Identifying disaster risk: How science and technology shield populations against natural disasters in Taiwan

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8.1 Introducing the developed and applied disaster technology in Taiwan

According to the global evaluation results of the World Bank for natural disaster risk in 2005, Taiwan was the only region on earth that was threatened the most by natural hazards with 73% of its population to face more than three different types of catastrophes (The World Bank, 2005). While hillsides cover areas equal to 27% of Taiwan's territory (Soil and Water Conservation Bureau, 2017), the Council of Agriculture, Executive Yuan of Taiwan announced 1687 debris flow streams just for the year 2015 (Soil and Water Conservation Bureau, 2017); fact that raises the landslide disaster potential for the island. Additionally, Taiwan is located in the Circum-Pacific Seismic Zone with 33 active faults as the Central Geological Survey of 2012 reported (Central Geological Survey, 2017); therefore, earthquake risk is high as well. Related reports from the Central Weather Bureau (CWB) show that there were more than 105 major earthquakes that caused casualties and damages in constructions from 1901 to 2016 (Central Weather Bureau, 2017). Besides all the aforementioned disasters, another frequent threat is the flood. During summer and autumn periods Taiwan can be easily hit by typhoons, mostly those directed from the eastern parts. In 2005, the Water Resources Agency (WRA) announced that the critical land subsidence areas cover the 3.5% of whole Taiwan (Water Resource Agency, 2017); causing flood phenomena in low-lying regions. Taiwan can easily be affected by storms, typhoons, earthquakes, debris flow, etc.; the natural disaster potential is shown in Fig. 8.1. Casualties, tree falling, collapses in buildings, and other structures are just few of the devastating results of such hazards that have a major impact on people's lives. Examples of disasters caused by windstorms and floods are shown in Fig. 8.2.

In addition to natural disasters, manmade disasters are most likely to occur as well, such as gasoline or dust explosions. It is more than essential to outline and

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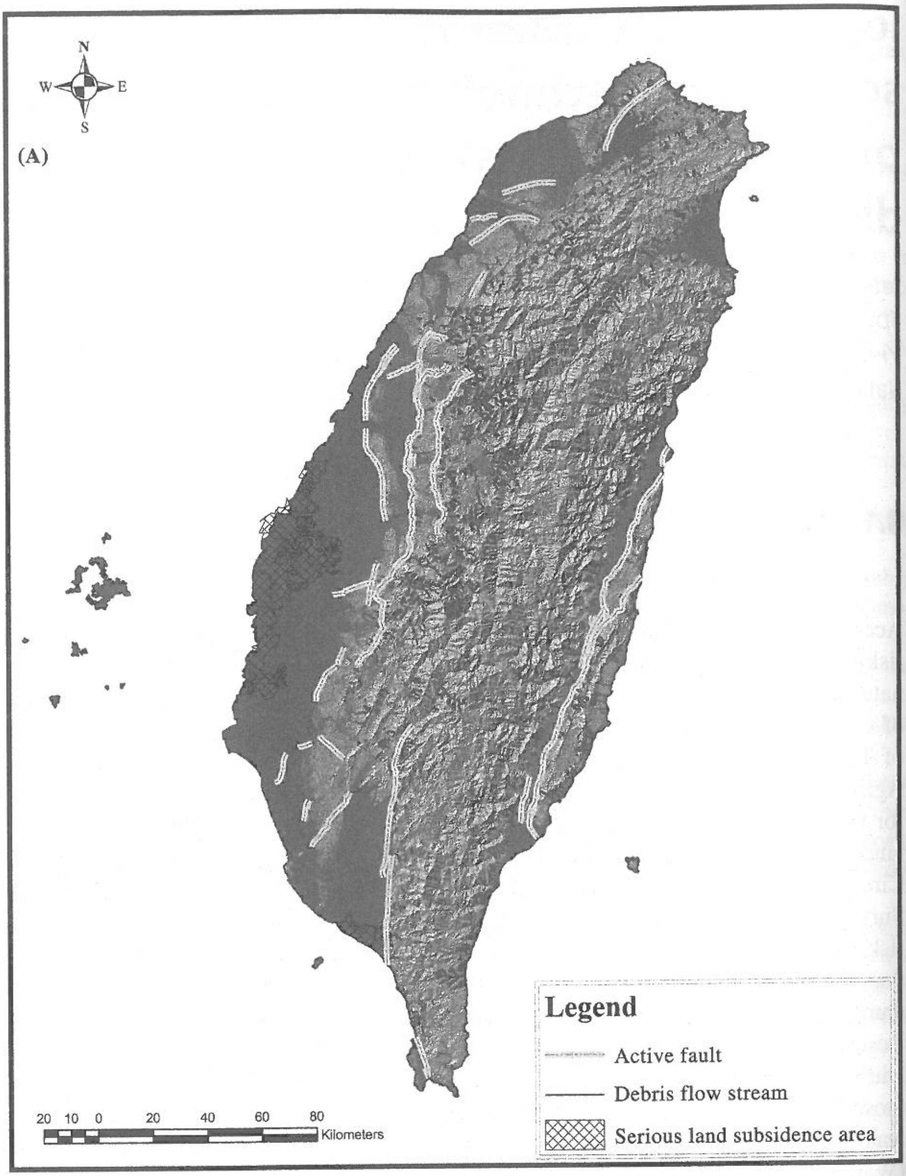

Figure 8.1 (A) Natural disaster potential in Taiwan. (B) Typhoon landing site statistics (1911–2010); major seismic epicenters (1901–2016). Disaster potential and historical disasters in Taiwan.
Source: Research Center for Soil and Water Resources and Natural Disaster Prevention of the National Yunlin University of Science and Technology (abbr. SWAN Research Center).

