THE HAZARD SYSTEM FOCUS ON LANDSLIDE – WU-FONG AND JIAN-SHIN TOWNSHIP IN HSINCHU COUNTY

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ABSTRACT

This research is based on various true landslide cases, to analyze the characteristics of landslide through different time scales and spatial patterns, and to find out causes of landslides. The vulnerability differentiates one from another. Conducting such method in this research is due to the variety of landslide formation in different areas. Through the case investigation, set the landslide factors into different categories, then to analyze different susceptible factors of mass movement in order to establish a landslide susceptibility map. The existence of hazard happens as it comes across the human interest. Hazard not only brings the destruction, it sometimes takes away innocent lives. So, to develop a better understanding on the residents' hazard perception could definitely enhance the knowledge of why the hazard is generated by residents. Research points out the greater hazard bring attention to residents of what it is. Resident's age, living time, and gender influence hazard perception. Existence of hazard perception and cause of hazard perception influence re-occurrence perception. Re-occurrence perception will influence resident's adjustment behavior. Furthermore, there is a significant connection of hazard perception between the experience of property loss, cause of changing lifestyle, and death of relatives and friends by natural hazards.

Keyword: Landslide susceptibility mapping, Landslide risk mapping, Hazard system of landslides, Hazard perception

INTRODUCTION

The Aere and Haima typhoons attacked Taiwan in 2004, and led to serious building damage and twenty people died in Wu-Fong and Jian-Shin townships. The Taiwan Government announced that study area is a high potential geological hazard region, representing vulnerability of the enviornment.

Research on natural hazard can be divided into several categories, such as the used of spatial analysis (RS, GIS, GPS), digitizing slope, stream, geology, fault...etc, and calculating risk value. (Remondo, 2003; Chau, 2005; Sarkar *et al.*, 2008). On other hand, in order to improve qualitative potential analysis, Chau (2005) used logistic regression and Remondo (2003) used Favourability Function approach. Most previous studies have taken place on emphasizing the

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hazard cause, but they ignore the relationship between hazard and individual.

White (1974) said the results of artificial facilities are often not good as expected. Natural hazard always involves human initiative and choice. Therefore, the discussions of hazard perception become the focus of hazard study. However, past studies focus on education level, occupation, gender, age...etc (Saarinen, 1976; Alexander, 1992; Burn, 1999; Burton *et al.*, 1993), and often ignored the environment makes a huge influence on hazard perception.

The aim was to use historical data to understand natural event causes, and through these factors make assessment of Susceptibility. However, the sensitive area is not equal to disaster, comparing to different degrees of risk to understand cause of hazard.

DESCRIPTION OF STUDT AREAS

Wu-Fong and Jian-Shih Townships are located in the southeast sector of the Hsinchu County, at an average altitude of 400-2910 m above sea level, covers an area of about 549 km^2, and a yearly average rainfall of 753 mm. The study area is in ten different lithology types. The majority of rock types are covered by sandstone, sandy shale, and shale. These are very fragile, easily cause erosion by weathering, river washing.

METHODLOGY

Mass Wasting is defined as the down slope movement of rock and regolith near the Earth's surface mainly due to the force of gravity. We will use a classification that divides mass-wasting processes into three broad categories: rock fall, landslide, debris flow. (Chuang, 1995；Shih, 2008)。

1. Historical sources

Field data analysis has also been integrated using a historical approach to reconstruct the main natural calamitous events. These events refers to the last forty years. Possible cause of hazard will be evaluated based on previous research. The following mass wasting susceptibility factor maps were generated: land-use, lithology, slope, elevation, aspect, proximity to fault, proximity to road, and proximity to stream.

2. Analysis of Potential Assessment

(1) Susceptibility assessment

The purpose of this research is to use the technology of the geographical information system (GIS) and instability index method to set up one quantitative method to estimate hillside fields (Lin *et al.*, 2002； Chao and Kao, 2006, 2007; Su *et al.*, 2009), the calculation model is expressed as the following equation:

$$D_{total} = D_1^{W1} \times D_2^{W2} \times D_3^{W3} \ldots \times D_n^{Wn} \quad (1)$$

Where D1, D2 and Dn denote instability index value. For example: slope, elevation, aspect...etc. W1, W2, Wn denote instability index weight. The D_{total} represents the relative susceptibility of a mass wasting occurrence.

