ESTIMATION OF INUNDATION WATER DEPTH USING FLOOD EXTENT INFORMATION AND HYDRODYNAMIC SIMULATIONS

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1. INTRODUCTION

Geographic position and topographic condition cause special climate characteristics resulting to serious and diversified disasters in Vietnam. Catastrophes occur almost all round year under numerous types of disasters. Flood is indicated as the most serious and frequent natural disasters in the region in which North Central part is one of the most flood – vulnerable region. The damage of due to severe flood disasters in 2010 was estimated to be once in 100 years and lead to the flooding of 182 in 243 communes and 6 billions of VND (300 million USD) just for 1 province. Most damage occurred in the agriculture sector and infrastructure.

The acknowledgement that flood risk remains even people tried to guard themselves with comprehensive flood – protection works has led to the need of specific research efforts for an improved risk assessment and prevention on regional and local level is evident. The traditional flood policies concentrated on the control or reduction of flood hazard have shifted to flood risk management of which flood damage assessment is an essential part and damage function are seen as a key in flood damage estimation.

In this regard, flood damage assessments are gaining widely interest in recent studies (Dawson et al., 2008; European Commission, 2007). Even though the technology may differ in specific applications, most functions have in common that the direct monetary damage relates to the inundation depth and classification of elements at risk, such as USACE (2000) for the USA, Reese and Markau (2002) for, Germany.

Thus, it is essential to know the inundation, water depth in flooded regions for proper flood damage assessments. However, it is considerably difficult in reality because in most cases information on inundation depth is limited except for high water marks and memory of disaster-affected residents. To overcome this difficulty, satellite imagery is often used in combination with methods for extracting flooded regions, which is helpful to detect the extent of flooded area while it does not give direct information on inundation depth. The current study develops a method to estimate inundation water depth using flood extent information and hydrodynamic simulation.

2. METHODOLOGY

As is discussed in the previous section, satellite imagery is often used to establish flood extent maps by defining flooded regions based on electromagnetic characteristics of the water body. Flood extent maps derived from satellite data show estimated location of flooded water body. In the proposed methodology, hydrodynamic simulations are used to convert information of water body location to water depth information.

A simplified shallow water equation model is applied to estimate water depth within the flooded regions under the boundary condition that water is drained only from the lowest point (outlet) on the boundary of flood extent extracted from satellite imagery. The boundary other than the outlet works as an imaginary wall, preventing the water from flowing into and out of the flood extent. A steady state water depth distribution is estimated with a temporary constant and spatially uniform rainfall input, and the side area of the flooded water body is calculated with the estimated water depth. The calculated side area is an index to determine the most likely estimation of flooded water depth. The hydrodynamic simulation is repeated with changing rainfall inputs so that the calculated side area shows a good agreement with that derived from the flood extent map.

3. HYDRODYNAMIC MODEL

A hydrodynamic model used in this study is a simplified shallow water equation model, which is recently called as an inertial formulation of the shallow water equation (Bates et al. 2010). This model is derived from the original shallow water equation model by ignoring the advection term. In most cases of floodplains flow the advection is not important compared to other terms in the equations. The advantage of this model includes the ease of coding and less computing costs. The model equations are given as follows:

$$\frac{\partial h}{\partial t}+\frac{\partial M}{\partial x}+\frac{\partial N}{\partial y}=r \tag{1}$$

$$\frac{\partial M}{\partial t}=-gh\frac{\partial H}{\partial x}-gn^2u\frac{\sqrt{u^2+v^2}}{h^{1/3}} \tag{2}$$

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$$\frac{\partial N}{\partial t} = -gh\frac{\partial H}{\partial y} - gn^2 v\frac{\sqrt{u^2+v^2}}{h^{1/3}} \quad (3)$$

4. APPLICATION

4.1 Study area

The study area is a part of CA River basin, located in the northern area of Vietnam (Fig. 1). The area sometimes suffers from flood disasters, causing considerable economic damages mainly due to agricultural failure. Figure 2 shows numerous flooded regions of a severe storm happened in 2010 (shown as red patches). Among the flooded regions, a relatively large region was selected as the target area because a field survey was conducted to collect information on flooding situations.