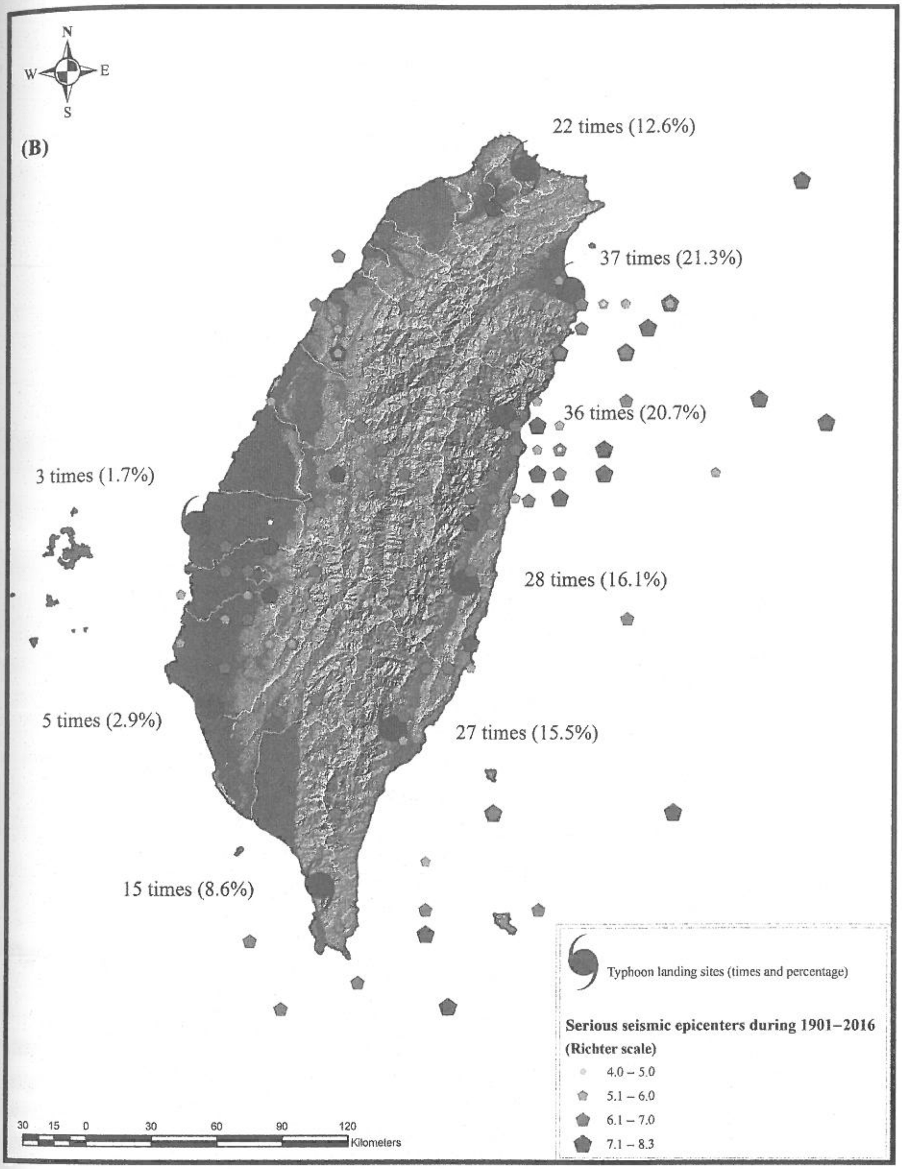

Figure 8.1 (Continued).

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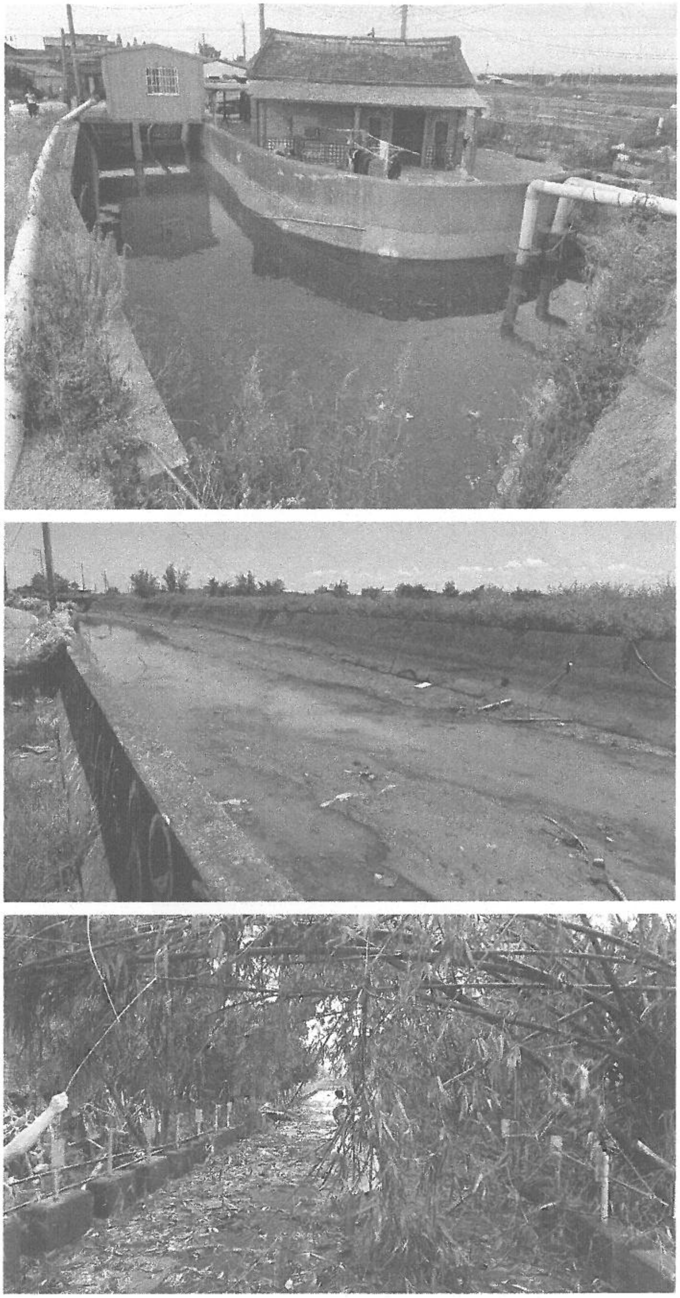

