AN EXTENSION OF METHODOLOGY FOR ESTIMATING THE FATALITIES AND INJURIES DUE TO FLOODS IN TRA KHUC – VE RIVER BASIN

Vu Thanh Tu
Thuyloi University, email: vutu@tlu.edu.vn

1. INTRODUCTION

The loss of life in floods is due to both drowning and/or the spread of disease epidemics. An improved flood risk management is a main purpose in order to reduce the flood losses and damages. When flooding occurs, the safety of people can be damaged, that due to the high flooding depth and flow velocity can exceed the ability of people to remain standing and/or cross a waterway. (Abt et al., 1989; ARR, 2011; Milanesi et al., 2013; Jonkman, 2001). Duiser (1989) presented a model that relates the local mortality fraction to the flood depth (h), and by adding more data on the 1953 floods. Waarts (1992) developed a general function for flood mortality (F_M) as a function of water depth. DEFRA (2006) suggested the number of injuries/deaths can be determined based on the hazard level, number of people within the floodplain, area vulnerability and proportion of those at risk who will suffer death/injury. Zhai et al. (2006), present a method to estimating the number of death/injure based on the based on the relationship between recorded number of damaged building and number of dead and injured people.

As the main river basin in Quang Ngai province, Tra Khuc - Ve river basin is one of the most flood-prone areas of Vietnam as floods cause heavy losses of lives and properties, every year. The assessment or prediction of flood damage is therefore really important to improve flood preparedness and awareness activities. The objectives of this study is to focus on estimating appropriate methods and functions for assessing the potential damages to human life in river basin due to floods.

2. METHODOLOGY

Estimating the number of expected injuries and deaths is a difficult task, because it depends on the natural and social elements. An alternative methodology developed by Zhai at al. (2006) for Japanese environment was tested. These Authors developed a framework for estimating the number of deaths and injuries due to floods based on the relationship between number of damaged building and number of dead and injured people. The number of buildings affected by floods can be clearly expressed as a function of flood intensity, regional vulnerability and resilience. Then, the relations between deaths/ injuries and damaged building can be empirically analyzed.

The number of deaths or injuries depends on the flood magnitude and population exposure. It can be mathematically expressed as (Zhai et al, 2006):

$$L = L(F,P) \quad [1]$$

$$P = P(F,N) \quad [2]$$

Then, $F = P^{-1}(P,N)$ [3]

Therefore, $L = L^*(P,N)$ [4]

where L is the number of injuries or deaths, F is flood magnitude expressed as flooding depth, P is the population exposed to the flood, N is the regional population, L(.) and L*(.) is an injuries or fatalities function,

P(.) is the function expressing the population exposed to the flood.

If the exposed population is proportional to the number of damaged buildings, the deaths and injuries function may be transformed into: L = S(B) [5]

where, S(.) is the function and B is the number of inundated residential buildings.

3. RESULTS AND DISCUSSIONS

3.1. Hazard level to human safety

Following results of flood simulation in Tra Khuc – Ve river basin (Vu, T.T and Ranzi, R., 2014) at each point of the study area the value of flooding depth (h), flooding duration (D) and flow velocity (V) are determined and mapped for different return period of floods. However, it is difficult to evaluate in real time the characteristics of the event that will happen, so in order to consider the hazard level and the possibility of level may be occurred, the values of flood magnitude will be synthesized in one indicator ($H_{synthesis}$) and classified as hazard level based on the flood intensity effect to human safety as shown in Figure 1 below.

The synthesized hazard level map (Figure 2) is not only supplies the information about the area where the magnitude of hazard frequently occurs in the study area; it also allows to identify, investigate and monitor any hazard to determine its potential, origin, characteristics and behaviours, raising awareness on hazards.

