DEVELOP A METHOD TO IDENTIFY WELFARE INSTITUTIONS WITH FLOOD OR LANDSLIDE RISKS IN TAIWAN

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***ABSTRACT*:** This study introduces a method to identify nursing homes and disabled's institutions with flood or landslide risks, as an alternative to the conventionally use of risk potential maps. The method proposed in this study combines the results of risk potential maps and survey that asks for disaster experiences and environmental risk elements. This study argues that using risk potential maps alone is insufficient because there are usually gaps between assumptions of risk potential models and real situations, e.g., inundation potential models assume that embankments would not break, which are usually not the case. In this study, an institution with highest flood risk is defined as possibly being flooded when 24-hour accumulated rainfall reaches 300 or 350 mm according to the risk potential map, or when an institution experienced flood in the recent ten years. An institution having a second highest level of flood risk is defined as not in the group with the highest level risk and possibly being flooded when 24-hour accumulated rainfall is more than 600mm, or when being located next to rivers, embankments, etc. An institution with the highest landslide risk means that it is in the debris flow potential area, or it has landslide related experiences in the past ten years. An institution with the 2nd highest land slide risk means that it is not in the group with highest risk, but has some environmental risk elements (e.g., near a cracked retaining wall). Department of Social Affairs helped this study to distribute the survey to all 1,057 nursing homes and 285 disabled's institutions in Taiwan. The response rate is 93%. The results show that 23% of the nursing homes and 30% of the disabled's institutions have the highest flood risk; 26% of the nursing homes and 34% of the disabled's institutions have the 2nd highest flood risk; 1% of the nursing homes and less than 1% of disabled's institutions have the highest landslide risk; 6% of the nursing homes and 15% of the disabled's institutions have the 2nd highest land slide risk. The researchers of this study are currently cooperating with Department of Social Affairs, using the results of the study to design mechanisms and tools for typhoon risk management of welfare institutions in Taiwan.

KEYWORDS: disaster risk, nursing home, disabled's institution

1. INTRODUCTION

In 2010 during Typhoon Fanapi, a photo of a flooded nursing home attracted the public attention—several elder residents floated in water and waited for rescue. This photo put pressure on the Taiwanese government so that the Department of Social Affairs was required to identify welfare institutions with high flood or landslide risks during a typhoon event. However, because the major body of the welfare institutions in Taiwan is nursing homes and nursing homes are regarded as private profit-seeking business units in Taiwan, welfare institutions were not treated as major targets of the official disaster management system. Department of Social Affairs

found itself not having the techniques to identify welfare institutions with high risks. Therefore, a team is formed which includes members from two sections of Department of Social Affairs and members from National Science and Technology for Disaster Reduction (NCDR) to develop a method to identify welfare institutions with high risks. The two sections are Senior Citizen's Institution Section that manages nursing homes and Disabled Person's Institution Section that manages disabled's institutions in Taiwan. The authors of this paper are also team members representing NCDR.

The team began to operate in 2010. The short goal of this team is to develop a method to identify welfare institutions with high risks during a typhoon event and list institutions with high risks for the government. The results are presented in this paper. The long-term goal is to help the government develop mechanisms and tools for the phases of disaster response and preparedness, especially for managing the institutions with high risks.

2. LITERATURE

2.1 Disaster Risk of Welfare Institutions

A commonly used definition of disaster risk refers to an overlap between hazard and vulnerability. Vulnerability is often distinguished into exposure and sensitivity. A welfare institution is often a collective living space so that its disaster exposure is high, if compared to a space with only one family. Because many institutionalized residents (e.g., elders or disabled) have mobility problems, they need other people's help when an evacuation is required during a typhoon event. Therefore, these residents' disaster sensitivity is high. With high disaster exposure and sensitivity, welfare institutions should be an important topic of disaster studies.

Yet, topics of studies on disasters and welfare institutions are very limited. Most focus on flood experiences of nursing homes, especially in the event of Katrina in 2005 in the US. Studies found that the disaster management related to nursing homes in the US had the following problems: (1) the government did not actively try to control situations related to nursing homes. The reason was similar to what happened in Taiwan--because nursing homes were regarded as private profit-seeking businesses; (2) many nursing homes did not receive warning messages or did not know when to evacuate; (3) some nursing homes had the problem of man-power shortage; (4) some nursing homes had problems to get transportation tools for evacuation; (5) some nursing homes did not have enough places to shelter their residents after evacuation; (6) many nursing homes did not have enough electricity to keep functioning the medical equipment of their residents (Brown, Hyer, and Polivka-West, 2007; Castro et al., 2008; Dosa et al., 2007; Hyer et al. 2009; Hyer, Polivka-West, and Brown 2007; Laditka et al., 2007; Laditka et al., 2008; Peek, 2010; Perkovic, Seff, and Rothman, 2007).

