To Establish Evacuation Decision-making Selection Modes of Aboriginal Tribes in Debris Flow Remote Areas from Disasters via Community-based Disaster Management

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Abstract— *In this study I try to utilize the concepts of "environmental vulnerability" and "evacuation behaviors among minority groups" and apply the evacuation selection mode generated from the public hazard perception to geographic information system, and analyze movement paths of residents during after disaster by using composite technology so that I can modify the suggested service scope and capacity of evacuation sites in the regions investigated in this study and provide minority groups with optimal selection mode.*

Keywords— Debris flow, Secondary disasters, Evacuation behavior, Minority groups, Earthquake, Geographic Information System (GIS), Disaster risk reduction.

I. INTRODUCTION

70% of the total area of Taiwan is filled with hillside lands with steep slopes, fragile geological structures, and short rivers with turbulent flow. Earthquakes and torrential rains of typhoons often lead to disasters such as floods, avalanches, and landslides due to improper land development and utilization. According to the statistics on typhoons hitting Taiwan before 2014 by the Central Weather Bureau, the impact of debris flow on remote villages is the most significant secondary disaster. Since the 921 Earthquake in 1999, it has been difficult for public constructions to fully recover. Minority groups in remote areas usually suffer from inconvenient external traffic with dangerous and scattered geographical locations. The inconvenient communications have also made it difficult for them to be aware of real time typhoon position and be ready for immediate evacuation whenever the Central Weather Bureau has issued typhoon warnings on land or at sea. Most people among these minority groups have to wait for rescues based on external assistances due to all aforementioned factors plus the intrinsic constraints of evacuation themselves. Take Typhoon Morakot for example. During the entire duration of this disaster, the Central Weather Bureau had issued typhoon warnings 29 times（Central Weather Bureau, 2009）with 86859 disaster relief trips dispatched from the disaster response center there had also been 653 deployments of helicopters evacuating 6264 people（Kaohsiung County Disaster Response Center, 2009）. However, according to apple daily on August 27, 2009, 1 million residents in Mainland China had been evacuated when Typhoon Morakot was hitting across Taiwan Strait. The catastrophe of the century in Taiwan actually turned out to be a demonstration of highly effective evacuation and disaster relief efforts by the Chinese government. Eight months of investigation and computer simulation of landslide process by research teams convened by academic institutions such as the National Science Council have led to the conclusion（Chen, 2010） that the tragic death of almost 500 people in Xiaolin village of Jiaxian township of Kaohsiung county was mainly caused by the two-stage landslide resulted from secondary debris flow. Mountain regions occupy about a quarter of the terrestrial land surface and control global climate. They provide goods and services to more than half the humanity. Global environmental change threatens the integrity of these systems and the people living there (Drager, 2013). Therefore, it is necessary to strengthen evacuation assistance measures during disasters for minority groups immediately and especially for the disabled (disadvantaged evacuee), residents in regions with no access to disaster information (difficult access to disaster warning, evacuation notification or instructions), elderly, children, pregnant women, handicapped, foreigners, and those with difficulties returning to their homes. In this study I plan to examine the environmental sensitivities of hillside settlements based on the "Demography" of ethnic group integrated with comprehensive analysis on "Environmental disaster-causing factors" (such as geology, vegetation conditions, fault distribution and slope) by DTM and satellite images. The completeness of disaster prevention preparation for these settlements will be analyzed and digital simulations will be

conducted with respect to overall evacuation plans for hillside aboriginal settlements so that I can examine the evacuation modes of minority groups in remote areas in cases of disasters.

II. LITERATURE REVIEW

Wolshon et al. (2005) has indicated that disaster prevention will affect training and education recognition process of evacuation behavior where experienced personnel will be able to accurately identify environmental disaster information and proceed with proper evacuation at earlier time. Chen et al. (2007) have pointed out that environmental assessment may vary from person to person. Ho and Lee (1988) have summarized the characteristics of human evacuation behaviors. Lindell et al. (2007) has recognized the close correlation between execution of evacuation policy and general public's perception, decision making and responsive behaviors with respect to disasters. According to the study by Chen (2010) on the evacuations of different groups, the main factor for decision making consideration is usually the safety of evacuation path. Canton (2006) has pointed out that townships and villages mostly rely on past experiences and local disaster situations as the basis for decision making. Lindell and Prater (2010) has suggested that government departments should take into consideration resources and assistances required for rescue evacuation of different groups. From the summary of literatures related to shelters and disaster prevention bases such as Tsai and Shen (2002), shelter has been defined as a facility capable of blocking or preventing disaster, or relatively safe premise, building or region capable of providing refugees with safety protection, temporary rest, and necessary functions and resources for living. Earthquakes have led to severe damages according to the statistics on major natural disasters in past years. For example, the Hsinchu-Taichung earthquake measuring 7.1 on Richter scale on April 21st 1935 with epicenter at Sanyi Township of Miaoli County killed almost 143276 people, and the earthquake measuring 7.3 on Richter scale took place on September 21th 1999 at Chichi Township near Taichung caused almost 3000 casualties. Post-disaster fires in Taiwan have not been as severe as those in US and Japan. Most damages to aboriginal settlements in remote mountainous areas came from secondary disasters such as debris flow induced by torrential rains and storms following the earthquake. Therefore, when the residences of civilians have been completely destroyed, or when they are living in areas with potential danger of secondary disasters, it will be imperative for the government to communicate with these civilians and provide assistance, enforce mandatory evacuation, or arrange temporary shelters in order to reduce the loss of properties and human lives.