Figure 8.2 (A) Flood-prone residence located near a drainage (photo taken by Yi-Chi Chen). (B) Accumulated sediment in a big drainage that may easily cause flood phenomena (photo taken by Chia-Chen Hsu). (C) Typhoon caused tree falls (photo taken by Tian-Chi Zhuang). (D) Typhoon caused floods (photo taken by Ming Ou-Yang). Usual disasters and their impacts in Taiwan.
Source: SWAN Research Center and Chiayi City Government personnel.

(D)

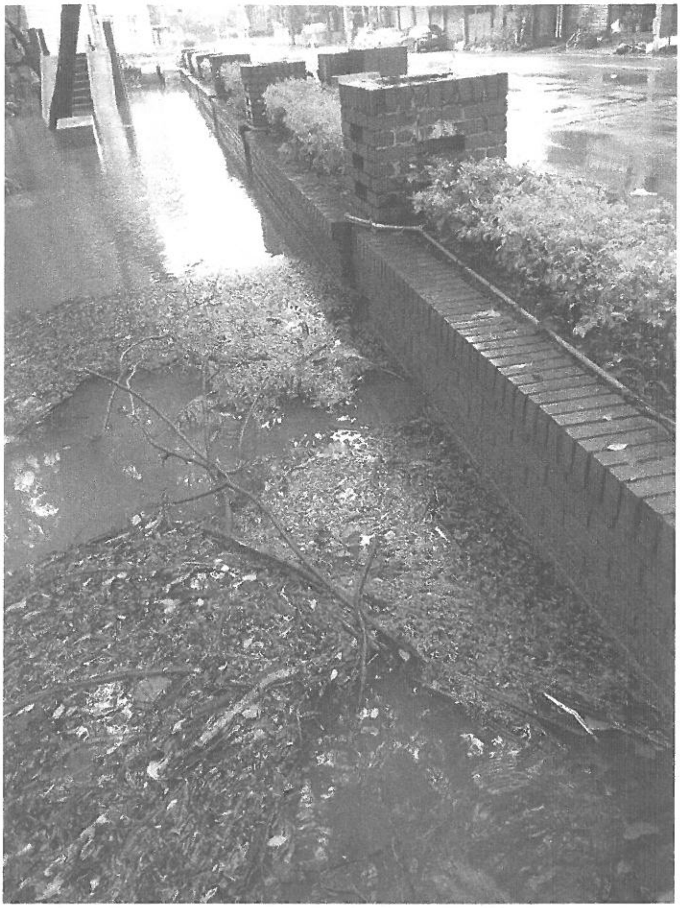

Figure 8.2 (Continued).

implement disaster prevention and protection actions in which technology holds an important role. As the related central regulatory authorities differ, various warning websites and mobile applications are developed to announce disaster messages and to monitor hazards. Such disaster precaution systems developed by central institutions are shown in Fig. 8.3; some of them are introduced in this chapter.

8.1.1 Public warning system

The Disaster Public Warning System (PWS) in Taiwan was first designed in 2011, after the Tohoku Earthquake (Great East Japan Earthquake) and it was officially completed in 2016. This system combines mobile communication and fire rescuing mechanisms. According to the data of National Communications Commission (NCC) (National Communications Commission, 2016), the main characteristic of