There are only a couple of studies on Taiwan's situation. The conclusions of these studies are very similar to those mentioned in the studies of Katrina. For instance, Tsai et al. (2006 in Chinese) points out that the main issues of nursing homes in Taiwan are man-power shortage and lack of contracts between nursing homes and institutions that can provide transportation tools and sheltering services. Chen (2011 in Chinese) and Tseng (2011 in Chinese) argue that man-power shortage is an important issue of nursing homes in Taiwan when facing disasters.

Since it is difficult to address all the problems mentioned at the same time, this study suggests that the Taiwanese government can first actively try to have welfare institutions with high risks under

control during a typhoon event. In order to do so, the government has to first find institutions with high risks. Then the government can put its focus on the possible problems of these high risk institutions (e.g., the above mentioned problems, including early-warning, man-power shortage, lack of transportation tools, lack of sheltering places, and lack of power) during the phase of Typhoon Response. For the long-term goal, the government can develop tools for other phases such as the phase of Disaster Preparedness.

2.2 Traditional Risk Identification Method

The traditional method to identify entities with disaster risk is to use risk potential maps. For instance, to find flood risk of an institution, the x and y coordinates of institution will be recorded in the inundation potential map to see if the institution is located in the inundation potential area. If the answer is yes, this institution is regarded as having a flood risk. This method is commonly used in Japan, US, etc.

However, our pilot study (Chen et al. 2011 in Chinese) shows that some nursing homes not located in the inundation potential areas were flooded in 2009 during Typhoon Morakot or in 2010 during Typhoon Fanapi. In other words, using potential risk maps alone cannot identify all institutions with high risks. The reason is that the risk potential areas are defined by scientific models with uncertainties or assumptions not necessarily meet the real situations. For instance, flood models assume that embankments will not break. Yet, broken embankments were the major cause of floods that many institutions interviewed in our pilot study encountered (See Picture 1). Therefore, this study develops a method to identify institutions with risks that not only uses risk potential maps but also incorporates a survey that asks for disaster experiences and environmental risk elements of institutions.

Picture 1 A broken embankment next to a nursing home in Taiwan

3. METHODOLOGY

3.1 Risk Potential Maps

Risk potential maps require overlaps of nursing homes' locations and inundation potential maps. This study obtains the list of nursing homes (dated on March 2011, N=1,057) from Senior Citizen's Institution Section and the list of disabled's institutions (dated on March 2011, N=285) from Disabled Person's Institution Section. Then the x and y coordinates of the institutions are found by using the Taiwan Geospatial One-Stop (TGOS) system, assisted with Google Map. The benefits and shortages of the TGOS system and Google Map are shown in Table 1.

The inundation potential maps used in this study are 300 or 350mm/24hrs and 600mm/24hrs maps developed by both Water Resource Agency (WRA, under Ministry of Economic Affairs) and NCDR. NCDR's maps are the first generation and produced in 1999-2001 whereas WRA's are the second generation and produced in 2007-2009. NCDR and WRA use different models which result in different inundation potential areas. To be more conservative, this study defines the unions of the two sets of inundation potential areas are the inundation potential areas of this study. That is, if an area is said

possibly flooded by either NCDR's or WRA's maps, it is regarded as possibly flooded in this study.

Table 1 Pros and Cons of TGOS and Google Map

	TGOS	Google Map
		
Pros	• Posit x/y coordinates based on the house registration data from the city/ county governments, theoretically more accurate than Google Map's method of interpolation • Can posit the x and y coordinates of many addresses at a time • Have the option of TWD97 coordinates which is commonly used in Taiwan	• High success rate on finding the Latitude and longitude coordinates of addresses • Provide street pictures
Cons	• There is no mechanism to ensure to quality of the house registration data • High failure rate on finding the x and y coordinates of addresses • A new system still under testing	• Can posit coordinates of only one address at a time • Use WGS84 coordinates which are not commonly used in Taiwan • Use the method of interpolation to find coordinates

The debris flow potential map used in this study is produced by Soil and Water Conservation Bureau, Council of Agriculture, Executive Yuan in 2010. It shows that Taiwan had 1,552 potential debris flow torrents. The recent released version (year 2012 version) shows that number of the torrents increases to 1,660. This study will update the results in the near future by using the year 2012 version.