III. METHODS

In this study I conduct analysis and investigation on current status of aboriginal settlements in Taichung City through field reconnaissance. I obtain the selection model for optimal evacuation route by statistical simulation in order to explore principles for shelters arrangement. The specific research methods for analysis on evacuation space information are as described below:

3.1 The analysis on catastrophability of remote mountainous settlements

It includes two categories: disaster prevention preparation by the settlement, and environmental conditions. First step of this investigation is to divide the preparation of overall disaster prevention software and hardware by settlements into three categories such as response system, monitoring system and reporting system. Each item will be divided into numerous sub-items of different contents, and importance evaluation will be conducted and weight distribution will be calculated with respect to these sub-items through questionnaires composed by experts. Secondly, in terms of analysis on environmental conditions of villages, the probability of occurrence of collapse slopes near settlements or debris flow in the vicinity of dangerous streams will be calculated, and their potential danger will be illustrated. In the end, the ratio between the number of secured households within affected range and the number of total secured households in the entire village will be used to conduct a follow-up evaluation. From the perspective of environmental catastrophability, in this study I adopt four factors of height, slope, geology and vegetation to calculate the potential. Logistic regression has been carried out based on satellite images, DTM analysis, and disaster statistics after major typhoons over the years, and index of debris flow impact range in order to calculate probability of environmental catastrophability.

3.2 Geographic information analysis

This is mainly the examination of graphical regional evacuation issues and solving the nearest neighbor evacuation route based on the "Nearest Neighbor Method". The simulation and verification of fields related to geographic information system (GIS) will be conducted according to the principles of distance with respect to cluster analysis and regional division.

3.3 Research Scope

According to the definition by the Ministry of Interior, remote areas are: townships and cities with population density less than one fifth of the national average population density, or isolated islands 7.5 km away from mulnicipality, county and city governments. Currently there are a total of 65 townships qualified as remote aeras. Due to the constraint factors such as time, manpower and traffic, the aboriginal tribes in remote area of Heping District of Taichung City is chosen as the area for main empirical investigation based on the concept of cross-sectional design concept as described in the followings:

3.4 Selection of remote area and scope of disaster categories

Located at the Northeast corner of Taichung City, with an area of 1037.8 square kilometers, the Heping District is the biggest among the 21 Districts in Taichung. The Heping District has a population of about 10,622 people. Heping has special geographical conditions. Three mountains surround the village. The mountain area was originally occupied by the Tai-Ya tribe, which now has a population of about 4000. The area of my study in this paper is mainly Bo-ai Village of Heping District located near the 29th kilometer of route 8 with an average altitude around 750 meters surrounded by the Central Mountain Range, Xue Mountain Range, and Baxian Mountain Range, and average temperature is 21.7 degrees Celsius. Bo-ai Village of Heping District has a population of about 150 people, which is not a densely populated Village. The hub of the Village is not connected by railways, high-speed rail or MRT public transport systems. It is becoming a forest, village and tourism hub of Taichung City. The Songhe tribe located in the left bank of Tachia Stream was severely damaged by 921 Earthquake with destroyed houses, human casualties and property losses. The consecutive Typhoon Mindulle and Typhoon Aere the next year further caused severe debris flows clogging the siltation of Tachia Stream resulting in settlements along Tachia Stream being flooded, turning into more severe secondary disasters. Every following typhoon or torrential rain could lead to severe soil and water disasters, so aboriginal tribes located in areas classified as environmental sensitive after Typhoon Morakot must be investigated for safety evaluation at all times.

