DEVELOPING FLOOD VULNERABILITY MAP FOR NORTH KOREA

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ABSTRACT

North Korea suffers from natural hazards, especially flooding, almost every year. One of the main reasons for natural hazards in North Korea is the clearing of forested areas for energy, logging, and agricultural land. These activities increase the likelihood of hazards such as landslides and flooding, and consequently make North Korea more vulnerable to natural hazards. A hazard vulnerability map can provide useful information for the development of hazard prevention policies. This study developed a flood vulnerability map, especially for flooding, for North Korea. The map includes five categories for the degree of vulnerability. It was found that roughly one third of the study area was vulnerable to flooding (very high and high vulnerable categories) and more than half of the cleared forest areas are vulnerable to flooding.

INTROUDUCTION

Natural hazards such as intense rain, typhoons, flooding, drought, etc occur worldwide, and North Korea has suffered from them almost every year. In North Korea, forest ecosystems have been converted into agricultural land in order to overcome food shortages and trees have been cut down for use as energy. This destruction of North Korea's forests allowed serious damage to occur from natural hazards, especially, flooding, since deforestation weakens nature's buffering ability to store water, and thereby increases vulnerability to severe weather conditions. The North Korean government realized the severity of this problem and made efforts to plant trees, however, as of yet, it has not been able to overcome the problem. To overcome the severe threats caused by natural disasters, comprehensive hazard prevention strategies should be made, and international cooperation and assistance should be provided to North Korea. However, areas where priority aid should be provided are not known yet. Hazard vulnerability maps provide very useful information when developing proper and efficient strategies to combat natural hazards. This study analyzed North Korea based on a variety of factors such as social, meteorological, land

use, etc., which may cause flooding, and developed a flood hazard vulnerability map.

METHOD

Factors for Estimating Natural Hazard Vulnerability and their Layering

Generally, natural hazards occur based on complicated interactions between many components such as meteorological, geological, and social factors. Therefore, to estimate the locations of vulnerable areas, factors with potential natural hazard should first be selected and analyzed. It would be useful if more factors were considered, however, because the area of study is in North Korea, acquiring information related to natural hazards has been very difficult. Therefore, some factors like disaster prevention systems such as dams and field measurements were excluded. This study used a two-level approach in finding vulnerable areas. The two levels were called high level factors and low level factors. The high level factors considered are land use, soil, social aspect, hazard history, hydrology, meteorology, and topography. These factors include the following sub-factors; elevation, slope, 100 year precipitation frequency, precipitation intensity, flood discharge, stream order, land cover, riparian buffer, soil permeability, soil loss potential, property damage from flooding, return period, and population. These factors were layered for hierarchical analysis.

Table 1. Factors for Estimating Natural Hazard Vulnerability

High Level Factors	Low Level Factors
Topography	Elevation
	Slope
Meteorology	100 Year Precipitation Frequency
	Precipitation Intensity
Hydrology	Flood Discharge
	Stream Order
Landuse	Landcover
	Riparian Buffer
Soil	Soil Permeability
	Soil Loss
Hazard History	Property Damage
	Return Period
Society	Population

Weighting for Factors for Natural Hazard Estimation

Since each factor has a different effect on the natural hazard, we applied weighting in estimating natural hazard vulnerability. A survey was conducted with natural hazard professionals working in public institutes, universities, and companies related to hazards. Weights were determined based on the surveying results using the AHP method.

Developing Flood Vulnerability Map

Since each factor has a different unit and range in value, each factor was standardized in order to ease the handling of data. After selecting factors, we classified each factor into 5 categories based on their value range; very low, low, medium, high, and very high. After this, all sub factors within the same high level factor were overlaid. Then, high level factors were classified further into five levels. After this, all high level factors were overlaid. At this point, the vulnerable areas were found. Weight was applied for each factor and once complete, a natural hazard vulnerability map was generated.

RESULTS AND DISCUSSION

The final natural hazard vulnerability map showed five levels of vulnerability: very low, low, medium, high, and very high (Figure 1). The vulnerable areas (high and very high levels) totaled about 35% of the study area. The portion for each vulnerability category can be found in Table 2. The results show that areas near the river and areas with high population density with low elevation are the most vulnerable to flooding. This indicates that land use plans should be carefully made along riparian areas and areas where many people live. Due to access limitation in North Korea, ground truth data could not be acquired. Therefore, verification was conducted mostly using paper reports regarding natural hazards in North Korea and our results did a good job reflecting the natural hazard history of North Korea.

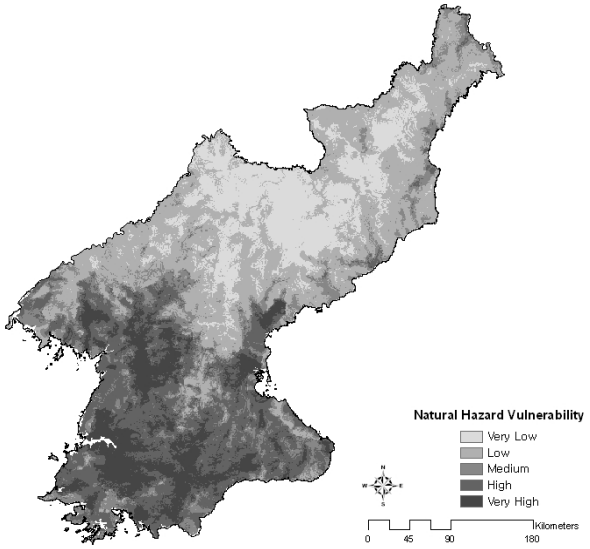

Figure 1. Natural Hazard Vulnerability in North Korea.

Table 2. Distribution of Natural Hazard Vulnerability by Level

Level		Proportion(%)
1	Very Low	17.78
2	Low	33.68
3	Medium	13.45
4	High	22.76
5	Very High	12.33
Total		100.00

The main reason for natural hazard vulnerability in North Korea is forest destruction due to food and energy shortages. Therefore, we examined natural hazard vulnerability of deforested areas. About 50% of the hazard vulnerability in deforested areas turned out to be vulnerable to natural hazards, which reflects the importance of forest ecosystem restoration. It is necessary to develop strategies for hazard prevention since damage from natural hazards in North Korea is continuously reported. Proper reforestation should be implemented in North Korea as soon as possible.

CONCLUSIONS

This study developed a hazard vulnerability map using available environmental data from North Korea to provide basic data useful for the development of strategies to prevent natural hazards. It was found that about one

third of North Korea was vulnerable to flooding, and areas near rivers and where population density is high are the most vulnerable to natural hazards. Strategies for disaster prevention and mitigation should be developed since damage from natural hazards in North Korea are reported almost every year. Further analysis with recent environmental data and additional research regarding other forms of natural hazards should be conducted in the future.

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