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Classification of Critical Disaster types by Region through Disaster Cases and Risk Assessment

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A B S T R A C T

Disasters have different characteristics and different types of disasters. Therefore, it is necessary to stockpile and mobilize resources suitable for disaster types. However, because there are various types of resources and many stockpiles that are required, disaster events are characterized by different occurrences and types of damage, and gaining possession of and effectively utilizing the resources is a difficult task. Therefore, it is necessary to stockpile optimal resources for disasters with a high probability of occurrence. In addition, plans should be established to efficiently operate and manage disaster management resources. In this study, data regarding five types of natural and nine types of social disasters that occurred for 24 years (1996-2019) were collected and studied. Based on this, the results of risk assessment by natural disaster type in 228 local governments have been derived by combining the results of those factors. With the types of disasters that are highly likely to occur by local governments, it is expected to be used to establish policies for efficient stockpiling and management of disaster management resources in the future.

Keywords: Natural Disasters, Social Disasters, Risk Assessment

1. Introduction

Since disaster types have become more complex, diversified, and large, disaster management is becoming difficult, and the possibility of spreading to a national crisis is increasing due to large-scale damage and secondary damage.

In the case of natural disasters, the amount of damage aggregated from 2008 to 2012 showed an increasing trend and decreased the following year, but it is showing a gradual increase until 2017(MOIS, 2017). Social disasters are also increasing the frequency of large-scale disasters such as MERS, the sinking of the MV Sewol ferry, and COVID-19 that have not occurred in the past 10 years(MOIS, 2017; Kim et. al., 2019). For disaster resources to be efficiently managed and supported, analysis of past cases by disaster type and risk assessment should be preceded, but it is still insufficient.

In this study, natural (heavy rain, typhoon, heavy snow, strong wind, high waves) and social disasters (fire, forest fire, collapse, explosion, marine vessel accident, marine pollution accident, environmental pollution accident, livestock disease, and infectious disease) types were analyzed through disaster cases that occurred in the past 24 years, and through the application of the risk assessment (RA) method, which was intended to select and present disaster types with a high probability of occurrence by local government.

2. Critical Disaster Types by Region through Disaster Cases

2.1. Analysis of Natural Disaster Cases

Data were collected and classified based on the disaster yearbook, which is statistical data, for natural disasters that occurred in the past from 1996 to 2019. Over the past 24 years, a total of 385 natural disasters have been reported, and the cumulative number of damaged local governments has been analyzed to be 10,556.

In the case of natural disasters, heavy rain accounted for the highest percentage of damage at 48%. Strong wind, snowfall, typhoon, wind wave,

and heavy rain (98.4% of the total) were selected as the critical disaster types through the analysis of the number of natural disasters and the damage in the past.

<Table 1> Analysis of natural disaster cases

Disaster type	Number of occurrences	Number of damaged district	Critical disaster type
Strong wind	49	481	●
Thunderbolt	1	1	-
Snowfall	69	1,405	●
Earthquake	2	33	-
Typhoon	52	3,149	●
Heatwave	2	83	-
Wind wave	20	227	●
Cold wave	1	1	-
Heavy rain	189	5,176	●
Total	385	10,556	-

2.2. Analysis of Social Disaster Cases

A total of 259 social disasters occurred in the past, which were classified and analyzed by major disaster types. Social disasters have tended to increase significantly since 2014, and 114 social disasters (45% of the total) have occurred in the past 6 years. Additionally, it was analyzed that 6 out of 15 types of social disasters accounted for 93.4% of all social disasters.

Through the analysis of past social disasters, fire, collapse, explosion, traffic accident, environmental pollution accident, infectious disease, and livestock disease were selected as the critical disaster types.

<Table 2> Analysis of social disaster cases

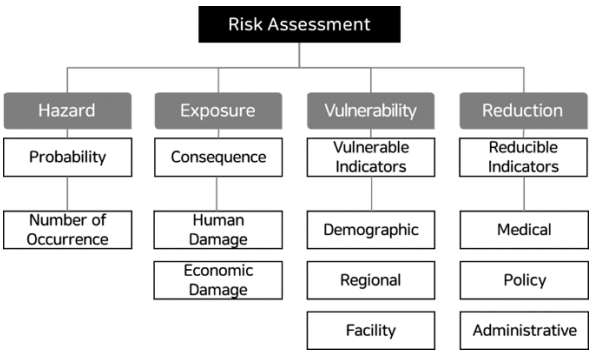
Disaster type	Number of occurrences	Critical disaster type
Fire	99	●
Collapse	23	●
Explosion	27	●
Traffic accident	48	●
Chemical accident	-	-
Environmental pollution accident	10	●
Energy	1	-
Communication	2	-
Traffic	-	-
Finance	-	-
Medical attention	1	-
Water supply	-	-
Infectious disease	3	●
Livestock disease	18	●
Others	27	-
Total	259	-

