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A Study on the Characteristics of Flood Damage Caused by Landslide and Its Minimization Using GIS - The Case Study in the Samwhadong, Donghae city, Kangwondo, Korea

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Abstract

This paper presents the disaster control due to flooding through the case study of Samwhadong, Donghae city, Kangwondo, broken out at 31, August 2002. In order to assess the characteristics of flood damage one must consider social and geological conditions, the factors of flood risk were derived based on GIS. For reduction of flood damage, flood hazard map was prepared for local residents. These information will support refuge activities, it would aid the reduction of flood damage.

Keywords : Flood risk, Landslide, GIS, Inundation map

1. Introduction

Recently, it is reported that global warming frequently gives rise to abnormal weather. Scientists also say that heavy rainfall events will increase as a result of global warming(Kazama et al., 2001). But the characteristic of the heavy rainfall is not global scale events; it is highly localized (Uda et. al., 1999).

These rainfall conditions increase the risk of flood in the down stream area. To reduce a flood disaster, natural looking river projects have been performed on a large scale in the channel by training the river into a straight river bed, there by increasing the river bed slope. This in tern gives rise to an erosion process that even today has not yet come to an equilibrium state. It is emphasized that the river be widened enough for the design flood to pass (Plate, 1988). In order to estimate flood damage, most of studies have been concentrated on a heavy rainfall event in the downstream or landslide area in the mountainous area(Katada

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et al,, 1999 : Kawaike et al., 2001 : Kang and Noguchi, 2001). There are rarely accurate procedures to assess flood damage. To reduce the damage of flooding, it is necessary to analysis its occurrence mechanism. To mitigate these damages an early evacuation system in the high risk area is critical. In this regard, our study was focused on the assessment of potential factors of flooding damage considering geographical conditions, and minimization of its damage using GIS. Most of results for our study are derived from practical experience and questionnaire survey in research area located in Samwhadong, Donghae city, Kangwondo.

2. The research area and refuge activities

2.1 The research area

The Samwhadong area chosen for this study is formed low land and two rivers meet one anther at this area as shown in Figure 1. The area has been suffering from natural disaster like flooding and landslide. In April, 2000, there was large wildfire in this area. Much of the forest was burnt, the mountain was left barren. Furthermore, on 31st August, 2002 typhoon RUSA attacked the area with heavy rainfall of about 315mm/day, which resulted in 4 deaths and compounded the damage to the area(Kim, 2002). As a result of that the government has taken steps towards improving the situation by declaring it a special disaster area.

2.2 The refuge activities

As shown in Figure 2, there was a refuge warning announcement at 7:00 p.m. from Samcheok Munwha Broadcasting Company(MBC) due to flooding in Samwhadong areas, it wasineffective because of interruption of electric

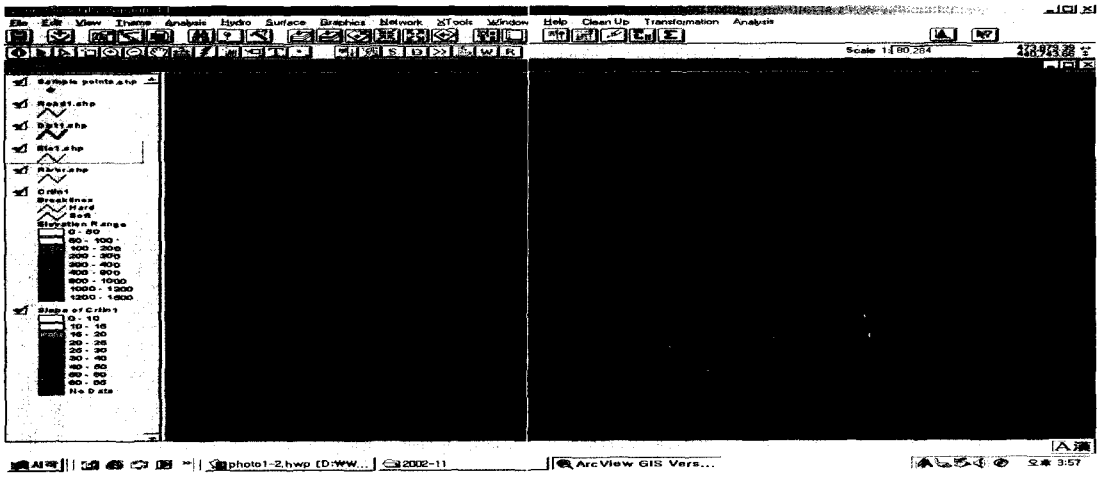
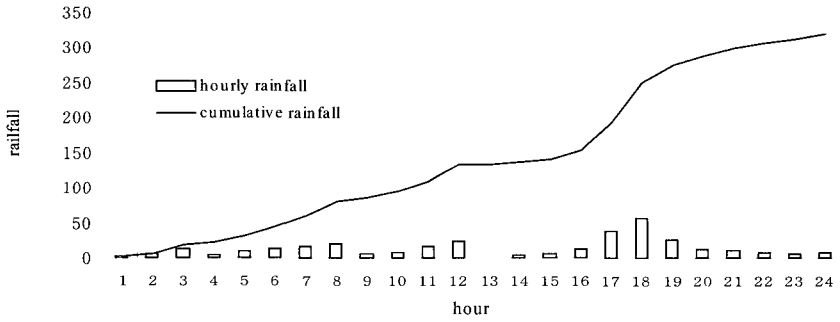


