoon left 22,000 victims of dead, injured, and displaced in Naseon. In a typical case of downpour in North Hamgyong Province, which occurred between August 29 and September 2, 2016, 138 people died and 680,000 people were displaced, as reported by the Chosun Central Broadcasting Corporation (Figure 3(a)).

North Korea, which is mostly mountainous and has high average altitude, experiences cold weather and heavy snow damage during the winter season between December and February. Heavy snowfall in Gangwon-do caused heavy damage and economic loss in February 2011. Droughts, on the other hand, occurred mostly between March and June and throughout all regions of North Korea. The number of droughts was higher in Hwanghae Province than in other regions. A drought lasting from March to August, 2015 was among the worst (Figure 3(b)). In 2017, a drought occurred in the granary areas of Hwanghae and Pyongan Provinces, and a state of emergency was declared in June. According to the report by the UN coordinator, in recent years, North Korea has suffered from water-related disasters every year [9].

2.2. Investigation and Classification of Techniques for Water-Related Disasters in South Korea. This section examined the current state of science and technology related to water-related disasters in South Korea to suggest an appropriate direction for North Korea's disaster response technique. The National Science and Technology Information Service (NTIS), a national science and technology knowledge information portal operated by South Korea's Ministry of Science and Technology, was used to collect information on projects pertaining to water-related disaster reduction techniques in Korea [12]. NTIS provides a range of information about the projects, including content, research equipment, and researchers. Based on the NTIS service, projects in science and technology undertaken through the last decade (2008–2017) were collected to serve as basic data for analysis.

To investigate science and technology projects related to water-related disasters, research and development projects were identified using related keywords and were then

(a)   (b)

FIGURE 3: Damage from water-related disasters in North Korea: (a) flood of Hwanghae Province in 2015 [10] and (b) flood of North Hamgyong Province in 2016 [11].

classified into the six types (typhoon, downpour, flood, landslide, heavy snowfall, and drought) determined previously. To reduce the damage in North Korea, South Korean techniques using remote sensing and spatial information were searched for and the resulting reduction in damage from water-related disasters was examined. Finally, 22 projects classified by the type of disaster were collected. The projects were examined with the aim of identifying a maximum of ten of each technique. These were then categorized according to the six types. By analyzing the technical elements of each technique, the importance of using radar satellite data for water-related disasters was also analyzed.

3. Results

3.1. Element Technique Analysis of Water-Related Disaster Reduction Techniques. To analyze the overall priority of water-related disaster-reduction techniques, the technique was analyzed based on the investigation and classification results of techniques in South Korea. Total 22 research and development technologies were determined to be reduction techniques for water-related disasters. Then, the elements of each technique for water-related disasters were derived based on the results. The basic data essential to each technique are also listed.

The final result showed high priorities in three categories: water-related disaster monitoring using spatial information technique, research infrastructure and database construction based on a geographic information system data (GIS), and complex disaster integrated management. Especially, research database construction based on water-related disaster monitoring technique in the form of spatial information for the whole of North Korea for integrated disaster management can be used as a fundamental technique for reducing damage.

Representative techniques are summarized in Table 2. Sixteen projects, 84.21% of the total, applied spatial information-related techniques. Synthetic aperture radar (SAR) remote sensing was also related to 12 techniques

(63.16%), and optical and meteorological methods were related to 3 and 10 techniques, respectively, for a total of 68.42%. In particular, the C band, such as from RADARSAT-1, RADARSAT-2, and Sentinel-1, was used for the main applications of SAR remote sensing for water-related disasters.

In addition to the high use of radar satellite images for water-related disasters, such as the use of C band data, a technique using additional data elements was also represented. Various national thematic maps such as soil, land use, land cover, and forest maps, which are based on satellite images, have been used. These fundamental data could be also constructed for North Korea based on satellite images. Due to the occurrence of disasters in North Korea, the utilization of a technique that employs climate change scenarios to predict rainfall pattern variability in the future is important because the damage caused by typhoons or downpours is high [13, 14].

3.2. Case Studies of the Application of Satellite Images to Water-Related Disasters. Water-related disasters have been increasing all over the world, but especially in North Korea, where the damage caused by the disasters such as floods and typhoons is severe; the disasters are widespread in inaccessible areas and are the most destructive. As a result of research, the importance of accurate and continuous monitoring using remote sensing satellite imagery is increasing with the research on water-related disasters. By comparing before and after data of various water-related disasters or by tracking the progress of disasters, research aims to obtain a variety of information for selecting indicators, e.g., topography and vegetation characteristics, and effective response to disasters. This study organized disaster-related projects in South Korea and analyzed the data used and the techniques developed in each project that might be applicable for water-related disaster damage reduction in North Korea. Due to the secretive nature of North Korea, it is difficult to obtain actual data; however, data were derived by reviewing the available techniques to identify potential inter-Korean cooperative measures.

Table 2: Results from priority analysis of techniques required in North Korea.