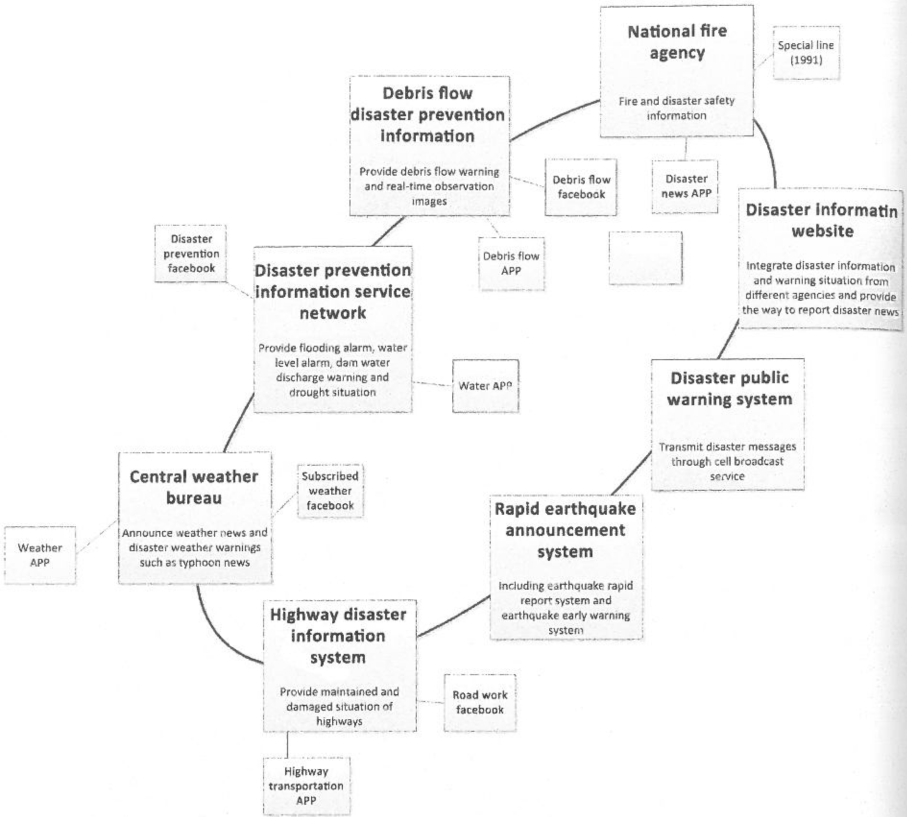

Figure 8.3 Disaster precaution systems in Taiwan.
Source: SWAN Research Center.

this system is the message transmission via Cell Broadcast System (CBS). This method requires few seconds to transmit alerts from disaster prevention management organizations to 4G cell phone users, located in specific areas. The PWS messages are announced by central governmental organizations and they are categorized as "Presidential Alerts" and "Alert Messages." The "Presidential Alerts" warn the public regarding massive and instant catastrophes, such as great earthquakes announced by earthquake rapid report systems or military attacks announced by air-raid alerts, whereas the "Alert Messages" are most proper for nonurgent but life-related warnings, such as real-time large thunderstorm warnings, earthquake reports, roadblock alerts, reservoir discharge alerts, mudslide alerts, contagious diseases, international travel disease cases, and Wan-An Drills that are related to airstrikes.

The PWS includes sections related to message sources, collection and delivery, message transportation, and terminal (National Communications Commission, 2016). Thus far, there are 7 central governmental organizations that can issue 10 types of CBS messaging; CWB, Directorate General of Highways, WRA, Soil and Water Conservation Bureau, Directorate General of Personnel Administration, Center for Disease Control, and Civil Defense Headquarters (Chang et al., 2016).

8.1.2 Rapid earthquake announcement system

Two types of systems are used in Taiwan to warn and report earthquakes directly. The first one is the "Earthquake Early Warning System (EEWS)" that detects earthquake waves rapidly and announces alarms to targeted areas prior strong ground shaking. The EEWS was developed by the CWB and it is a regional-seismic-network-system constructed by several seismic stations near an earthquake location (Central Weather Bureau Seismological Center, 2016). Furthermore, this regional EEWS reports the earthquake magnitude, epicenter, and other earthquake information prior the seismic wave spreads. It requires approximately 20 s to distribute the shaking warning alarms; however, it cannot be efficient for the "blind areas"; areas that are located 50–70 km away from the epicenter. Therefore, in order to minimize the blind area issue, the National Center for Research on Earthquake Engineering (NCREE) has established the onsite EEWS that can calculate various earthquake parameters by one seismometer and transmit alarms in shorter time. While the regional EEWS is more accurate, the onsite EEWS detects useful earthquake information faster. It should be mentioned that, so far, two EEWS have been established by NCREE.

The fact that the EEWS warns regions close to the epicenter in short time makes it extremely practical. For instance, people can evacuate their locations and start transferring to shelters, high-speed transportation can reduce speed, critical infrastructure can be shut down automatically, factory procedure lines can stop operating, and computer discs can stop reading or writing (Central Weather Bureau, 2016). Many central regulatory authorities and public organizations such as the CWB and educational institutions have installed this system to receive warning messages when earthquakes occur. Since the EEWS has limitations such as the blind areas, disaster education and training are necessary for the involved populations. There are 3450 junior high schools and elementary schools (2016) that have established the EEWS software in their facilities. Furthermore, teachers and students practice self-protection and evacuation techniques in case of emergency through this system.

The second system used in Taiwan to report earthquakes is the "Earthquake Rapid Report System" that provides important information including seismic sources, magnitude, intensity scales, and infrastructure shaking cases once an earthquake occurs in order to speed the rescuing procedures (Central Weather Bureau Seismological Center, 2016; Central Weather Bureau, 2016). To further expand its efficiency, a plethora of tools such as e-mail, worldwide websites, phone/fax lines, mobile phone Short Message Service (SMS), and public TV are connected to it to spread the earthquake news. These tools make the system completely automatic both for receiving data and announcing information (Central Weather Bureau Seismological Center, 2016). Rapid report information not only minimizes secondary disasters, speeds rescuing procedures, and maximizes the efficiency of the recovery process from disasters (Central Weather Bureau, 2016), but also, it allows rescuing institutions to send their limited resources to areas where needed the most, effectively and urgently (Central Weather Bureau Seismological Center, 2016).

8.1.3 Mobile water situation APP

In Taiwan, Mei-Yu (plum rains), typhoons, or sudden storms are the causes of flood. In order to announce accurate rainfall and/or flood alarm messages in real time, the WRA has developed a mobile application called Mobile Water Situation APP, which is a freeware program (Water Resources Agency, 2016). Users may check the water and flood alarms of different locations via this application, as well as to be informed about the precipitation, water levels, reservoir levels, etc. This application is also connected with the CWB so as to provide weather charts such as satellite images, radar echoes, and other instant weather information. Most impressively, it receives data from monitoring systems/closed-circuit television (CCTV) of central rivers and main drainage facilities, where it can be observed if the water level is higher than the alarm level in real time.

