APPLICATION OF REMOTE SENSING AND GIS FOR FLOOD VULNERABILITY AND MITIGATION: A CASE STUDY OF FLOOD AFFECTED HIGHWAY 6, HOA BINH PROVINCE

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ABSTRACT

Highway 6 in Hoa Binh province is the only route that links Hanoi Capital with the Vietnam Northwestern mountainous provinces. This region has a steep terrain, a high slope with Da River and Hoa Binh Lake stretches along Highway 6 so the flood vulnerability of this route is very high, especially in the rainy season. It causes not only the paralyzed traffic but also damage to people and property. In this research paper, remote sensing is used for flood vulnerability mapping on Highway 6. GIS software is used for flood evacuation plan based on elevation, population density and available nearby resources.

1. INTRODUCTION

Flooding is a natural danger due to the extreme weather, which directly threaten the road traffic, the road infrastructure as well as the lives of people living on both sides of the road. Flood vulnerability mapping on the highway is one of the most effective ways of managing natural hazards that help managers to realize the flood vulnerability areas easily and to have evacuation planning during flood. In recent years, there are many studies on the application of remote sensing and GIS in flood vulnerability mapping (S.M.J.S.Samarasinghe et al., 2010; Kartic Bera et al., 2012; Kabir Uddin et al., 2013; Muhammad Isma'il and Iyortim Opeluwa Saanyol, 2013; Muhammad Shakeel et al., 2015; Idelbert Dagbégnon Behanzin et al., 2015; Fusami A. A and Aleem K. F, 2016; Costas Armenakis et al., 2017). The objects in these studies are mainly urban areas which located near major rivers.

In Vietnam, National Highway 6 is considered an important route linking the Hanoi capital with the northwestern mountainous provinces. In which, National Highway 6 in Hoa Binh province has received much attention from the government, the transport ministry and related departments. The content of these studies assessed the landslide vulnerability of this highway based on the road surface material (United Nations Development Program, 2015) or focused on statistics landslide positions along the route (Ministry of Transport, 2013) or identified high risk areas for landslides by DEM analysis (Nguyen Thi Hong, Do Minh Ngoc, Nguyen Manh Hieu, 2015). The products of these studies are landslide vulnerability mapping, not flood vulnerability mapping.

This study has used topographic maps, high spatial resolution remote sensing images, a

terrain digital model and a flow accumulation model to create the flood vulnerability zonation mapping on National highway 6 in Hoa Binh province. It has also used GIS software for identify and higher vulnerability villages evacuation planning. This result was verified with historical data as well as interview with local people, field survey on 11-10-2017, at the time of recording some segments on National Highway 6 were flooded and damaged after the heavy rain lasted from October 8 to October 14, 2017.

2. STUDY AREA

National Highway 6 in Hoa Binh province has about 115km length, which connects Hanoi capital with the North-West and Thuong Lao areas. It starts from K38 to K153. Hoa Binh province has a dense network of rivers and streams, as: Da River, Buoi River, Boi River, Ma River and Hoa Binh Lake,.... Due to the high mountainous terrain, a high slope with Da River and Hoa Binh Lake stretches along Highway 6 so the flood vulnerability of this route is very high, especially in the rainy season.

3. MATERIALS AND METHODOLOGY

3.1 Materials

In this study, high spatial resolution satellite images were used to describe the flood vulnerability on National Highway 6 preliminarily (Tab.1). In addition, it has used the digital elevation model (DEM) to observe the elevation change of the terrain surface. This study has also used topographic maps in 1/5000 and a flow accumulation model which was created from DEM in the ArcGIS 10.5 environment.

Table 1. High spatial resolution remote sensing images were used in this study.