3.5 Selection of subjects

My study in this paper has been focused on the aboriginal settlements in remote mountainous areas and minority groups within these settlements such as elderly, women and children, low-income families, disabled and handicapped. I conducted the investigation and analysis in ordination with the perception of evacuation facilities and distances of traffic routes among these residents, and digital simulation of flow situation.

IV. RESULTS AND DISCUSSION

4.1 Case study by interview and result analysis

4.1.1 Description of sampling for interviewees

The Delphi survey group size appears to be very different in the literature. However, it is often recommended to have a group between 9 and 18 participants in order to draw some relevant conclusions and avoid at the same time difficulty to reach consensus among experts (Vidal, 2011). In order to obtain representative views, knowledge coverage and different academic viewpoint of the decision makers should also be considered, the ratio of security professionals, management technicians, and workers should be reasonably considered (Zheng et al., 2012). The sampling targets for the questionnaire survey include the decision making group consisting of experts from disaster preparedness and mitigation plan in earthquake Evacuation selection modes's experts and other experts and scholars with relevant background who have authority at their own branches.

The main targets of interview in this paper are mainly from experts, scholars, Fire Department of Taichung City and Heping District Office who work in disaster prevention and relief. This interview was conducted with a respect of 41 interviewees (as shown in Table 1) with semi-structure outlines during a 151 days period from Jan 6th to Jun 26th in 2013. After removing unanswered and invalid questionnaires, 38 valid questionnaires (about 92.7 %) were recovered. I hope to obtain more objective results and directions for improvements with respect to debris flow prevention and relief by integrating different points of views among disaster prevention and relief personnel at all levels.

TABLE 1.
NUMBER OF PERSONS FILLING IN THE QUESTIONNAIRE WITH THE ASSESSMENT BENCHMARKS

Number of people who completed the questionnaire Background	Number of people
Experts and scholars	12
Government agencies	5
Police and fire service departments	23
aboriginal settlements in remote areas	1
Total	41
Notes: Questionnaire survey period: March 26th to Jun 26th, 2011.	

4.1.2 Summary and Analysis of opinions of interviewees

4.1.2.1 Specific actions in terms of early warnings with respect to debris flow disaster during typhoons by residents of disaster potential areas.

Residents will utilize the rainfall estimation by Central Weather Bureau and Debris Flow Disaster Prevention Information Network of Soil and Water Conservation Bureau to monitor status of typhoon and streams with potential debris flows as the preparation for early warnings. From the comparison between the areas with preventive evacuation and the areas with actual evacuation of minority groups, I found that people in most areas were seeking onsite shelters while remote evacuation has only been adopted in few areas. In addition, due to the lack of considerations for minority groups, helicopters and military resources must be deployed to help with the evacuation of dementia elderly, nursing home, students, tourists, serious patients and dialysis patients.

4.1.2.2 Specific preparation actions for pre-disaster warning reporting related to debris flow by disaster prevention and relief personnel during typhoons.

Disaster response center will be established at level 2 based on typhoon warning at sea by Central Weather Bureau. It will be established at level 1 based on typhoon warning on land. Chiefs and officers of all villages will be notified to be ready for alert status anytime. Fire brigades will be the first to receive report of disaster before notifying disaster response center. All related supporting units will then be notified by phone calls or text messages, and radio communication will be tested. The commander of disaster response center will urge people to be better prepared for typhoon by broadcasting, while Township Offices will be on call 24 hours a day to receive disaster reports from all tribes. From the aspect of reporting system, radio communication is only available in Heping Township, while the communications among all other Township Offices can only reply on cable phones can mobile phones. Although Township Offices have been leading the evacuation operations, disaster prevention works have not been taken seriously among local governments where they are usually managed by personnel who are responsible for several heavy loaded tasks simultaneously. There have been not enough efforts and manpower devoted to the professional disaster prevention techniques in spite of continuous subsidy of fund and hardware. Insufficient software and inheritance of disaster prevention and relief experiences have led to enormous pressure.

Evacuation regulations for alert area along streams with debris flow potentials should be implemented for effective disaster reduction.