Figure 1. Description of surveying station with GIS base

power. Besides, the Samhadong office gave a typhoon warning at 8:00 p.m., most of residents had already took refuge in an to uphill area around 5:00 p.m. and part of Shinhungchon was choked caused by landslide around 1:00 p.m. and part of Shinhungchon dike was destroyed at 3:00 p.m.

the residents of the town were evacuated from their homes to uphill area by themselves without the information of flood. The residents are entirely isolated from the outside for one week. The peoples could not understand their situation till it was nearly to late. Their house was flooded up to the floorboards before some decided to leave. This describes the damage situation why there were victims with an enormous loss to property.



River situations and administrative actions	Damage and residents actions
Warning of refuge from Samwhadong office Advice of refuge from Samcheok MBC Dike break of Shinhungchon Interception of Shinhungchon due to landslide Power failure in Samwhadong areas Typhoon warning announcement Typhoon alert announcement	Isolation from outside during one week Four missing Inundation depth of 60 cm in main road Finish of refuge activities Start of refuge activities Inundation depth of 30 cm in main road Start of inundation in main road

Figure 2. Countermove due to Flood with rainfall conditions

3. The assessment of flooding damage with GIS

3.1 The characteristics of flooding damage

The floods are hydrological cycle like storm water, typhoon, and cyclones, etc. Floods are sometimes especially greatly influenced by geographical, topographical and land cover. Moreover, the degree of flooding damage depends on urbanization related to population density, the concentration of property to riverside. In order to assess flooding damage, it is necessary to understand mutual interaction between geographical and social conditions. In the case of Samwhadong area as shown in Figure 3, the population concentrates on the floodplain and the town is surrounded by hills that were burned in a large scale wildfire in April, 2000. These geo-social conditions aggravated the flooding damage in the Samwhadong area. The tremendous soil erosion, charred wood, and stone by landslide with heavy rainfall dammed up the flow of the river.

Figure 3. Inundation situation in Samwhadong area(→flow direction)

3.2 The evaluation process of landslide

studies have been carried out to predict landslide areas. Spatial and temporal layered informations have been required to assess potential landslide hazard. Despite of these efforts for landslide, at present, there is no agreement either on the methods for or even on the occurrence mechanism of landslide. Thus, in order to analyze landslide mechanism we derived the geographical factors of its occurrence using GIS. This method illustrated in Figure 4 and described below.

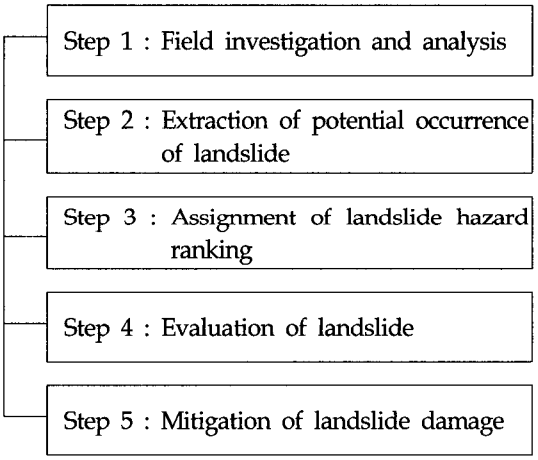


Figure 4. Steps in evaluation of landslide

Field investigation and analysis began with a detailed field survey of the landslides present in the area of study. Using historical records or statistical estimates, risk can be assessed by looking at the probability, frequency, strength and distribution of occurrence of the hazard and its effects. Besides its, secondary effects such as

landslides caused by heavy rainfall and flooding , should be considered. As shown in Figure 2, eighteen points were surveyed to estimate landslide occurrence. *Extraction of potential occurrence factors of landslides* was carried out by literatures. As geography is critical factor in assessing a landslide hazard, a geographic information system was used to understand potential effects of landsliding throughout the evaluating process. *Assignment of potential hazard rankings and its evaluation* was performed based on observed factors. These include the relative occurrence and frequency of landslide, potential source areas, and its activity. *Mitigation of damage* depends on flood information and people' s consensus. In order to reduce flood damage, overall estimation may be need including local surrounding conditions. In this regard, several kinds of efforts to reduce landsliding damage will be described in the next section.

3.3 Evaluation of potential landslide

As shown in Table 1, all items for assessment of landslide risk were sorted and identified to assign occurrence frequency. Then, we derived 11 categories according to degree of natural impact for landslide. Therefore, surveying points that have many categories characterize high hazard areas. Otherwise, surveying points that have little categories mean low hazard areas. In general, it is well known that the landslide concentrate in the range of 10~20 degree(Takami, 1980). In the case of Samwhadong, landslides broke out in the range of 10~40 degree. The affects from the wildfire in the hollow area contributed to a landslide. If wildfire occurs in the hills, the surfaces gradually weaken under the influence of weathering, soil erosion infiltration of water, and other physical processes.