3. Risk Assessment for Critical Disaster Types

3.1. Methods of Risk Assessment

The method of risk assessment (RA) proposed in this study is shown in Figure 1. In this study, the risk assessment consists of four main factors: hazard, exposure, vulnerability, and reduction. These factors are evaluated in terms of disaster indicators for probability, consequentiality, vulnerability, and reducibility, respectively. The evaluation criteria for hazard and exposure have been proposed by analyzing the occurrences and damages of natural and social disasters, according to data measured by local governments over the last 24 years.

And, based on available statistical data for each local government, demographic, social, and facility indicators are selected for vulnerability factors, and medical, policy and administrative indicators that are reduction factors are selected.



<Figure 1> Methods of risk assessment

The calculation formula for risk assessment reflecting hazard, exposure, vulnerability, and reduction is as follows.

$$Risk = \frac{Hazard \times Exposure \times Vulnerability}{Reduction}$$

3.2. Indicators of Risk Assessment

3.2.1. Criteria for Hazard and Exposure Assessment

Hazard is the probability of occurrence according to the number of disasters by local government, and exposure is a method of evaluating the scale of casualties and property damage caused by disasters. To prepare the criteria for evaluating hazard and exposure, 228 local governments in 17 metropolitan cities and provinces were calculated for the number of occurrences, life, and property damage by disaster types that occurred over the past 24 years (1996~2019), and a quartile analysis was performed.

<Table 3> Hazard indicators

Index	Natural disasters	Social disasters
1	Frequency ≤ 1	Frequency = 0
2	1 < Frequency ≤ 5	0 < Frequency ≤ 1
3	5 < Frequency ≤ 10	1 < Frequency ≤ 2
4	10 < Frequency ≤ 20	2 < Frequency ≤ 3
5	20 < Frequency	3 < Frequency

<Table 4> Exposure indicators

Factors	Index	Natural disasters	Social disasters
Death & Missing (person)	1	Damage ≤ 0	Damage ≤ 0
	2	0 < Damage ≤ 1	0 < Damage ≤ 1
	3	1 < Damage ≤ 3	1 < Damage ≤ 5
	4	3 < Damage ≤ 6	5 < Damage ≤ 10
	5	6 < Damage	10 < Damage
Victim & Injury (person)	1	Victim ≤ 1	Injury ≤ 0
	2	1 < Victim ≤ 25	0 < Injury ≤ 1
	3	25 < Victim ≤ 130	1 < Injury ≤ 10
	4	130 < Victim ≤ 600	10 < Injury ≤ 30
	5	600 < Victim	30 < Injury
Economic (billion won)	1	Damage ≤ 1	Damage ≤ 0
	2	1 < Damage ≤ 4	0 < Damage ≤ 1
	3	4 < Damage ≤ 40	1 < Damage ≤ 2
	4	40 < Damage ≤ 200	2 < Damage ≤ 20
	5	200 < Damage	20 < Damage

3.2.2. Criteria for Vulnerability and Reduction Assessment

Factor analysis was performed to select vulnerability and reduction evaluation indicators. Through factor analysis, including principal component analysis, some indicators selected for each disaster types were simplified into indicators related to each other. Through this, factors evaluating vulnerability included demographic factors, facility factors, and regional factors, and factors evaluating reduction were classified into medical factors, administrative factors, and policy factors.

<Table 5> Vulnerability indicators

Types	Factors
Demographic	No. of disabled people (C), No. of disaster vulnerable people (C), No. of social assistance recipients (N), No. of elderly care facilities (S)
Regional	Area of residential district (C), Length of coastline (C), Population density (N), Ratio of impervious area (N), Ratio of urban area (N), Area of road (N),Length of road (N), Area of commercial district (S), Area of manufacturing district (S), Area of farmland (S), Area of Forest (S), Area of construction site (S), Area of new building (S), Area of fish farm (S), Area of parks (S), No. of habitat for migratory birds (S)
Facility	Area of commercial district (C), No. of (semi)basement households (C), No. of ports (C), No. of manufacturing companies (N), Area of industrial district (N), Area of vinyl greenhouses (N), No. of fishery harbors (N), No. of service industry (S), No. of manufacturer (S), No. of vehicle registration (S), No. of farm & stock farm (S), No. of stock (S), No. of ships (S), No. of fishery households (S), No. of school & library (S),