Upon establishment of response center, every disaster relief unit will be notified and the radio base station will be activated by every village offices for better disaster preparations. When Heping Township is listed as debris flow alert area, the Township Mayor will be notified by phone to adopt necessary evacuation measures. In cases of torrential rains, personnel of response center at county or township level will notify captains of Neighborhood Rescue Teams and every village chief to take care of monitoring and investigation tasks. Fire Brigades will also notify Neighborhood Rescue Teams to implement disaster status investigation and to test radio communication in order to establish solid control and reporting system of first-hand information. Fire brigades and township offices should be able to use Debris Flow Disaster Prevention Information Network and the regulations for streams with debris flow potential alert issued by Soil and Water Conservation Bureau of Council of Agriculture as references and follow the instructions by Taichung City Response Center to conduct evacuation advice or mandatory evacuation with respect to residents within areas with the danger of debris flow. Fire Brigades will contact and urge every Village Chief to pay attention to prevention measures for debris flow disasters. Currently the tribal sanctuary is equipped with enough energy for independent operation for 7 to 21 days yet with unsound interior facilities and the environmental is lacking the design to meet the living habits of residents. Currently, competent authorities for all types of disasters have either adopted two levels or three levels of evacuations leading to confusion among general public. Fragile

roads in mountainous areas and unstable temporary bridges have increased the risks for settlements seeking nearby shelters to become deserted island of disaster. Actually there can be frequent need for emergency evacuation when settlements originally predicted to be safe suffer from unexpected disaster. Therefore, emergency evacuation methods on the ground or in the air based on disaster prevention plan are usually different from the evacuation strategy under adverse weather conditions.

4.2 Simulation and Verification of Geographic Information System

The objective of the analysis in this paper is to figure the nearest evacuation premise and route assuming emergency disaster has taken place in Songhe Tribe. The route maps and the locations of important schools, parking lots and public premises near Songhe Tribe are used the data for analysis. Tools I use are desktop geographic information system Super GIS 2.2, earthquake damage evaluation system, and SPSS statistical analysis software and road network analysis module.

4.2.1 Analysis result 1: evacuation sites and distances

Here I assume Songhe Tribe is the site of incident, and BaiLeng Elementary School, Bo-ai Elementary School and its Bo-ai branch school are designated evacuation sites. From the result of this analysis, the most important access road in the mountainous area is Dongguan Road connecting BaiLeng elementary school, Bo-ai elementary school and its Bo-ai branch school. The evacuation path starts from Songhe westward along Dongguan Road all the way to aforementioned evacuation sites. The nearest evacuation site is the Bo-ai branch school of Bo-ai elementary school which is roughly 0.8 km away (as shown in Figure 1). The second nearest evacuation site is Bo-ai elementary school 6.64 km away (as shown in Figure 2). The farthest evacuation site is BaiLeng elementary school which is 13.495 km away (as shown in Figure 3).

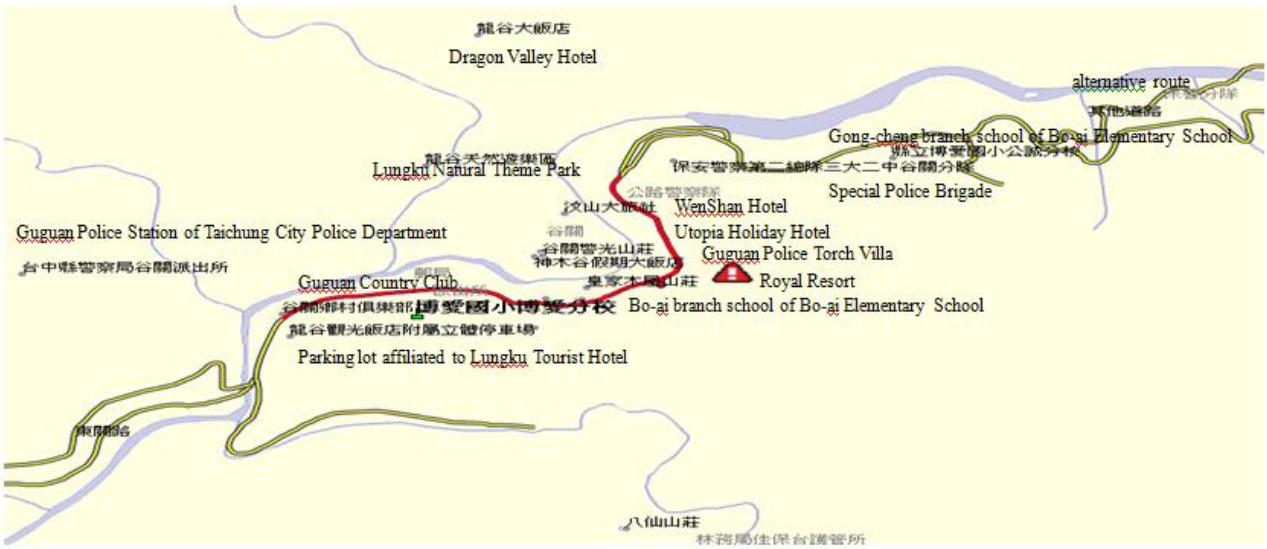

FIGURE 1. EVACUATION ROUTE FROM SONGHE TRIBE TO BO-AI BRANCH SCHOOL OF BO-AI ELEMENTARY SCHOOL (DONGGUAN ROAD)