8.1.4 Disaster information website

When Taiwan was hit by Morakot Typhoon in 2009, the average precipitation for the 3 involved days was 2500 mm/day. Major disasters such as floods, debris flow, landslides, broken bridges, damaged river and sea embankments, transportation problems, and agriculture damages caused tremendous catastrophes and losses. Until that period, there was no system or platform that could combine and operate with different disaster information; the data obtained from each damage report could only be presented through statistic tables. Therefore, the Ministry of Science and Technology (MOST) built the Disaster Information Website (National Science and Technology Center for Disaster Reduction, 2016) for which the research results of technological achievements in disaster management, the Geographical Information System (GIS) and the environmental monitory and survey data owned by each central governmental department are collected and evaluated annually. Up to now, the website has become an important reference for disaster response works.

The disaster information website shows the data of all the disaster regulatory authorities effectively, fact that reduces the user's inquiry time for searching. For example, many and different disaster alarms are all shown in the same interface. Users can be informed regarding water situations and onsite environment conditions through water level stations, rainfall stations, and CCTV. Another vital service of this website is the image uploading function by the disaster reporting personnel, mostly for damaged locations and facilities.

8.2 Applications of local governments (examples of Chiayi City and the counties of Changhua and Yunlin)

Since 1995 and for further improving disaster prevention potential, the National Fire Agency (NFA) implements related programs and assist counties to boost the potential of their township offices. Besides the NFA, several central institutions also participate in disaster prevention works such as floods and debris flow resistant community programs executed by the WRA and the Soil and Water Conservation Bureau. The following information shows some of the related services and counseling actions of the SWAN Research Center for Chiayi City and the counties of Changhua, Yunlin (all located in central and southern Taiwan) in order for their local populations to adapt science and technology in the disaster prevention, preparedness, and response.

8.2.1 *Exploiting disaster precaution systems and tools*

Over the last years, many central institutions have developed disaster precaution tools; yet, many local governments are still developing their own for their populations, including mobile phone applications and websites, such as the following:

1. Disaster prevention application

   The technology of a disaster prevention application uses smartphones to inform populations about disasters in real time. The users receive messages regarding typhoons, rainfall/water levels, and weather information. Moreover, this application also shows available shelters and their location in case of urgent evacuation.

   The "Yunlin County Disaster Prevention App" was developed by the Yunlin County Fire Bureau; this application connects several central institutions such as the CWB, WRA, Soil and Water Conservation Bureau, and Yunlin County Emergency Operation Center in order to provide the latest weather messages and shelter locations for its users (Yunlin County Disaster Prevention APP, 2016). In order to increase the usage rates, it also provides useful information for daily life; the Taiwan receipt lottery results and the timetable of the high-speed rail and railway of Taiwan are just a few of its additional services. Based on the data of 2016, this application was downloaded more than 1000 times.

   In like manner to Yunlin County, the government of Chiayi City has built the "Chiayi City Mobile Disaster Prevention APP" (Chiayi City Mobile Disaster Prevention APP, 2016). The information of this application varies; from disaster alarm messages and evacuation information to parking area locations, offices for paying parking tickets, hospital procedures, art activities, railway timetables, electric and water bill information, etc. Based on the data of 2016, this application was downloaded more than 5000.

2. Disaster prevention information website

   Since 2015, the SWAN Research Center has been providing assistance in developing the disaster prevention websites of Chiayi City and the counties of Changhua and Yunlin. The "Chiayi City Disaster Prevention and Rescue Information" (Chiayi City Disaster Prevention Information Website, 2016) website, for example, provides weather information, disaster prevention and rescue information, hazard maps and local disaster information. Moreover, this website provides a pioneering evacuation information section that includes simple evacuation maps for each village as well as it shows clearly evacuation ways for disasters such as floods, earthquakes, landslides, and toxic chemical materials (Chiayi City Government Fire Bureau, 2016).

3. Water situation monitoring system

The Chiayi City Public Works Bureau has built a flood precaution system that is connected to the 5th River Management Office. This system monitors the onsite discharges and delivers images to emergency operation centers (EOC) for determining the condition of the disaster situation.

The Yunlin County Water Resources Department has created a website for flood resistance (Yunlin County Government Water Resources Department, 2017) that is divided into three subsystems; monitoring, precaution and decision, and map system. Through the precaution and decision system, the personnel can be informed regarding real-time weather conditions, rainfall, and water levels through. Additionally, this subsystem can produce a real-time water situation table automatically and abbreviate the time to produce a document for accelerating response efficiency.

Those systems can detect real-time monitoring anomalies, dispatch water pumps in advance to avoid flood phenomena, and provide necessary information for the evacuation of populations living in low-lying lands.

8.2.2 Analyzing the evacuation priority of socially vulnerable groups

When disasters are about to strike, socially vulnerable groups such as people with disabilities, elderly living alone and dialysis patients have limited response abilities and they are not able to protect themselves. The government takes actions to minimize the disaster risks, especially for such people. The SWAN Research Center has collected important data that involve socially vulnerable groups and disaster potential areas in order to detect such groups living in high disaster potential regions. In the future, these populations will be listed and managed for emergency contact.

Furthermore, the SWAN Research Center has also organized similar disaster risk response actions for the socially vulnerable groups in Chiayi City. The priority of their evacuation is categorized as high, medium, and low disaster potential, as is it showed in Fig. 8.4.

In order to determine the priorities' order, the disaster potential areas need to be defined. In the case of flood disasters for example, the SWAN Research Center refers to the simulated results obtained from WRA as well as real flood cases to classify the high, medium, and low flood potential of each region. The classification

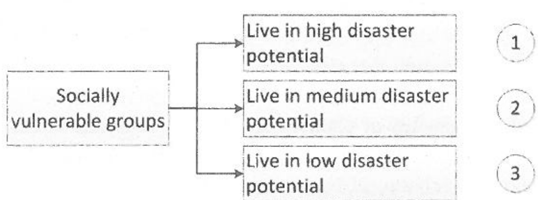

Figure 8.4 Evacuation priority of socially vulnerable groups.
Source: SWAN Research Center.