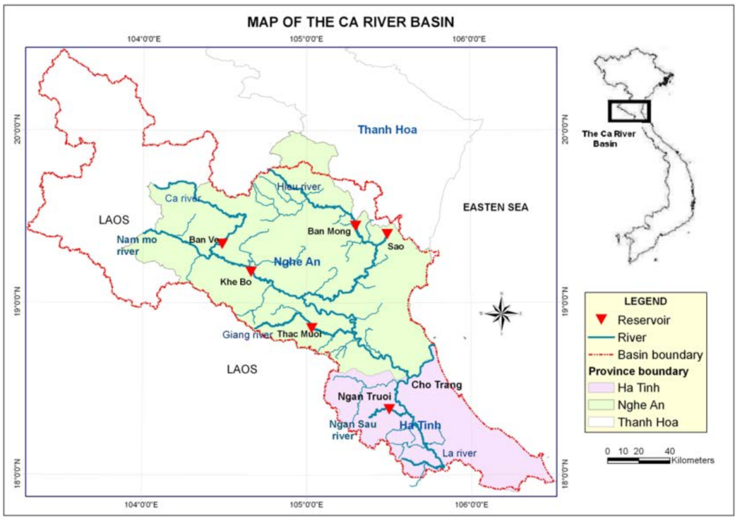

Fig. 1 Ca River basin

4.2 Used datasets

Figure 2 is the flood extent map used in this study, which was downloaded at the website of UNOSAT. This map was provided in PDF format and the boundary line of the target flood region was extracted from the map so that a GIS software was able to handle it as a polygon dataset. Moreover, the polygon dataset was converted into a raster type dataset to be used as an input information for the hydrodynamic model.

To capture the topographic features of the target area, a point-based elevation dataset was collected and converted into a raster type dataset using a spatial interpolation method implemented in a geographic toolbox of ArcGIS. Figure 3 shows a topographic map created from the dataset.

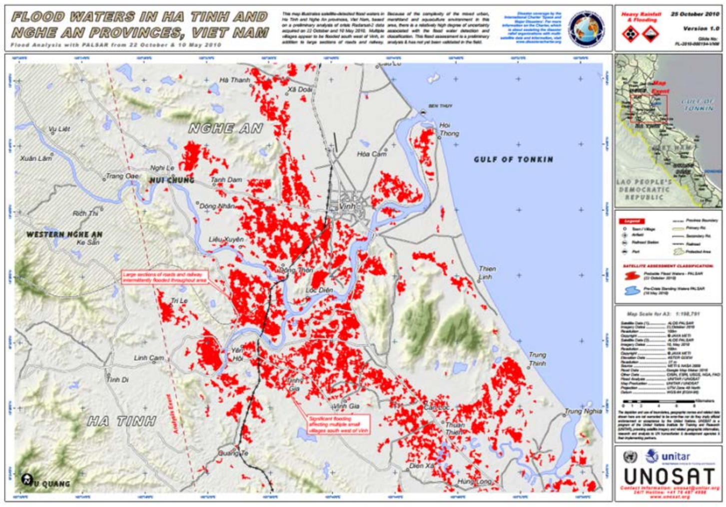

Fig. 2 Flood extent map for the lower area of Ca River basin

5. SUMMARY

A methodology for estimating inundation water depth from flood extent information and hydrodynamic simulations was briefly described. The application results will be given at the presentation of the conference.

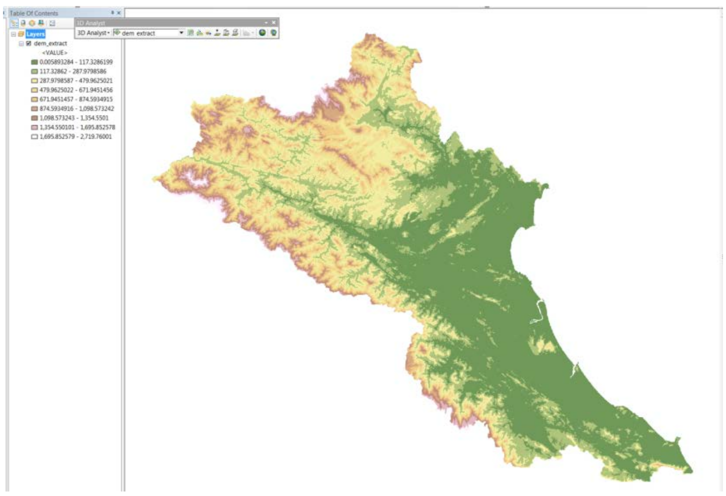

Fig. 3 Topographic map of the study area

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