Table 1. Proposed hazard risk items and its assignment of frequency

Item	Category	Assignment of occurrence points											
		1	2	3	4	5	6	7	8	9	10	11	12
Slope	0~10°												
	10~20°			O			O	O	O	O	O	O	
	20~40°	O	O		O	O							O
	over 40°												
A longitudinal section	凹 type	O	O	O	O	O	O	O	O	O	O	O	O
	凸 type												
Forest fire	occurrence		O	O	O	O	O	O	O	O	O	O	O
	nonoccurrence	O											
Land use	a coniferous forest												
	broad leaf forest	O											
	others		-	-	-	-	-	-	-	-	-	-	-

4. Mitigation of flooding damage

Flooding risk can be reduced in two different processes : direct control and indirect prevention. The direct control for flooding involves constructing a levee. Otherwise, indirect prevention involves the effort to reduce flooding damage by refuge activities. In this paper the latter, which is major activity to save peoples lives against flooding has been estimated.

The purpose of making flood hazard map is to provide the information of flood for refuge activities. It must be a precondition that the results of the investigation for a natural disaster must be supplied directly to local residents. In order to determine what kind of map will be useful for refuge activity, the questionnaire survey including the contents, scale, and the method of publishing was carried out. Based on these questionnaire and field investigation, the flood hazard maps can be integrated as following : 1) the local government should be subjective to prepare flood hazard map, 2) the initial planning committee member needs to include local residents, 3) the information of hazard map should be known and distributed directly to the residents, 4) the map should contain the information of refuge activities, and 5) the map should be used for flooding control only. Figure 5 shows the hazard map based on the aerial photo. These efforts will serve to understand flooding and it ultimately would help to reduce flood damage.

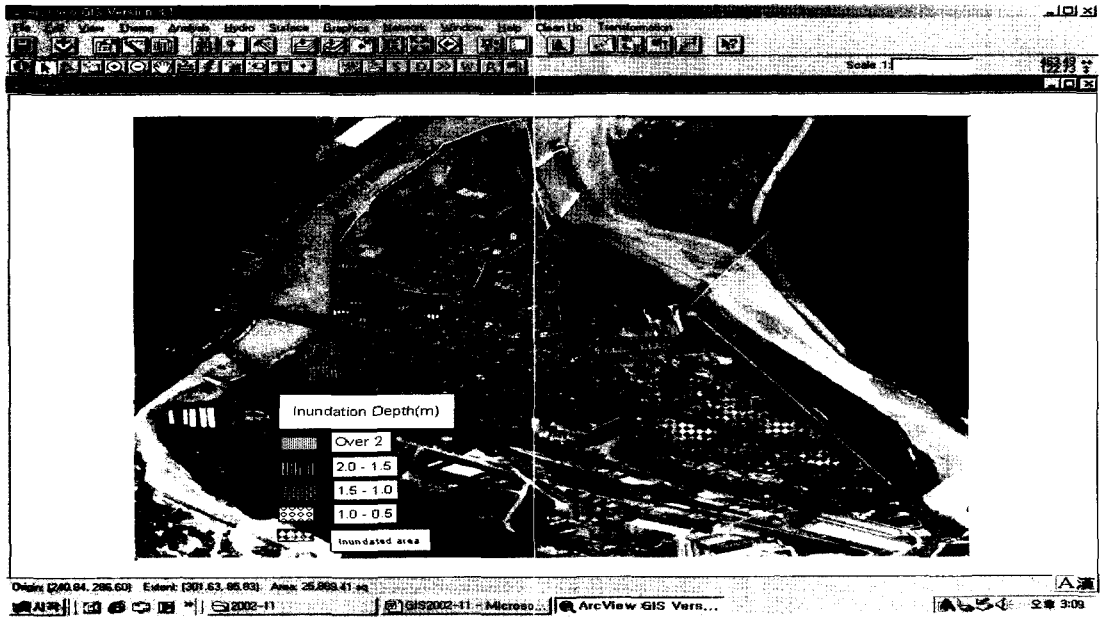


Figure 5. Hazard map in the Samwhadong area

5. Summary and conclusions

The socioeconomic losses due to flood disaster are rising steadily as human development expands into the floodplain and unstable hillslope areas. In addition, the timing of these disasters is random, which indicates that our activities to reduce flood damage will be emphasized not only on the flooding control, but also on the refuge activities. Especially, our study was focused on the reduction of flooding damage and the following conclusions were made on the basis of the questionnaire and field surveying :

1) The procedure of flood damage including landslide was analyzed in the Samwhadong area. The important factor for landslide was obtained using GIS.

2) Based on aerial photo with GIS, flood hazard map was prepared to understand flooding risk to local residents. The map will support refuge activities, can minimize flood damage.

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