Type	Sensors	Spatial resolution	Date of received
GeoEye-1	Panchromatic	0,5m	21/10/2011
GeoEye-1	Panchromatic	0,5m	05/06/2013
GeoEye-1	Panchromatic	0,5m	25/09/2015
SPOT 5	Multi-colour	2,5m	27/02/2013
SPOT 5	Multi-colour	2,5m	30/06/2015

3.2 Methodology

3.2.1 *GIS approach*

First, topographic maps in 1/5000 were imported into ArcGIS 10.5 to provided an overview of location, length and hydrological network on National Highway 6 in Hoa Binh province and they also provided the positions of hospitals, schools, medical stations, road networks, railway networks,... From these data, this study used the spatial analysis tools in ArcGIS 10.5 to build a digital terrain model (DEM) to observe the elevation change of the

terrain surface (Fig.1). Then, it used GPS coordinate points to give remote sensing images into the same coordinate system with topographic maps, VN-2000 system.

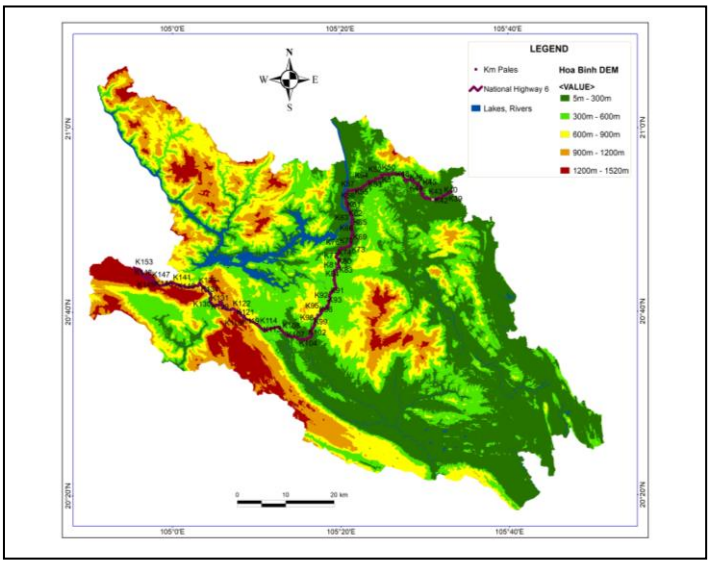

Figure 1. Digital elevation model and hydrological network in Hoa Binh province.

In addition, it also built the flow accumulation model from DEM in ArcGIS 10.5 (Fig.2). Then, it overlaid all of the above-mentioned data in ArcGIS 10.5 to create the flood vulnerability zonation mapping on National Highway 6, Hoa Binh Province.

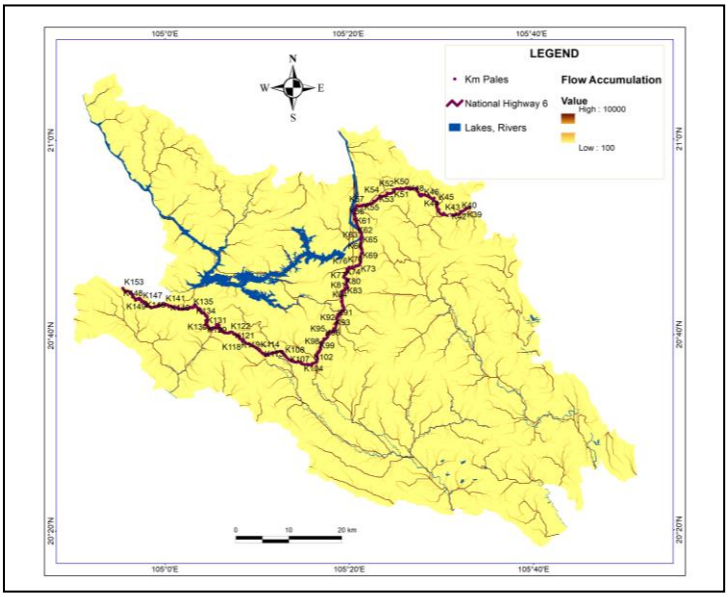

Figure 2. The flow accumulation model in Hoa Binh province.

This flood vulnerability zonation mapping was divided into three levels: high, medium and low. It mainly based on the elevation changes, the flow accumulation model and the interpretation results of the high spatial resolution satellite images (Fig.3).