Water-related disaster class of project	Project	Element technique	Main data
Flood	Development of system for vulnerability analysis of natural disaster	(1) SAR remote sensing (2) GIS	(1) RADARSAT-1, RADARSAT-2 (2) Land use and cover (3) DEM (4) Forest map
Flood	Development of system for flood of stream and risk analysis	(1) GIS (2) SAR remote sensing	(1) DEM (2) Land use and cover (3) Location of flood
Flood	Development of flash flood damage prediction method in mountainous areas	(1) SAR remote sensing (2) GIS	(1) RADARSAT-1, RADARSAT-2 (2) Land use and cover (3) DEM (4) Forest map
Flood	Pilot development and operation of urban flood forecasting project based radar-rainfall -	(1) SAR remote sensing (2) Optic remote sensing	(1) Sentinel-1 (2) COSMO-SkyMed (3) WorldView-2, WorldView-3
Flood	Development of the evaluation technology for complex causes of inundation vulnerability and the response plans in coastal urban areas for adaptation to climate change	(1) GIS	(1) Land use and cover (2) Climatic change scenario (RCP 4.8, 8.5)
Flood	Development of flood forecasting technology for catching golden time	(1) GIS	(1) Climatic change scenario (RCP 4.8, 8.5)
Flood	Establishment of city flood response system by region	(1) SAR remote sensing (2) GIS	(1) RADARSAT-2 (2) Sentinel-1 (3) Land use and cover (4) DEM etc.
Flood	Urban flood analysis and flood safety improvement technology	(1) SAR remote sensing (2) GIS	(1) RADARSAT-2 (2) Sentinel-1 (3) Land use and cover
Flood	Development of hydrological model for decision making to flood response	(1) SAR remote sensing (2) GIS	(1) RADARSAT-2 (2) Sentinel-1 (3) Land use and cover
Flood	Intelligent flood prediction and warning system	(1) SAR remote sensing (2) GIS	(1) RADARSAT-2 (2) Sentinel-1 (3) COSMO-SkyMed (4) Land use and cover
Typhoon	Implementation of typhoon related disaster information database using remote sensing data	(1) SAR remote sensing	(1) RADARSAT-1, RADARSAT-2 (2) Sentinel-1
Typhoon	Developing detection/prediction technique for tropical cyclone formation based on satellite and numerical model	(1) Meteorological satellite remote sensing	(1) Chollian 1, Chollian 2 (2) Meteorological data
Typhoon	A research for typhoon track prediction using end-to-end deep learning technique	(1) Meteorological satellite remote sensing	(1) Chollian 1, Chollian 2
Typhoon	Developing typhoon prediction system by multi-model ensemble technique	(1) Meteorological satellite remote sensing (2) SAR remote sensing	(1) Chollian 1, Chollian 2 (2) RADARSAT-1, RADARSAT-2 (3) Sentinel-1 (4) COSMO-SkyMed
Typhoon	Prediction of medium- and long-range tropical cyclone activity using the statistical-dynamical forecast system	(1) Meteorological satellite remote sensing	(1) Chollian 1, Chollian 2 (2) Meteorological data

TABLE 2: Continued.

Water-related disaster class of project	Project	Element technique	Main data
Typhoon	Study on methods to track northwestern Pacific typhoons paths using seismic array data	(1) Meteorological satellite remote sensing	(1) Chollian 1, Chollian 2
Typhoon	Disastrous weather/climate analysis and prediction	(1) GIS	(1) Meteorological data (2) Climatic change scenario (RCP 4.5 and 8.5)
Downpour	Improvement of understanding and prediction capability for high-impact heavy precipitation systems over the Korean peninsula	(1) Meteorological satellite remote sensing (2) SAR remote sensing	(1) Chollian 1, Chollian 2 (2) RADARSAT-1, RADARSAT-2
Downpour	Development of a prediction system for heavy rainfalls caused by cloud clusters over the Korean peninsula	(1) GIS (2) SAR remote sensing	(1) Meteorological data (2) Sentinel-1 (3) COSMO-SkyMed
Drought	Development of the software module in response to drought events based on satellite imagery in Korea	(1) Optic remote sensing	(1) Landsat 5, Landsat 6, Landsat 7
Drought	Development of a drought monitoring system through integrated modeling of multi-sensor data	(1) Meteorological satellite remote sensing	(1) Chollian 1, RADARSAT-2 (2) Meteorological data
Heavy snowfall	Development of a prompt action technique using remote sensing	(1) Optic remote sensing	(1) Landsat 5, Landsat 6, Landsat 7

Various satellite images were used to analyze cases of flood disaster-related hazards (downpour, flood, typhoon, drought, landslide, etc.). Representatively, there was one case of massive flood mapping using optical satellite images [15]. Landsat satellite images, which are medium- to low-resolution satellite images, were used to evaluate the flood surface [16], and methodologies for mapping the inundation site were compared [17]. On the other hand, high-resolution satellite images have been used to monitor dam reservoirs [18] and to analyze spatial changes in floods over time [19]. Precise mapping of flooding in plain basin boundaries was studied [20]. In relation to typhoons, studies have been carried out to establish early warning systems for sea hurricanes [21] and information on sea-level environments [22].