<Table 6> Reduction indicators

Types	Factors
Medical	No. of medical workers (C), No. of doctors (C), No. of special medical equipment (C), No. of medical institutions (C), No. of veterinarians (S)
Administrative	No. of rescue workers (C), No. of public officers (C), No. of fire fighters (C), No. of maritime police officer & patrol ship (S), No. of police officer (S), No. of tug boat & water surface cleaner (S), Rate of vaccination rate (S), No. of sterilization facilities (S)
Policy	Administrative management capability for facility damage (N), Maintenance for natural disaster-prone areas (N), Administrative management capability for inland inundation (N), Administrative management capability for river disaster (N), Network construction with disaster prevention institutions (N), Establishment of measures for snow disaster (N), Administrative management capability for coastal disaster (N), Disaster response capability (N),

3.3. Risk Assessment of Natural and Social Disasters

The results of natural and social disaster risk assessment (RA) for each of 228 local governments in 17 metropolitan cities and provinces were standardized and classified into 5 levels. Level 1 is an area with few disasters in the past or little damage in the event of a disaster and Level 5 is an area with many disasters and a large amount of damage.

In the case of natural disasters, the risk of heavy rain and typhoon increased by 7~9% compared to the results of previous studies, and the risk of snowfall and strong wind decreased by 11~14% compared to results of previous studies.

And in the case of social disasters, the risk of fire, forest fire, livestock disease, and infectious disease increased by 6-10% compared to the results of previous studies, and the risk of collapse, explosion, and environmental/marine pollution accidents decreased within 5%.

<Table 7> Risk assessment of natural disasters

Index	Heavy rain	Typhoon	Snowfall	Strong wind	Wind wave
1	10	39	105	152	197
2	47	77	79	59	61
3	92	75	38	10	114

4	63	29	5	4	32
5	16	8	1	3	8

<Table 8> Risk assessment of social disasters

Index	Fire	Forest fire	Collapse	Explo-sion	Infectious disease
1	96	114	171	97	1
2	14	72	5	77	9
3	40	7	2	3	86
4	58	9	7	39	99
5	20	26	43	12	33

Index	Livestock disease	Ship accident	Environ-mental pollution	Marine pollution
1	29	199	174	195
2	8	8	0	7
3	27	16	2	6
4	140	4	37	9
5	24	1	15	11

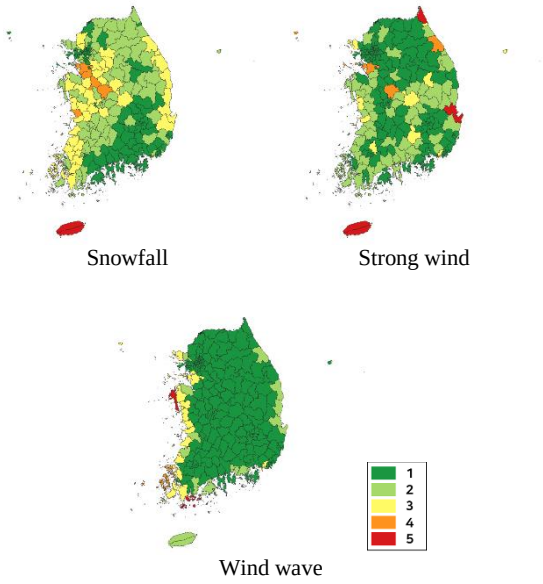
4. Selection of Critical Disaster Types by Local Government

The critical disaster types by region were selected and classified by using spatial analysis for the results of the natural and social disaster risk assessment.

4.1. Selection of Critical Natural Disaster Types

As a result of the risk assessment for natural disasters, it was analyzed that heavy rain was a high rating in Gyeonggi and Gyeongnam regions, and the typhoon had a high rating on the southern coast, Gangwon coast, and Jeju-do.

Snowfall was analyzed to have a high rating in the west coast region, the east coast region, and Jeju-do, and strong winds were analyzed to have a high rating in Jeju-do and coastal areas of Gyeongsangbuk-do. Wind waves were found to have a low risk in most of the east and south coast regions, except for the west coast regions.