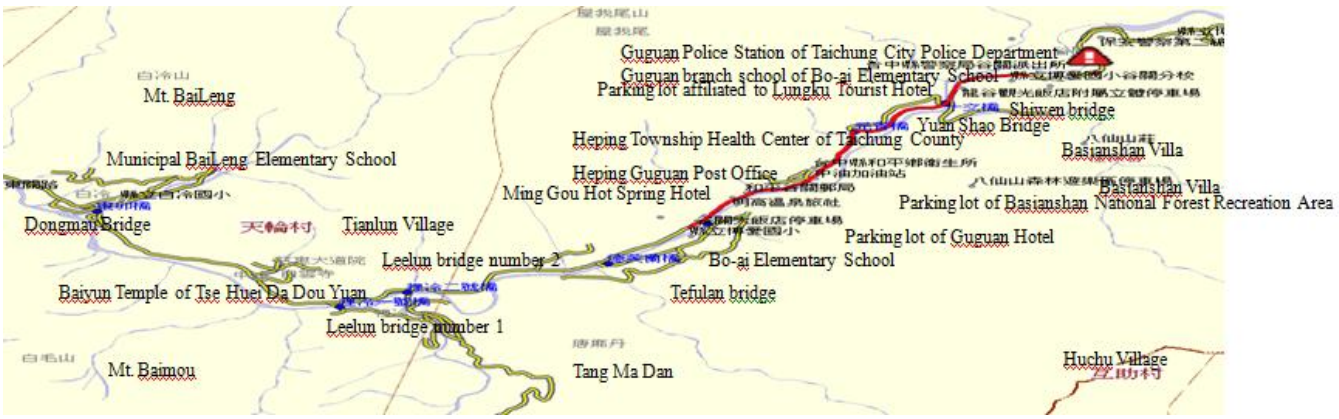

FIGURE 2. EVACUATION ROUTE FROM SONGHE TRIBE TO BO-AI ELEMENTARY SCHOOL (DONGGUAN ROAD)

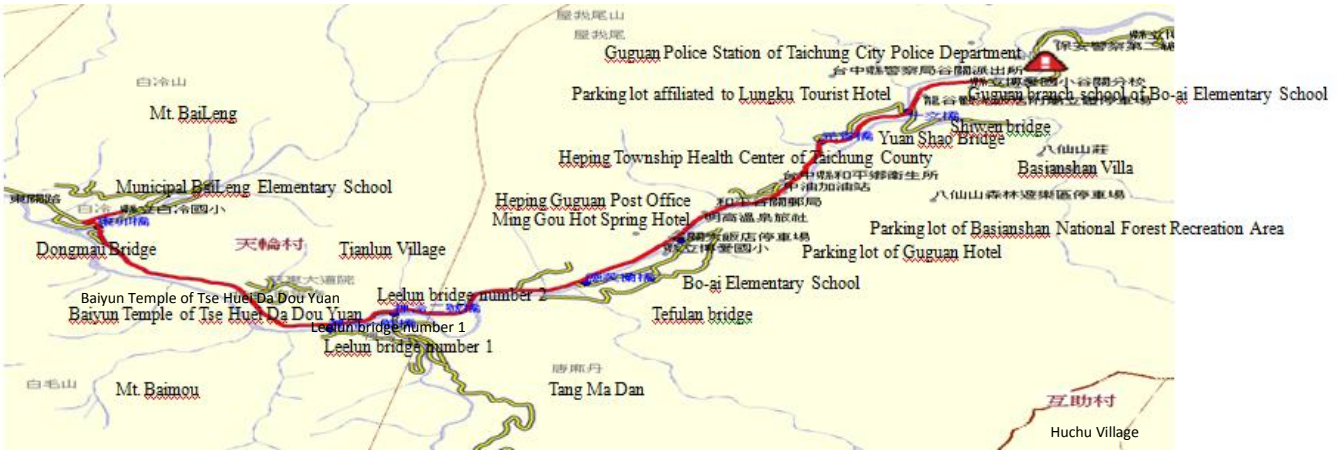

FIGURE 3. EVACUATION ROUTE FROM SONGHE TRIBE TO BAILENG ELEMENTARY SCHOOL (DONGGUAN ROAD).