Calculating “D” value with a range of 1-10:

$$D = (9(Xi-Xmin)/(Xmax-Xmin))+1 \qquad (2)$$

Where Xi denotes density of mass wasting, Xmin and Xmax represent maximum or minimum value of variable, respectively.

(2) Risk Assessment

Risk Assessment represents Landslide Susceptibility required to join the human factor. Then we follow the building vulnerability to set up landslide risk map. The vulnerability includes building, cropland, road and forest.

(3) Hazard perception

Hazard perception includes existence of hazard perception, seriousness of perception, cause of hazard perception, and re-occurrence perception. Interviews and questionnaire with residents are conducted on the landslide risk map. Interviews and questionnaire conducted among the scattered villages with high and low hazardous degree. It is also important to compare whether these villages have a difference over the hazardous perception level. This study interviewing with resident’s hazard perception could be helpful to our understanding of causes of hazard transfer disaster, that causes may be gender, age, occupation, hazard experience, living time, information gain, and magnitude of disaster...etc.

RESULTS AND DISCUSSION

1. Hazard characteristics of time and space

The rock fall hazard increases progressively every year, particularly in the last 20 years. The landslide hazard increases faster than rock fall hazard, particularly in 2000 to 2008. Historical sources didn’t recognize the debris flow hazard until media started using it, so the study gathered debris flow hazard from 2000 to 2008. The maximum amount of debris flow hazard occurs in 2004 from 2000 to 2008.

2. Landslide Susceptibility Mapping

The calculated mass wasting distributions in terms of five susceptibility levels for eight landslide susceptibility variations, the eight factors are land-use, lithology, slope, elevation, aspect, proximity to fault, proximity to road, and proximity to stream. An integration of these variation with certain weights and conditions yielded landslide susceptibility values.

The statistical analysis discovered that lithology, land use and elevation condition of the specified area are the most important elements on the cause of rock fall. Therefore, the non-cemented alluvial fan enjoys the highest hazardous potential from the lithology sector;

the road pavement also demands the highest degree of hazard from the land use. Cause of landslide is based on three factors of land use, slope and geology. The Aoti formation layer of sand and shale consist of the highest hazardous degree in the lithology sector; landslide also happens easily at the former landslide sites. The convergence of debris flow is mostly influenced by these factors such as geology, fault, and elevation. The sand and shale formation of sandstone layer locates in Mt. Kuanyingshan has the highest hazardous degree in the geology sector (Tab 1)

Table 1 Weight of Mass Wasting

Mass Wasting	Rock fall		Landslide		Debris flow	
Variation	Coefficient of Variation	weights	Coefficient of Variation	weights	Coefficient of Variation	weights
Proximity of road	81.12	0.087	5.88	0.011	53.46	0.108
Proximity of stream	65.21	0.07	34.02	0.064	26.59	0.053
Land use	188.71	0.203	213.74	0.407	39.19	0.079
Aspect	85.26	0.091	51.9	0.098	29.49	0.059
Lithology	214.73	0.231	66.13	0.126	108.03	0.219
Proximity of fault	103.7	0.1118	11.62	0.0221	104.79	0.212
Elevation	114.78	0.123	38.11	0.072	61.1	0.123
Slope	74.34	0.08	103.55	0.197	35.41	0.071
Shape factor					35.2	0.071

3. Landslide Risk Assessment

We follow the building vulnerability to set up landslide risk map. The vulnerability includes building, cropland, road and forest (Tab 2).

Table 2 Elements at Risk

Categories	Building	Cropland	Road	Forest	Stream	Grassland, Mass wasting
value	10	5	5	1	1	1

The maximum risk assessment value of rock fall was about 60, represented the Building located on extremely Susceptibility area. The maximum risk assessment value of landslide was about 29, represented the Building not located on extremely Susceptibility area. The maximum risk assessment value of debris flow was about 82, represented the Building located on extremely Susceptibility area. The study represented village selected settlement along stream, rather than the slope.

4. Hazard perception and Adjustment

The study in total interviewed seventy residents, the result as follow:

(1). Relationship between perception and socio-economic characteristic

Research points out the age, living time, information gain and magnitude of hazard will affect existence of hazard perception. The age, living time, occupation and hazard experience will affect seriousness of perception. The gender, information gain, age and living time will affect cause of hazard perception. Most of the residents assumed that the disaster will happen again (Tab 3).