Table 8.1 **Flood potential classification method**

Condition / Flood potential class	Simulated flood potential diagram	Real flood cases
High	Over 0.5 m flood probability while the accumulated precipitation is 450 mm/24 h	Flood was over 0.5 m and recorded at least twice in the last 5 years
Medium	0–0.5 m flood probability while the accumulated precipitation is 450 mm/24 h	Flood was over 0.5 m and recorded once in the last 5 years
Low	Very low flood probability while the accumulated precipitation is 450 mm/24 h	No flood over 0.5 m was recorded in the last 5 years

Source: Chiayi City Government Fire Bureau (2016).

method is shown in Table 8.1. For example, an area with over 0.5 m flood probability while the accumulated precipitation is 450 mm/24 h or an area in which flood was over 0.5 m and recorded at least twice in the last 5 years is classified as a high flood potential area. The results are shown in Fig. 8.5. It can be observed that the western side of Chiayi City has higher flood potential compared to most parts that have low flood potential.

Another equally vital service is the data collection of the socially vulnerable groups in Chiayi City. According to the data of 2016 (Chiayi City Government), there are 14,677 people with disabilities, 161 elderly living alone, and 392 dialysis patients. Based on the resident's location and flood potential regions as shown in Fig. 8.5, it can be stated that there are 31 people of socially vulnerable groups living in high flood potential regions, 101 persons living in medium ones, and 15,098 living in low ones as it is shown in Table 8.2.

The aforementioned process could be used for different types of disasters as well; the results may enhance actions by the governments to promote evacuation ways to social vulnerable groups. Furthermore, governments can also design proper shelters and/or social welfare institutions for the affected populations during an emergency evacuation.

8.2.3 Determining flood situation by precipitation or water level

In Taiwan, the WRA uses the precipitation values as a flood warning system. In each hour of precipitation, there are two different warning values; first- and second-class flood warning; results are shown every 3, 6, 12, and 24 h of precipitation. The first-class values are higher than the second one. When a measured

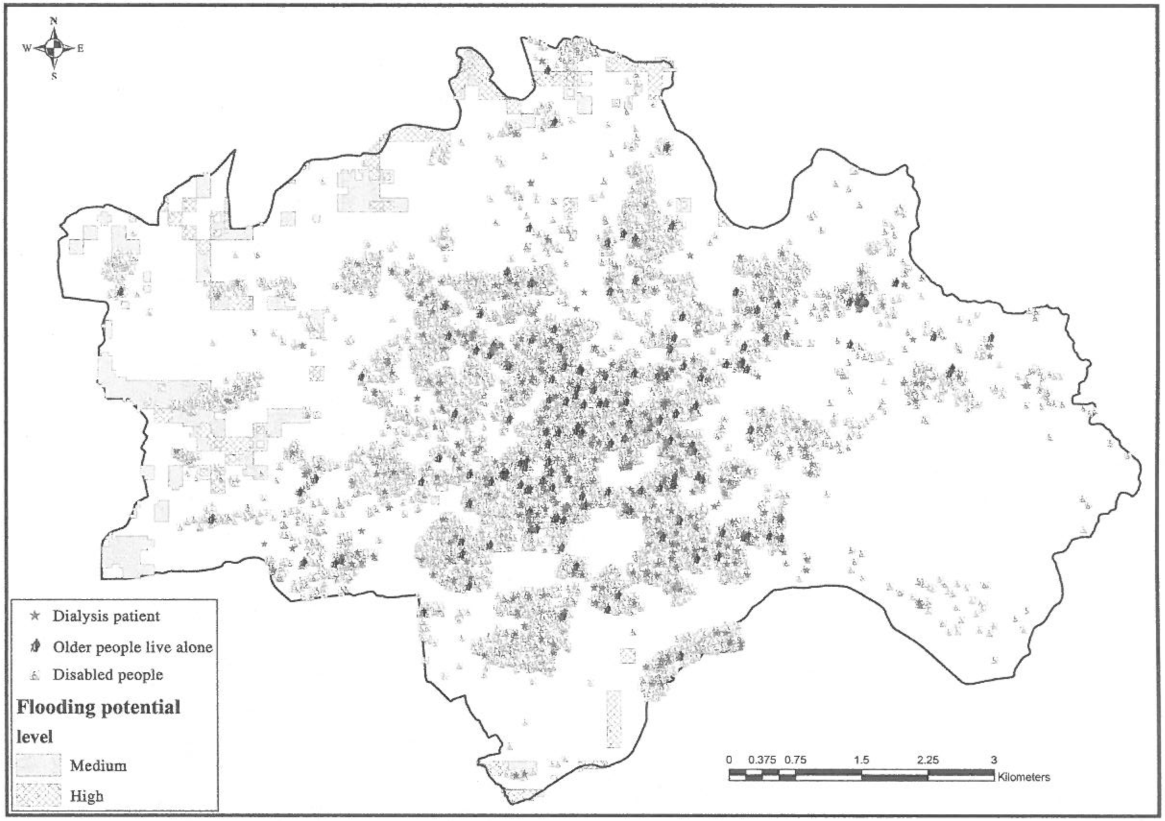

Figure 8.5 Socially vulnerable groups distributed in flood potential regions of Chiayi City.
Source: SWAN Research Center.

Table 8.2 Individuals of socially vulnerable groups distributed in flood potential regions of Chiayi City

Flood potential class	Individuals
High potential	31
Medium potential	101
Low potential	15,098

Source: SWAN Research Center.

real-time precipitation is higher than the second or first warning value, a flood warning will be announced depending on the level. The flood warning is defined as follows.