3.2 Disaster Risk Survey

The survey questions were designed based on the purpose of this study which should include questions of disaster experiences and environmental risk elements. The results of pilot study, literature review, and cases in Taiwan and in other countries reported in newspapers were used to design the survey questions. Then two expert meetings were held to discuss the drafts of the survey. Attendants of the first meeting were scholars who gave suggestions mainly from the viewpoint of disaster management. Attendants of the second meeting were representatives of Social Affairs Bureau of each city or county who provided us suggestions based on their experiences of institution management.

Department of Social Affairs from the central government and Social Affairs Bureau of each city or county then helped the study to distribute the surveys to all institutions in July 2011. The response rate of nursing home is 93% (returned n=983). That of the disabled's institutions is 93.33% (returned n=266).

3.3 Definitions of Flood and Landslide Risks

In order to take into consideration of both the risk potential maps and the survey results, our definitions of risks:

1. Highest Flood Risk: When the inundation potential map (300 or 350 mm/24hrs—definition

of a regular heavy rain) defines that an institution is possibly flooded, or when the survey results show that the institution had flood experience in the past 10 years;

2. 2nd Highest Flood Risk: Not in the group with highest flood risk; when the inundation potential map (600mm/24hrs—an extreme weather event) defines that an institution is possibly flooded, or the survey results show that the institution has some environmental risk elements that might be related to high flood risk, e.g., having a river nearby;
3. Highest Landslide Risk: When the debris flow potential map defines that an institution possibly suffers from landslide during a typhoon event, or when the survey results show that the institution had landslide related experiences in the past 10 years;
4. 2nd Highest Landslide Risk: Not in the group with highest landslide risk; when the survey results show that an institution has some environmental risk elements that might related to landslide risk.

4. RESULTS

4.1 Risk Potential Maps

The result of 300 or 350mm/24hrs flood risk potential maps show that 109 nursing homes are located in potential inundation potential areas. As for disabled's institutions, there are 32 institutions located in inundation potential areas.

The result of 600 mm/24hrs flood risk potential maps show that 223 nursing homes are located in potential inundation potential areas. As for disabled's institutions, there are 95 institutions located in inundation potential areas.

The result of the debris flow risk potential map shows that while there is 1 nursing home located in the potential risk area, there is no disabled's institution found in the risk area. The nursing home found in the risk area is in Nantou City.

4.2 Disaster Experiences

The survey results show that in the past 10 years, there were 59 nursing homes being flooded whereas 125 nursing homes' neighborhoods were flooded. We count both cases as having flood experiences. In total, there are 133 nursing homes that had flood experiences in the past 10 years. As for the disabled's institutions, there were 33 being flooded and 42 having flooded neighborhoods in the past 10 years. In total, there are 52 disabled's institutions having flood experiences.

In the past 10 years, there were 6 nursing homes having landslide nearby and 8 had experiences of having all access roads being cut off. Both situations are considered as having landslide related experiences in this study. In total, there are 10 nursing homes having landslide related experiences in the past 10 years. The figure of the disabled's institutions is 2 for either having landslide nearby or having all access roads being cut off.

4.3 Environmental Risk Elements

The survey results of the environmental risk elements related to flood are shown in Figure 1. The most common flood risk environment elements of both nursing homes and disable's institutions are having channels, ditches, or rivers nearby. The percentage of nursing homes having at least one flood risk environment elements is about 30% which is high. The major reason is that in year 2003, the Taiwanese government encouraged private companies to set up nursing homes to meet the societal needs. To save the cost, many nursing homes were established in remote areas which are also risk potential areas.

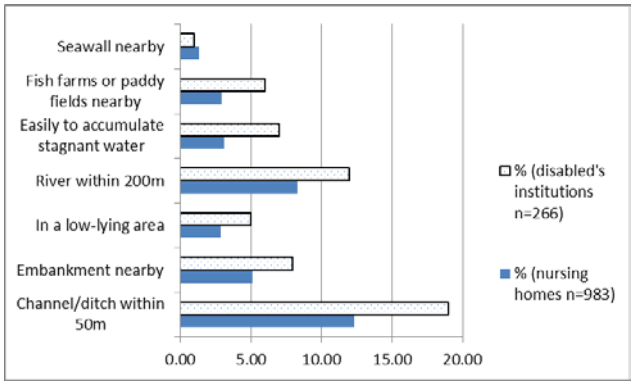

Figure 1 Environmental Risk Elements to Flood

The survey results of landslide risk environment elements are shown in Figure 2. The major issues for both nursing homes and disabled's institutions are having institutions on or near land slop. However, the percentages of these issues for disabled's institutions are higher than those for nursing homes.