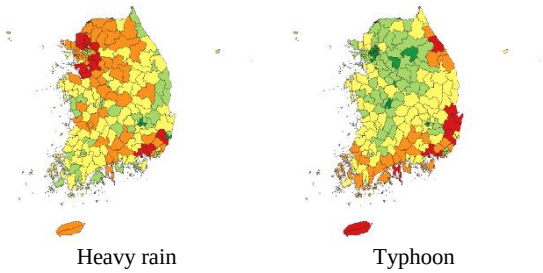


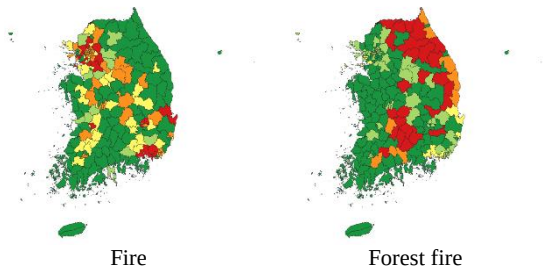
<Figure 2> Critical natural disaster types

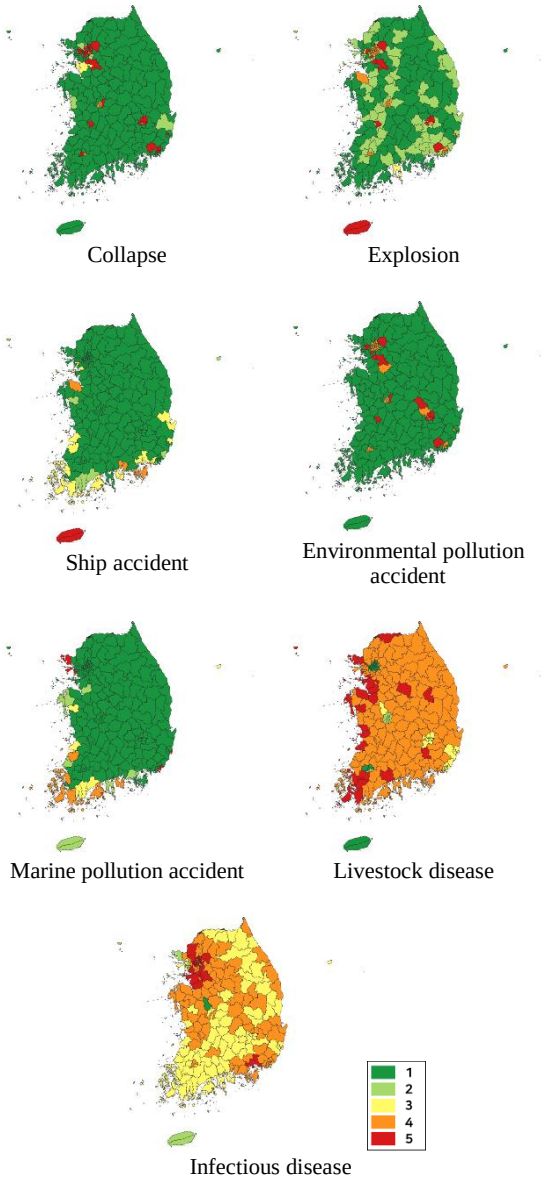
4.2. Selection of Critical Social Disaster Types

As a result of the risk assessment for social disasters, the risk rating of fires was high in 20 local governments, including Gyeonggi-do and metropolitan cities. And, a forest fire was rated highly by 26 local governments, including Gangwon-do and southern inland areas.

The collapse was rated high by 43 local governments, including Seoul, Gyeonggi-do and metropolitan cities, and the explosion was rated high by 12 local governments, including Gyeonggi-do, metropolitan cities, and Jeju-do. The ship accident was highly rated in southern coastal cities, including Jeju-do, while environmental pollution accident was high in local governments adjacent to major rivers, and marine pollution accident was high in the western and southern coastal cities. The livestock disease was high nationwide except for metropolitan areas, and infectious disease was high in 33 local governments, including Seoul and metropolitan cities.







<Figure 3> Critical social disaster types

5. Conclusions

In this study, we analyzed disaster cases that occurred over the past 24 years and selected heavy rain, typhoon, snowfall, strong wind, and wind wave as the critical natural disaster types. And, fire, forest fire, collapse, explosion, marine ship accident, marine pollution accident, environmental pollution accident, livestock disease, and infectious disease was selected as the critical social disaster types. By applying the risk assessment (RA) method, the types of disasters that should be intensively managed by local governments were classified and proposed.

The results of the critical disaster types and risk assessment conducted in this study will be able to contribute to establishing efficient and systematic disaster prevention measures for 228 local governments.

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