A. *Second-class flood warning*: If precipitation is continued, the flood-prone areas might be flooded in 3 h.

B. *First-class flood warning*: If precipitation is continued, the flood-prone areas may have already been flooded.

In order to make people understand the meaning of flood warnings, several institutions hold flood-resistant drills where they provide information and train the involved parties. When people participate in these drills, they learn how to observe the precipitation value prior a disaster's occurrence and to evacuate the condition of locations and facilities while checking if the precipitation value is higher than the warning value. Professionals and experts usually provide assistance and counseling to communities that hold such drills; these communities are called "disaster resistant communities." During the drills, the residents of a community are separate in several groups with different roles for each. Some of these groups involve members of the precaution class that observe the precipitation value via mobile applications or a volumetric cylinders (Fig. 8.6A), members of the evacuation class that assist in the evacuation process (Fig. 8.6B), members of the guide class that control the evacuation traffic and members of the shelter class that assist the affected populations to remain calm and safe.

In addition to the precipitation as a flood warning tool, a water gauge can be used to determine the flood situation. When the flood is above a certain height (30 cm, for instance) and the rainfall is predicted to be continuous, the flood may become more serious. In that case, populations living near the flood areas must evacuate the soonest possible. This is also one of the reasons why several villages in Taiwan paint water gauges on walls of buildings and other constructions (Fig. 8.6C and D).

8.2.4 Earthquake damage simulation

Earthquakes cannot be predicted accurately; yet, they can be simulated. The National Center for Research on Earthquake Engineering (NCREE) of Taiwan has developed the "Taiwan Earthquake Loss Estimation System" (TELES) (National

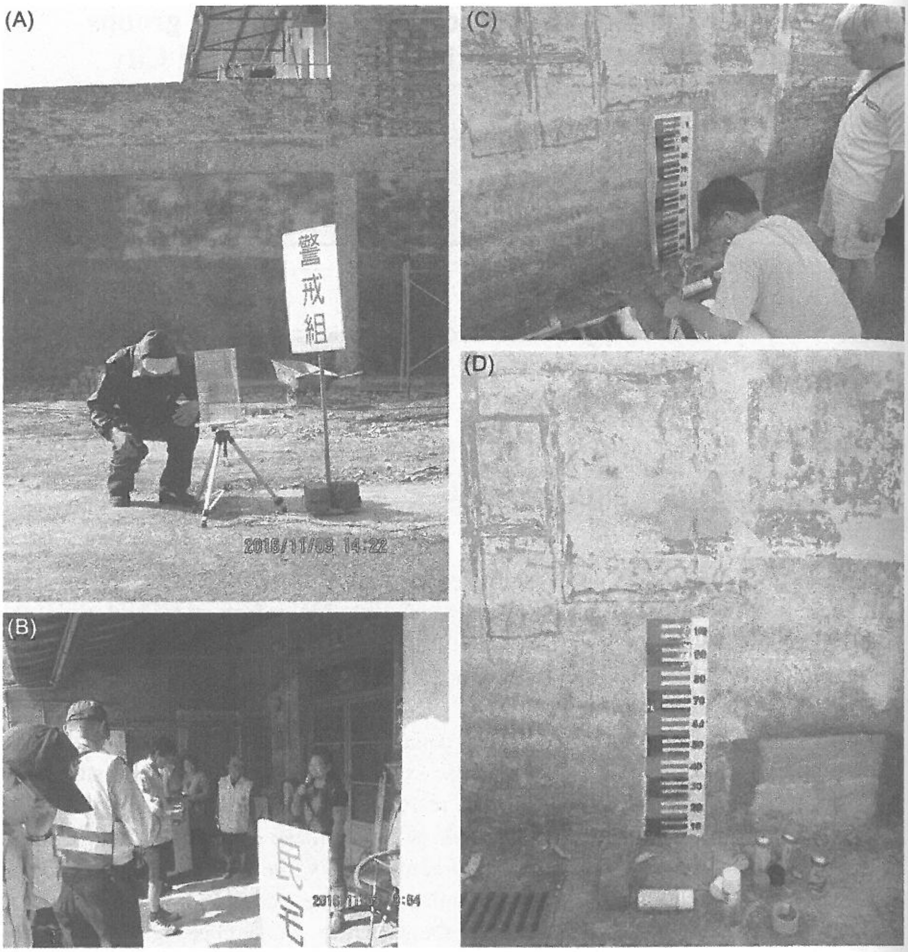

Figure 8.6 (A) Members of the precaution class are observing the precipitation value (photo taken by Spyros Schismenos). (B) Members of the evacuation class are assisting in the evacuation process (photo taken by Spyros Schismenos). (C) Water gauge is being painted (photo taken by Ya-Wen Chang). (D) Result of a painted water gauge (photo taken by Ya-Wen Chang). Flood-resistant drill held in a disaster resistant community in Changhua County; preparing and finalizing a painted water gauge in Changhua County.
Source: SWAN Research Center.

Center for Research on Earthquake Engineering, 2016) and the National Science and Technology Center for Disaster Reduction (NCDR) has developed the "Taiwan Earthquake impact Research and Information Application platform" (TERIA) (Wu et al., 2016). These two programs can simulate a database of areal population, buildings, and line pipes. They can calculate damages under different earthquake conditions. The difference between these two programs is that TELES simulates a scenario in unit(s) of village(s), but TERIA in unit(s) of a 500 m × 500 m grid. This, of course, affects the simulation results.

Regardless of the differences in the results of these programs, the regulatory authorities use them to formulate preparedness measures such as the establishment of shelters, fire prevention, and designing and confirming directions to hospitals. Such study results may also be used as a reference for decision-making policies, especially when rescue personnel and medical resources are required. In the case of an earthquake drill for example, when the scenario is set, the damages can be simulated by these software. This can be useful for institutions participating in the drill since they can evaluate related rescue mechanisms and analyze their efficiency.