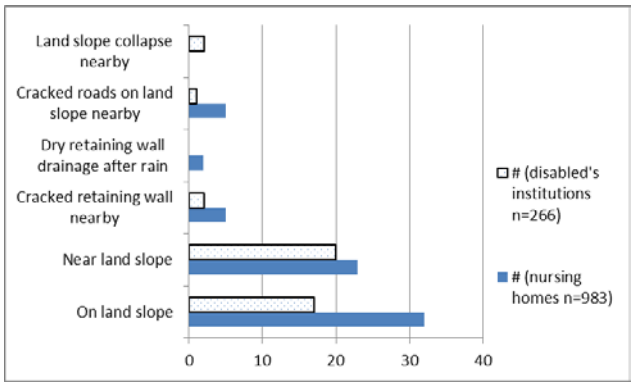

Figure 2 Environmental Risk Elements to Landslide

4.4 Number of Institutions with Risks

Combining the results of risk potential maps and the survey, we find that there are 230 nursing homes having the highest flood risk and 256 nursing homes with the 2nd highest flood risk. As for the disabled's institutions, 80 of them have the highest flood risk and 91 have the 2nd highest flood risk.

Regarding the landslide risk, 12 nursing homes have the highest risk and 63 have the 2nd highest risk. There are 2 disabled's institutions having highest landslide risk, whereas 41 have the 2nd highest risk.

Table 2 Cities/Counties with Flood/Landslide Risks

	Cities/Counties having the most nursing homes w/ the type of the risk	Cities/Counties having the most disable's institutions w/ the type of the risk
①Highest flood risk	Kaohsiung City (n=44); Tainan City (n=40); New Taipei City (n=30)	Tainan City (n=15); Kaohsiung City (n=12)
②2nd highest flood risk	New Taipei City (n=35); Kaohsiung City (n=32); Taipei City (n=30)	Taipei City (n=15); Taichung City (n=12); Tainan City (n=11); New Taipei City (n=10)
①+②	Kaohsiung City (n=76); Tainan City (n=69); New Taipei City (n=65)	Tainan City (n=26); Kaohsiung, Taipei, and Taichung Cities (n=18 each);
③Highest landslide risk	Kaohsiung (n=4)	Taichung City (n=2)
④2nd highest landslide risk	New Taipei City (n=12); Taipei City (n=12)	Taipei City (n=9); New Taipei City (n=7)
③+④	New Taipei City (n=13); Taipei City (n=13)	Taipei City (n=9); New Taipei City (n=7)
①+②+③+④	Kaohsiung City (n=76); Tainan City (n=69);	Tainan City (n=26); Taipei City (n=25);

	New Taipei City (n=68); Taipei City (n=62);	Kaohsiung City (n=21); New Taipei City (n=20)
①+③	Kaohsiung City (n=3); Tainan City (n=2)	Taichung City (n=2)

If combining the results of flood and landslide risks together, in total, there are 511 nursing homes having at least one type of risk; 191 disabled's institutions have at least one type risk. The major contribution to these high figures is from the numbers of institutions that have environmental risk elements. Among all the cities and counties, four of them have more than 100 institutions with risk (See Table 2). If we look at only the highest level of flood or landslide risks, there are 9 nursing homes having both highest risks, whereas the figure for disabled's institutions is 2.

In short, most institutions with flood risk are in Kaohsiung and Tainan Cities in South Taiwan, New Taipei and Taipei Cities in North Taiwan, and Taichung City in Middle Taiwan (also see Table 2). Most Institutions with landslide risks are in Taipei and New Taipei Cities in North Taiwan. Cities or counties that have most institutions with risks are Kaohsiung and Tainan Cities in South Taiwan and New Taipei and Taipei Cities in North Taiwan. Kaohsiung, Tainan, and Taichung Cities should especially pay attention to those institutions that have both highest flood and highest landslide risks.