Unlike optical satellite images, SAR images can be used to monitor floods irrespective of weather conditions and during both day and night. Accordingly, SAR is advantageous when estimating urban and agricultural damage from river flooding; and flood mapping techniques using SAR images have been studied continuously [23, 24]. In particular, studies to observe floods with the data obtained immediately after the flood have been actively conducted [25, 26]. A flood risk mapping study using 16 years of rainfall and historical satellite data was also carried out employing the advantages of satellite images, which can be monitored periodically [27]. In addition, flood depth was estimated using high-resolution SAR images [28], and filter comparison analysis was performed to interpret radar images for flood mapping [29].

In recent years, research has been conducted to solve additional environmental problems (landslides, slope stability, etc.) by applying GIS and machine learning technique to the monitoring of information constructed through satellite images. Typically, hydrological modeling for flood forecasting based on GIS [30], spatial modeling using GIS for

flooding in urban areas [31], and flood risk assessment in hazardous areas [32] have been performed. Recently, machine learning has been used to analyze the risk of floods [33], and multiple risks for complex disasters have been mapped [34]. In addition, in one case, disasters were evaluated by applying deep learning to satellite imagery [35]. There are also cases of employing various GIS-based techniques that use remote sensing data for vulnerability analysis of water-related disasters [36–38]. Satellite imagery is also being used actively to assess technological developments related to landslides, which have high frequency and cause large damage in North Korea [39, 40]. Various studies have been conducted to map landslides, including studies on soil moisture [41] for landslide risk assessment [42, 43].

Despite the low priority in the results from priority analysis of this study, satellite images are also used in studies related to drought and heavy snow, which need to be expanded in the long term. Satellite images are especially used for drought monitoring [44]. In addition, in some cases, the risk of drought has been assessed by geospatial methods [45]; for example, the impact of land destruction due to drought has been assessed in Brazil [46]. Examples of estimating snow depth due to snowfall based on MODIS images [47] and surface modeling [48] have also been reported.

The use of satellite images for water-related disasters and global disaster monitoring in the Korean Peninsula and other inaccessible areas will help prevent the occurrence of and mitigate the damage caused by the disasters [15, 49–51]. In this regard, South Korea is planning to launch the Compact Advanced Satellite 500-5 (CAS500-5) to reduce the damage caused by water-related disasters occurring in South and North Korea through inter-Korean cooperation. In particular, water disaster satellites with high-resolution C band SAR, which will be directly applicable to water-related

disasters, are scheduled to be launched by the Ministry of Environment and K-water. The C band radar satellite images will continuously monitor the disasters in South and North Korea, and integrated disaster management on the Korean Peninsula will finally be performed using a database constructed from the accumulated satellite images.

4. Discussion and Conclusions

There is a need for technological measures to reduce the damage caused by disasters at the levels of international relations and government development in North Korea. In particular, it is necessary to reinforce the basic capacity of North Korea's disaster response. However, North Korea's closed attitude allows only one-time assistance rather than fundamental technological improvements. Due to social and economic conditions in North Korea, the quality of life of North Korean citizens is lower than that in neighboring countries, and needs that affect daily life are therefore more important. Thus, it is necessary to lay the foundation for joint research and development with North Korea. Therefore, this study is aimed at providing a scientific support system for responding to water-related disasters. In particular, techniques related to water-related disasters, such as downpours and typhoons, which cause serious damage are shown as a high priority. In the case of earthquakes, on the other hand, although the frequency of occurrence is high, the importance is low because losses from earthquakes are not great.

Research already conducted and techniques already employed in South Korea are similar to those needed in North Korea [15, 52, 53]. The research and development technologies which have the highest priority among the investigated techniques should be developed first because they can provide accurate water-related disaster information for North Korea over the long term. Finally, based on the disasters investigated in this study that are currently occurring in North Korea, the techniques to be applied to North Korea can be classified into three categories in terms of their priority for development against water-related disasters: techniques for disaster monitoring using remote sensing and spatial information, those for geoinformation system and GIS-based database construction, and those for integrated water-related disaster management.

In conclusion, an integrated response system for water-related disasters on the Korean Peninsula could be established by comprehensively managing information pertaining to water-related disasters occurring in North Korea. The application of spatial analysis is essential for reducing damage caused by the disasters in spatially adjacent areas. Therefore, the construction of a spatial database, which is not currently available for North Korea, and the infrastructure for basic research are fundamental to all future disaster management efforts. Research and development technologies of low priority must also be developed continuously over the mid to long term.

The characteristics of North Korea make it difficult to manage spatial data for water-related disaster techniques. Therefore, it is necessary to establish a basic infrastructure for research based on GIS to integrate data from various types of water-related disasters. Recent water-related disasters have tended to evolve from a single disaster into a more complex form, so an integrated disaster response system must be established through monitoring and cumulative analysis of the spatial distribution of disasters through continuous remote sensing data. Furthermore, information on water-related disasters should be integrated and managed systematically through joint development and international cooperation. The results of priority analyses of technological developments can enhance the application of scientific and technological products to practical situations. In addition, it will be possible to lay the groundwork for coping with water-related disasters and for reducing damage through the systematic sharing of the technique.

Conflicts of Interest

The authors declare that there is no conflict of interest regarding the publication of this paper.

Acknowledgments

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