4.2.2 Analysis result 2: analysis on alternatives for blocked roads

Songhe tribe is located on both sides of the upstream of Tachia Stream. Only those who live on the left side (facing the source) of Tachia Stream must cross the river while moving from Songhe tribe to the nearest evacuation site at the Bo-ai branch school of Bo-ai elementary school, residents live in other areas can reach that evacuation site by going on Dongguan Road. One must pass through Changqing Bridge No. 1 from Dongguan Road in order to reach Bo-ai elementary school from Songhe tribe (as shown in Figure 4). If that bridge was destroyed by debris flow, the alternative route will go through the downstream Tefulan Bridge. Dongguan Road is also the only main road leading to the farthest BaiLeng elementary school from Songhe tribe while going through Shi Wen Bridge (Shi Wen Lane) and Duming Bridge (Dongguan Road). These two bridges control important passing points from Songhe tribe to Bo-ai elementary school. One must cross Dongmau Stream through Dongmau Bridge while approaching the destination. This is an important bridge connecting to BaiLeng elementary school.

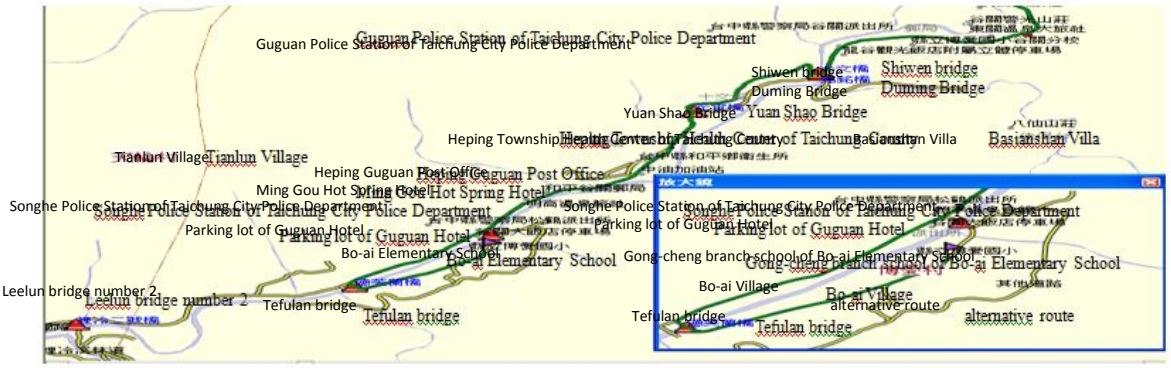

FIGURE 4. ALTERNATIVE EVACUATION ROUTE (DONGGUAN ROAD) WITH BLOCKED CHANGQING BRIDGE NO. 1.

4.2.3 Analysis result 3: road terrain analysis

Dongguan Road is located on the left side of Tachia Stream (facing the source) and is almost parallel to Tachia Stream. In addition to aforementioned necessary bridges as important blocking factors, there can be other possible factors (not related to broken bridges) blocking the transportation of human, vehicle and resources to evacuation site such as the frequently encountered avalanche, debris flow, landslide and water accumulation along Dongguan Road (as shown in Figure 5). The entire Dongguan Road is beneath the hillside so it can be vulnerable to road disruption due to excessive rainfall in mountainous area leading to unstable upper debris or hillside. Through overlay analysis we figure that the road connecting Sonhe tribe to Bo-ai Elementary School, and the first half of the road connecting Bo-ai elementary school to BaiLeng Elementary School are both steep sections. Therefore, attention must be paid to smoothness of routes during evacuation operation. In cases of debris flow disaster in mountainous area due to torrential rain or earthquake, the hillsides on both sides of the road can be most prone to rock falls affecting the accessibility during evacuation (as shown in Figure 6).