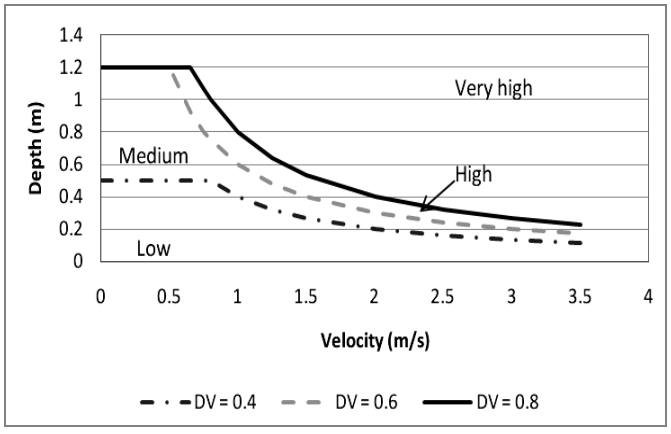

Figure 1. *The flow hazard level for people*

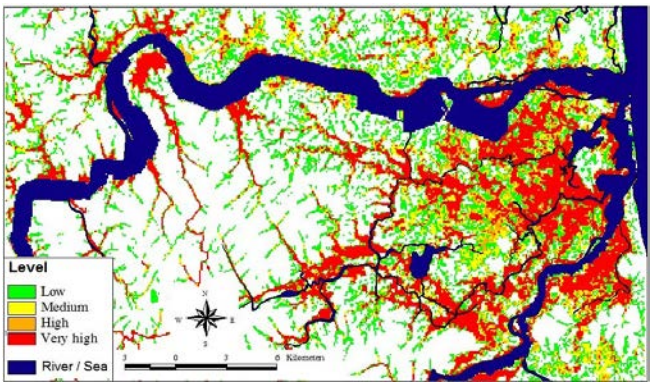

Figure 2. *The synthesized hazard level at each point in study area*

3.2. Estimating the number of deaths and injured people.

Following the method suggested by Zhai et al. (2006), the relationship between the number of injuries/deaths and damaged buildings are developed based on the number of deaths, injuries and number of damaged building as well as the frequency of major floods collected in Quang Ngai province from 1996 to 2009. The number of deaths/injuries corresponding to different return periods of flood were determined as shown in Table 1.

Table 1. Number of injuries and deaths corresponding to various hazards.

Return period (T)	Mean of flooding depth (m)	Num. of damaged building NB	Num. of injuries NInj	Num. of deaths ND
200yr	1.13	143 720	630	64
100yr	1.05	137 080	611	63
50yr	0.97	128 840	587	62
20yr	0.83	118 920	557	60
10yr	0.71	104 920	514	58

3.3. An extension of methodology for estimating the number of deaths and injuries.

Assuming, after observations and inquiries (Vu et al., 2014), that during the flood event most of people shelter in their house/building. Then, based on the relationship between the number of deaths/injured people and damaged buildings (as shown in Table 1, see [1] to [5]), this

paper develops some functions for estimating the percentage of injuries/ deaths based on the percentage of damaged buildings and from the mean of flooding depth in the floodplain area as shown in Figure 3.

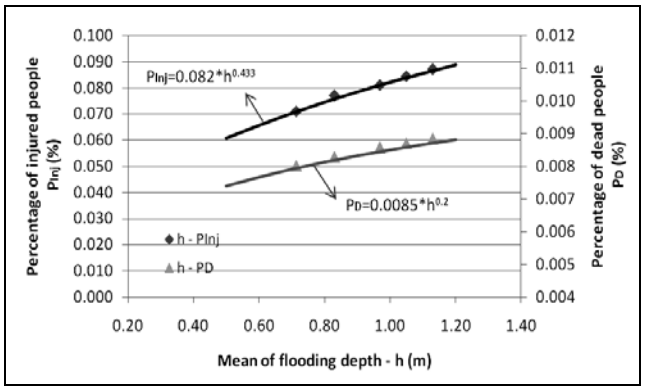

Figure 3. *The relationship between the mean of flooding depth and percentage of deaths and injured people.*

In order to understand how the functions can be applied, a verification was done. The calculated number of dead people is close to that recorded in 1999, 2005 and 2009, but was overestimated for the 2003 flood. For the number of injured people, the calculated number of injuries in 2003 and 2005 is very different to the recorded data, but quite reliable for the 1999 and 2009 floods (see Table 2).

Table 2. The calculated and recorded number of dead and injured people in some year.

Year	Mean of flooding depth(m)	Num. of injured people		Num. of dead people	
		Cal	Rec	Cal	Rec
1999	1.2	642	334	64	53
2003	0.7	508	38	57	21
2005	0.8	538	35	59	45
2009	0.6	475	380	55	38

4. CONCLUSIONS

For flood warning, flood hazard map could be considered to better target people or communities more exposed to the hazard and possibly to fund improved warning systems where these will be more effective in reducing risk to people and properties.

Based on the result of floods simulations, number of damaged building and damage to people, the relationship between mean of flooding depth and percentage of death/ injured people are constructed. Comparing to some recorded data of mean of flooding depth, number of death/injured people, the results show that the functions developed from the above mentioned relationships are acceptable in some years. Although estimating the number of death/ injured people is a very difficult task, it depends on many factors such as natural, social, psychological and technical factors as discussed. However, predictions indicating the number of death/injured people are also necessary in order to understand the relevance of the flood hazard

5. REFERENCES

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