Table 3 Relationship between perception and socio-economic characteristic

		Existence of hazard perception)		p	Seriousness of perception		p	cause of hazard perception		p	cause of hazard perception		p	Re-occurrence perception		p
		Profound (%)	Not Profound (%)		Profound (%)	Not Profound (%)		Profound (%)	Not Profound (%)		Correct (%)	Incorrect (%)		Profound (%)	Not Profound (%)	
Gender	male	91.7	8.3	0.63	69.4	30.6	0.208	88.9	11.1	0.002*	80.6	19.4	0.484	88.9	11.1	0.099
	female	88.2	11.8		82.4	17.6		55.9	44.1		73.5	26.5		73.5	26.5	
Age	<20	0	100	0.0*	33.3	66.7	0.011*	33.3	66.7	0.216	33.3	66.7	0.166	66.7	33.3	0.738
	20-50	90	10		63.3	36.7		70	30		76.7	23.3		80.0	20.0	
	>50	97.3	2.7		89.2	10.8		78.4	21.6		81.1	18.9		83.8	16.2	
Occupation	farmer	96	4	0.16	76	24	0.292	80	20	0.091	88.0	12.0	0.364	92.0	8.0	0.240
	Service	90	10		90	10		80	20		60.0	40.0		80.0	20.0	
	laborer	50	50		50	50		50	50		100.0	0.0		100.0	0.0	
	public service	100	0		50	50		100	0		75.0	25.0		87.5	12.5	
	No	84	16		80	20		56	44		72.0	28.0		68.0	32.0	
Living time	<5	66.7	33.3	0.005*	33.3	66.7	0.037	33.3	66.7	0.019*	50.0	50.0	0.245	50.0	50.0	0.067
	5-15	50	50		50	50		50	50		100.0	0.0		100.0	0.0	
	15-40	91.3	8.7		82.6	17.4		65.2	34.8		73.9	26.1		73.9	26.1	
	<40	97.3	2.7		81.1	18.9		86.5	13.5		81.1	18.9		89.2	10.8	
Hazard experience	No	90.2	9.8	0.92	66.7	33.3	0.004*	76.5	23.5	0.265	80.4	19.6	0.289	80.4	19.6	0.715
	Yes	89.5	10.5		100	0		63.2	36.8		68.4	31.6		84.2	15.8	
Information gain	Oneself and relative	95.2	4.8	0.14	71.4	28.6	0.183	83.3	16.7	0.000*	83.3	16.7	0.292	85.7	14.3	0.296
	Media	75	25		62.5	37.5		12.5	87.5		62.5	37.5		62.5	37.5	
	Both	85	15		90	10		75	25		70.0	30.0		80.0	20.0	

(2). Relationship between perception and adjustment

Most of the residents selected to leave home would significantly reduced vulnerability to avoid occurrence of hazard. A Small section of residents will select to reduce vulnerability, if they have no hazard experience, but most residents didn't apply any adjustment behavior. The residents both selected to reduce vulnerability and change environment, having the profound and correct hazard causes.

Table 4 Relationship between perception and adjustment behavior

		Adjustment behavior				P
		No Adjustment	Reduce vulnerability	Change Environment	Both	
Existence of hazard perception	Profound	16(25.4%)	36(57.1%)	1(1.6%)	10(15.9%)	0.986
	Not profound	2(28.6%)	4(57.1%)	0(0%)	1(14.3%)	
Existence of hazard perception	correct	14(25.9%)	31(57.4%)	1(1.9%)	8(14.8%)	0.935
	Incorrect	4(25%)	9(56.3%)	0(0%)	3(18.8%)	
Seriousness of perception	Profound	12(22.6%)	31(58.5%)	1(1.9%)	9(17%)	0.702
	Not profound	6(35.3%)	9(52.9%)	0(0%)	2(11.8%)	
Cause of hazard perception	Profound	16(31.4%)	24(47.1%)	1(2%)	10(19.6%)	0.049*
	Not profound	2(10.5%)	16(84.2%)	0(0%)	1(5.3%)	
Cause of hazard perception	correct	16(29.6%)	27(50%)	1(1.9%)	10(18.5%)	0.172
	Incorrect	2(12.5%)	13(81.3%)	0(0%)	1(6.3%)	
Re-occurrence perception	Profound	17(29.8%)	29(50.9%)	1(1.8%)	10(17.5%)	0.171
	Not profound	1(7.7%)	11(84.6%)	0(0%)	1(7.7%)	