This study used the query and analysis tools in ArcGIS 10.5 in order to identify residential areas which were in the flood areas from low level to high level. It was done easily because of the flood vulnerability zonation mapping (Fig.4).

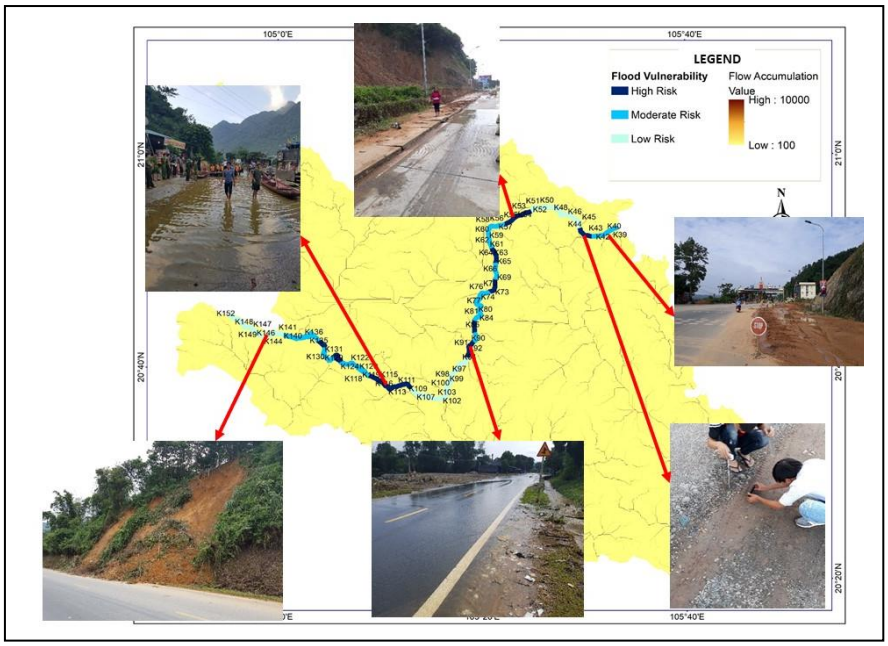

Figure 3. The flood vulnerability zonation mapping on National Highway 6, Hoa Binh province.

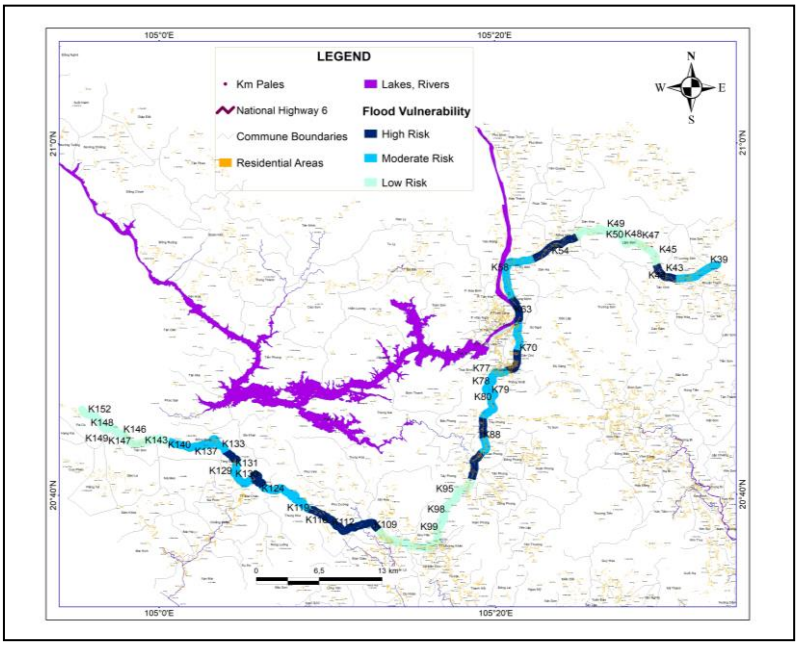

Figure 4. Identify residential areas in the flood areas based on the flood vulnerability zonation mapping.