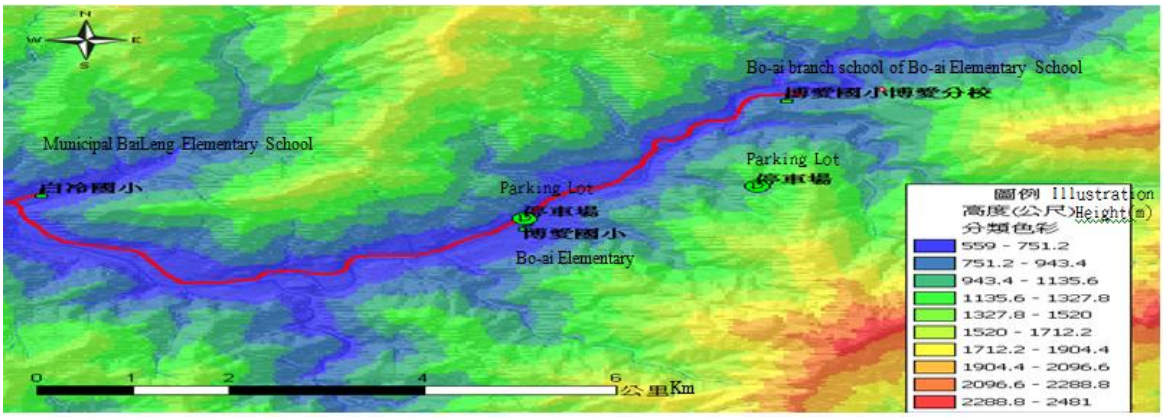

FIGURE 5. TERRAIN DIAGRAM OF EVACUATION ROUTE FOR SONGHE TRIBE

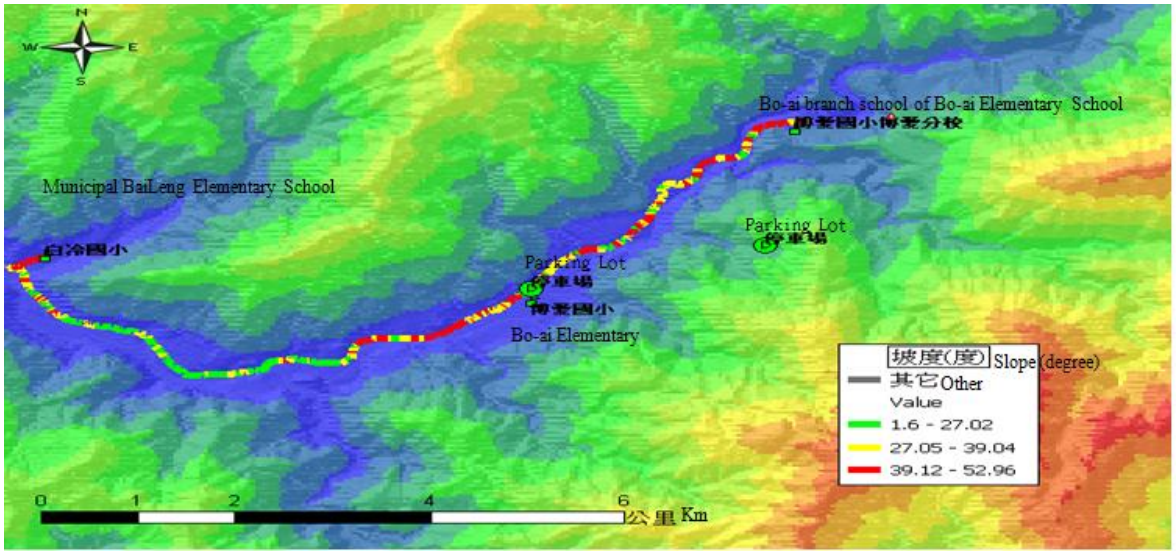

FIGURE 6. TERRAIN DIAGRAM OF EVACUATION ROUTE ALONG THE ENTIRE DONGGUAN ROAD

V. DISCUSSION

Songhe tribe is located at the upstream of Tachia Stream with simple evacuation route where only one Dongguan Road can be used to reach three major evacuation sites. However, Dongguan has been located on the terrain with numerous steep slopes and passes through important bridges, so attentions must be paid to disrupted evacuation route caused by broken bridges or avalanche, debris flow or mud flow along this road. I had studied characteristics, behaviors and factors affecting the selection of evacuation routes among residents by questionnaires and interviews. It is found that the top three choices for the selection of evacuation sites are schools, nearby open spaces, and parks. In addition, factors of high priorities for consideration of evacuation route selection are safety, shortest distance, familiarity of route, and least travel time. Therefore, during planning of disaster prevention and evacuation routes, relevant departments and units should first review literatures of historical rainfalls and physiographic information related to scope of environmental sensitivity potential and catastrophability evolvement in order to further understand the requirements from minority groups during selection of evacuation routes such as humanity information of aboriginal tribes and village settlements, and structure of residents and communities. In the end, the study on structures of various systems such as policies and regulations, disaster prevention and evacuation plans, and responsive rescue will be carried out. Onsite investigation of existing locations, capacity, and structure of connecting roads of evacuation sites (shelters), parks, green lands and schools will be implemented so that field reconnaissance report for disaster prevention and evacuation can be composed for establishment of feasible post-disaster evacuation modes.