(3). Relationship of hazard perception, adjustment behavior and risk

This study revealed few residents' mention of rock fall event. Research points out that the greater hazard has drawn resident's attention to it. There is a significant connection of hazard perception between the experience of property loss, cause of changing lifestyle, and death of relatives and friends by natural hazards. In summary, the residents even located on extremely hazard and had no hazard experience, few were affected by Susceptibility environment (Tab 5).

Table 5 Relationship of hazard perception, adjustment behavior and risk

		Rock fall			Landslide			Debris Flow			
		Middle (%)	High (%)	Extremely high (%)	Low (%)	Middle (%)	High (%)	Low (%)	Middle (%)	High (%)	extremely high (%)
Existence of hazard perception	Profound	93.8	97.3	70.6	87	100	100	100	100	85.7	89.7
	Not profound	6.3	2.7	29.4	13	0	0	0	0	14.3	10.3
p		0.008*			0.316			0.666			
Existence of hazard perception	correct	87.5	75.7	70.6	75.9	100	75	100	81.8	100	58.6
	Incorrect	12.5	24.3	29.4	24.1	0	25	0(0	18.2	0	41.4
p		0.489			0.532			0.110			
Seriousness	Profound	81.3	78.4	64.7	77.8	100	58.3	0	90.9	85.7	75.9

of perception	Not profound	18.8	21.6	35.3	22.2	0	41.7	100	9.1	14.3	24.1
p			0.465			0.185				0.165	
cause of hazard perception	Profound	81.3	81.1	47.1	68.5	100	83.3	100	90.9	71.4	72.4
	Not profound	318.8	18.9	52.9	31.5	0	16.7	0	9.1	28.6	27.6
p			0.023*			0.263				0.578	
cause of hazard perception	correct	81.25	81.1	64.7	70.4	100	100	100	81.8	85.7	69
	Incorrect	18.75	18.9	35.3	29.6	0	0	0	18.2	14.3	31
p			0.373			0.046*				0.660	
re-occurrence perception	Profound	87.5	83.8	70.6	77.8	100	91.7	100	100	71.4	75.9
	Not profound	12.5	16.2	29.4	22.2	0	8.3	0	0	28.6	24.1
p			0.397			0.330			0.288		

CONCLUSION

Disaster, as a synthesis of extremely natural phenomenon, causes of hazard and people agents. Field data analysis has also been integrated using a historical approach to reconstruct the main natural calamitous events and find out cause of landslides. Conducting such method in this research is due to the variety of landslide formation in different areas. Through the case investigation, set the landslide factors into different categories, then to analyze different susceptible factors of mass movement in order to establish a landslide susceptibility map. However, the risk assessment area and true hazard are not all the same, mainly because the calamity is known by people's hazard perception and adjustment behavior, or magnitude of hazard. From the result, some major conclusions are as follows:

1. Three types of mass wasting hazard increase progressively every year, particularly in the last 10 years.
2. The statistical analysis discovered that lithology features, land use and elevation condition of the specified area are the most important elements on the cause of mass wasting. The study represented village selected settlement along stream and valley, rather than the slope.
3. Research points out the age, living time and information gain often affect hazard perception. On other hand, few residents were affected by occupation and gender. Most of the residents selected to leave home would significantly reduced vulnerability to avoid occurrence of hazard. The residents both selected to reduce vulnerability and change environment, having the profound and correct of hazard causes. These residents understand well how hazard causes, as to avoid disaster.
4. Research point out the greater hazard to bring resident's attention the hazard is. But, the residents located on extremely hazard and no hazard experience, the residents few were affected by Susceptibility environment and showed no adjustment behavior.

The environment affected the degree of risk is not equal to the residents were attacked by probability of disaster. If they have correct and active hazard perception, the residents will be not attacked by disasters. Therefore, the study set up landslide risk map and understands resident's hazard perception, to know where easily be attacked by disaster. To learn more about how to improve the environment and enhancing residents' hazard perception in order to avoid the occurrence of disasters.

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