3.2.2 *Field survey*

To verify the research results, the author has compared with the historical data over the years. In addition, the author also conducted field surveys and interviewed people living along National highway 6, Hoa Binh province in October 11, 2017 (Fig.3). This time recorded National highway 6 was flooded and damaged seriously after the heavy rain lasted from 8-10-2017 to 14-10-2017. Many houses were damaged and flooded, some residential areas had to been evacuated due to the risk of flash floods and landslides (Report on flood damage in Hoa Binh province in October, 2017).

4. RESULT AND DISCUSSION

The flood vulnerability zonation mapping on National highway 6, Hoa Binh province was compared with the historical data over the years and verified with field surveys and interviewed people living along this road. The accuracy of this map had quiet high reliability, approximately 83% because these high spatial resolution satellite imageries were received quite far, 2013 and 2015. However, when overlaid the flow accumulation model and DEM in ArcGIS 10.5, it helped to predict the flood vulnerability segments accurately. The detail results were shown as follow:

- The high flood vulnerability segments were: K42-K44; K52-K57; K63-K65; K70-K73; K85-K90; K92-K94; K109-K118; K126-K130; K131-K135;
- The moderate flood vulnerability segments were: K39-K42; K57-K61; K65-K69; K73-K84; K90-K92; K119-K124; K129-K131; K135-K141;
- The low flood vulnerability segments were: K44-K52; K96-K109; K142-K152;

From the flood vulnerability zonation mapping on National highway 6 and topographic maps in 1/5000, this study used the query and analysis tools in ArcGIS 10.5 to identify the residential areas which were in the flood areas from low level to high level (Tab.2).

Table 2. The residential areas were at the risk of flood from low level to high level.

No	Name of villages (Name of commune)	Elevation intervals (m)	Flood vulnerability level
1	Lam Son, Rong Vong, Xom Chua, Go Bui (Lam Son). Xom Denh, Ao Trach, Dong Giang (Dan Hoa). Xom Bang, Pho Nep (Tay Phong). Xom Dom, Xom Cong (Quy Hau). Xom Khang (Tan Lac).	300 - 600	Low
2	Bai Bau, Ho Da (Tan Son). Sai Linh (Pa Co).	1200 - 1520	Low
3	Cau Son, Dong Bai, Cho Mo, Xom Mo (Luong Son). Doan Ket, Xom Pheo (Ky Son). Xom Ru, Xom Mieu, Ben Ngoc (Trung Minh). Lang Su, Lang Ngoi (Su Ngoi).	5 - 300	Moderate
4	Xom Bo, Xom Tam, Xom Buoi (Phu Cuong)	900 - 1200	Moderate
5	Dong Bang, Xom Vat, Dong Xa (Dong Bang).	600 - 900	Moderate
6	Xom Rom, Dong Moi, Pho Cun (Hoa Binh City). Bac Son (Thu Phong).	300 - 600	Moderate
7	Rong Tam (Luong Son Town).Hang Nuoc, Bai Nai, Xom Du (Mong Hoa). Xom Mo, Xom Nut (Dan Ha). Pho Ngoc (Trung Minh). Dong Tien (Thinh Lang). Bai Yen (Dan Chu). Mat Tren (Cham Mat).	5 - 300	High
8	Bac Phong, Xom Khu (Cao Phong). Phong Phu (Phu Vinh). Xom Trong, Xom Trao, Xom Bai (Phu Cuong). Thung Cum, Xom Nhuoi, Tong Dau (Tong Dau).	300 - 600	High

5. CONCLUSION AND RECOMMENDATION

This research paper provides the flood vulnerability zonation mapping on National Highway6, Hoa Binh province by using remote sensing and GIS metholodogy. The results of this research are very useful during disaster for decision making and movement of local people to more safety places. This study helpful for informing local people living along the highway 6 about flood occurrence and also making evacuation planning based on local available resources.

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