5. DISCUSSIONS

Figure 3 and Figure 4 compare the results of using flood risk potential maps alone to identify institutions with risks and of the method used in this study (i.e. the differences between the results of section 4.1 and 4.4 in this paper). Both results of 300 or 350mm/24hrs flood inundation maps and results of institutions with "highest flood risk" in this study can be used in a regular heavy rain situation. The difference between "the highest flood risk" defined in this study and the flood risk implied in a 300 or 350mm/24hrs inundation potential map is that the former takes into consideration of past disaster experiences. When disaster experiences are included in the picture, nursing homes with flood risks increase from 109 to 230 and disabled's institutions with flood risks increase from 32 to 80. These figures mean that there are 121 nursing homes and 48 disabled's institutions that have flood experiences in the past 10 years but are not identified by the 300 or 350mm/24hrs flood inundation maps.

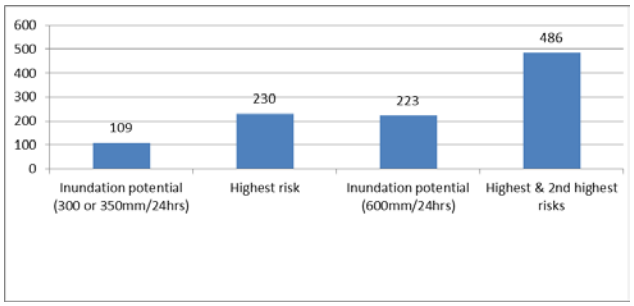

Figure 3 Comparisons between Results of Risk Potential Maps and Results of the Method in this Study (Nursing Homes)

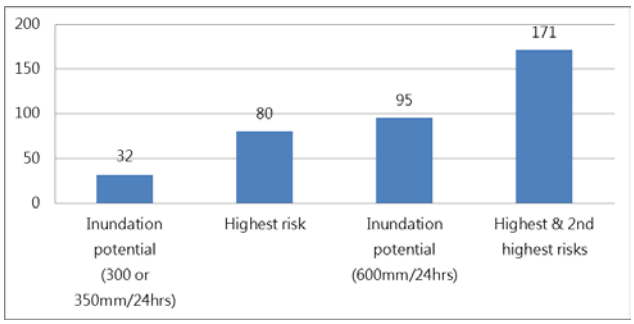

Figure 4 Comparisons between Results of Risk Potential Maps and Results of the Method in this Study (Disabled's Institutions)

Both results of 600/24hrs flood inundation maps and results of institutions with "the 2nd highest flood

risk" in this study can be used in an extreme weather event. The difference between "the 2nd highest flood risk" in this paper and the flood risk implied in a 600mm/24hrs inundation potential map is that the former takes into consideration of past disaster experiences and environmental risk elements. When flood experiences and environmental risk elements come into the mind, nursing homes with flood risks increase from 223 to 486, and disabled's institutions increase from 95 to 171. These figures mean that there are 263 nursing homes and 76 disabled's institutions that have flood experiences in the past 10 years or have environmental risk elements are not identified in the 600mm/24hrs inundation potential maps.

As for landslide risk, the debris flow potential risk map identifies only 1 nursing home and 0 disabled's institutions. When taking disaster experiences and environmental risk elements into consideration, there are 75 nursing homes and 43 disabled's institutions with landslide risks.

In short, there are huge gaps between the results of risk potential maps and the results of survey that asks for disaster experiences and environmental risk elements of the institutions studied. If one uses only the results of risk potential maps to identify institutions with risks, one would overlook situations that the underlying models of risk potential maps cannot explain.

6. CONCLUSION AND NEXT STEP

This paper develops a risk identification method for the Taiwanese government to manage welfare institutions during a typhoon event. In contrast to the traditional method that uses risk potential maps alone to identify institutions with risks, this paper uses both risk potential maps and surveys of disaster experiences and environmental risk elements. The results show that the Taiwanese government should especially pay attention to 230 nursing homes and 80 disabled's institutions during a regular Typhoon event with a heavy rain. The government should especially pay attention to 486 nursing homes and 171 disabled's institutions when there is an extreme weather event.

In the near future, this study will continue to develop tools and procedures that can help the Taiwanese government manage the institutions with the highest or 2nd highest risks. The tools will include name lists of institutions with risks, contact sheets of these institutions, and a procedure for Emergency Operation Centers to contact institutions with risks during a typhoon event. For the long run, this study plan to develop mechanism and tools that can help institutions to prepare for disasters, e.g., a guideline to write a disaster management plan.

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