Numerous large scale natural disasters in recent years have threatened a huge amount of people. I found out from statistics in Taiwan and Japan that the elderly accounts for the highest portion among disaster casualties due to inferior physical and physiological functionalities. From the investigation in Japan I also found that handicapped, pregnant women, foreigners and children are also high-risk groups in addition to the elderly during disasters. Therefore they should all be provided with evacuation support such as appropriate disaster information communication. My study shows the information resource most trusted by disabled groups is the propaganda by administrative units. Disabled groups with higher incomes, awareness of

crisis, and disaster prevention knowledge for debris flow are those more likely to proceed with evacuation. It is also found that disabled groups are in most urgent needs of assistances by vehicles and auxiliary equipments. Besides, disabled groups tend to choose familiar routes for evacuation leading to more a time consuming process for evacuation of the entire family. In terms of the willingness to comply with evacuation among secured households, most interviewees have stated that minority groups tend to choose to seek shelters in homes of relatives and friends unless they witness the threat by natural disasters forcing them to take mandatory evacuation. Evacuation planning is currently one of the main disaster relief approaches for debris flow which will demand better cooperation of local people as compared to previous disaster prevention plans. The exploration of human feelings, attitudes and responses in disaster environments from the perspective of disaster perception should be helpful to the planning and promotion of debris flow evacuation.

VI. CONCLUSIONS

In this paper I summarize the "Environmental catastrophability factors" of aboriginal settlements in remote mountains and ethnical "Humanity attribute information" to analyze the completeness of disaster prevention preparation among settlements in conjunction with the results. Then I compose the digital simulation model for overall evacuation of hillside aboriginal settlements so that it is possible for follow-up studies to include existing evacuation sites (such as parks, green lands and schools) in remote areas and to utilize geographic information system to analyze evacuation modes and improvement strategies available for residents based on the boundary conditions of supply of evacuation facilities and demands of residents. I can also conduct qualitative or quantitative analysis with respect to sources of risks (such as laws and regulations, environmental catastrophability, economic environment, human behavior, technology, management activity and control) in the areas of post-earthquake secondary disasters, and investigate its effect on social and economic aspects.

The proper collection and disclosure of disaster information can improve the perception of environmental risk and disaster potential. The preventive strategy and disaster prevention ability can make residents react to disaster more efficiently. Hazard map is provided for the convenience of residents' perception and inquiry for environmental safety. Community resources and disaster information system integration, the periodic communication can improve the emotions of residents and make consensus when disaster occurs.

REFERENCES

[1] Wolshon, B., E. Urbina, C. Wilmot, and M. Levitan, "Review of Policies and Practices for Hurricane Evacuation I: Transportation Planning, Preparedness, and Response", Natural Hazards Rev, 2005, Vol. 6 (129), pp. 1527- 6988.

[2] Chen C.- C., " Computer Simulation of Avalanche, Solving the mysterious annihilation of Shaolin Village", Chinatimes, (2010/ 04/ 15); 02:04, Taipei.

[3] Zheng, G., N. Zhu, Z. Tian, Y. Chen, "Binhui Sun. Application of a trapezoidal fuzzy AHP method for work safety evaluation and early warning rating of hot and humid environments", Safety Science, 2012, Vol. 50, pp. 228–239.

[4] Drager, K.- H., "International disaster prevention to climate change, trend and approach", 2013 New Taipei City Disaster management international Conference, 2013, pp. 163-201.

[5] Canton, L., " Emergency Management: Concepts and Strategies for Effective Programs", Space Magazine, 2006, Vol. 92, pp. 74-80.

[6] Chen, L. C., S. – Y. Ma, " Studies on formulations of government instructions mode and evacuation strategies in response to large-scale disasters—with typhoon induced debris flow disaster as an example of Studies on requirements and support for evacuation strategies in response to large-scale disasters", Executive Yuan, Taipei, National Science Council, Vol. 2007, pp. 35-45.

[7] Lindell, M. - K., C. - S. Prater, and W. - G. Peacock, "Organizational Communication and Decision Making for Hurricane Emergencies", Natural Hazards Rev, 2007, Vol. 8(50), 1527-6988.

[8] Lindell, M. - K., C. - S. Prater, "Tsunami Preparedness on the Oregon and Washington Coast: Recommendations for Research", Natural Hazards Rev, 2010, Vol. 11(69), pp. 1527-6988.

[9] Vidal, L. A., F. Marle, J. C. Bocquet, " Using a Delphi process and the Analytic Hierarchy Process (AHP) to evaluate the complexity of projects", Expert Systems with Applications, 2011, Vol. 38, pp. 5388–5405.

[10] Tsai, Y. - C., T. - S. Shen, "First attempt of design and planning of urban shelters in cases of large-scale earthquake disasters", Journal of Disaster Mitigation and Rescue, 2002, Vol. 3, pp. 481-485.