In March 2016, the Yunlin County Government held an earthquake disaster rescuing drill (Yunlin County Fire Bureau, 2016). A 7.5-M_s earthquake, caused by Tachienshan fault shaking, affected the central Taiwan with a hypocenter of 17 km underground. The life and property loss of every township was simulated with TELES, including peak ground acceleration (PGA), numbers of collapsed building, numbers of casualties, and numbers of people who evacuated for a temporary period. The analyzed results are shown in Fig. 8.7.

8.2.5 Using social networks to inspect and notify for damages

Nowadays, many social media and network applications are used for instant messaging. The frequency of using such tools is much higher than traditional methods such as phone, fax, and SMS. The Chiayi City like other local governments has built a network named "Chiayi City disaster prevention and response network" for LINE application (Chiayi City Government Fire Bureau, 2016). In this network, everyone can provide information or images of the damages during the disaster response phase. Based on the past experiences, the Chiayi City government has developed regulatory procedures and timing policies in which the involved personnel inspects and notifies for damages when the precipitation of 10 min is higher than 10 mm or the intensity scale of an earthquake is higher than 3. Tools such as LINE, SMS, cell phone, fax, and radio are used to inspect and notify for damages. This mechanism succors to understand the level of the damage in short time and to organize rescue works when an extreme disaster occurs.

8.2.6 Drawing hazard maps

Disaster prevention and protection relies on basic databases that include environmental data such as humanities and cultures, hydrology, traffic, basic structure, and resource data such as machinery, equipment, vehicles, and experts. Governmental authorities categorize and manage such data. Nevertheless, due to the circumstances, such data may variate often and a regular update is mandatory. In order to present the data in tables, GIS technology can be utilized to draw maps for distributing disaster response acts. Therefore, hazard map drawing could be considered as disaster prevention technology. Experts can use GIS for different maps; whereas

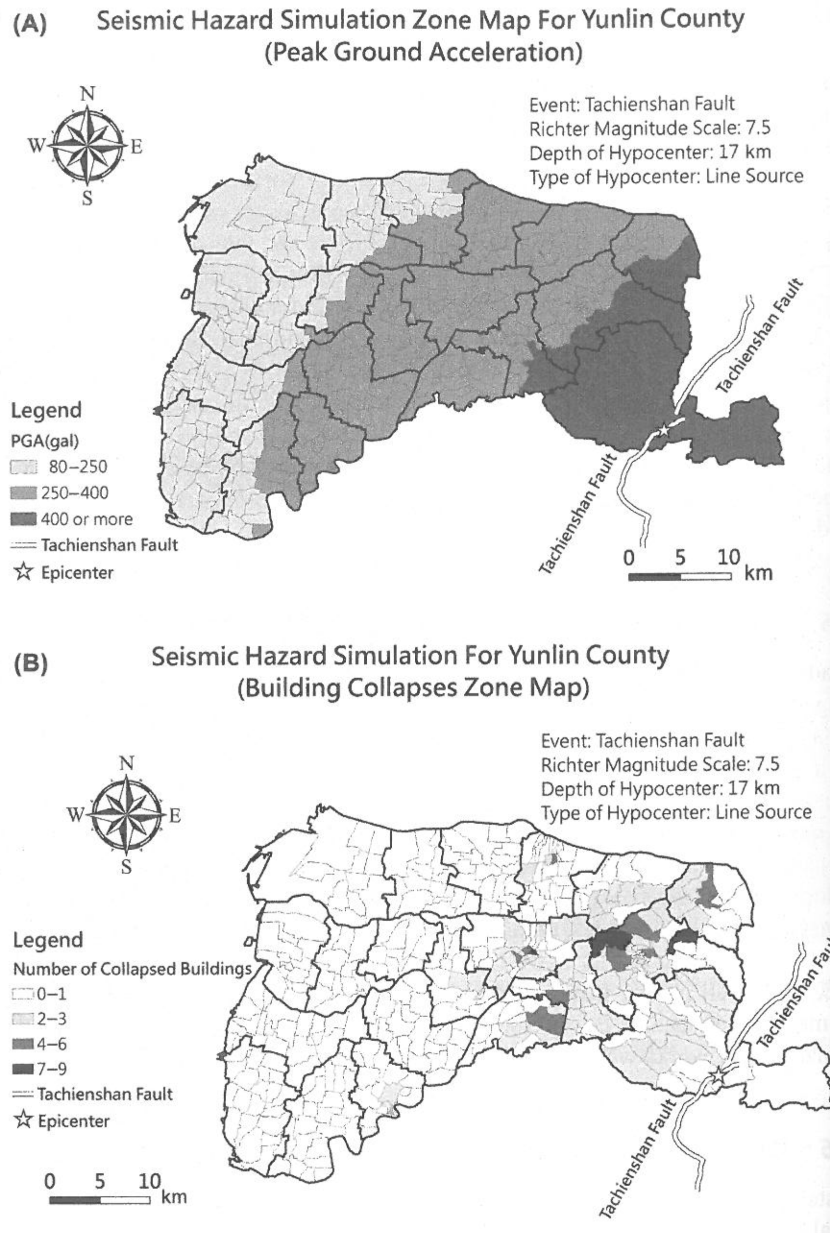

Figure 8.7 (A) Peak Ground Acceleration. (B) Building Collapses Zone Map. (C) Casualties Zone Map. (D) Temporary Evacuation Zone Map. Simulation results of an earthquake caused by the Tachienshan fault shaking in Yunlin County.
Source: SWAN Research Center.

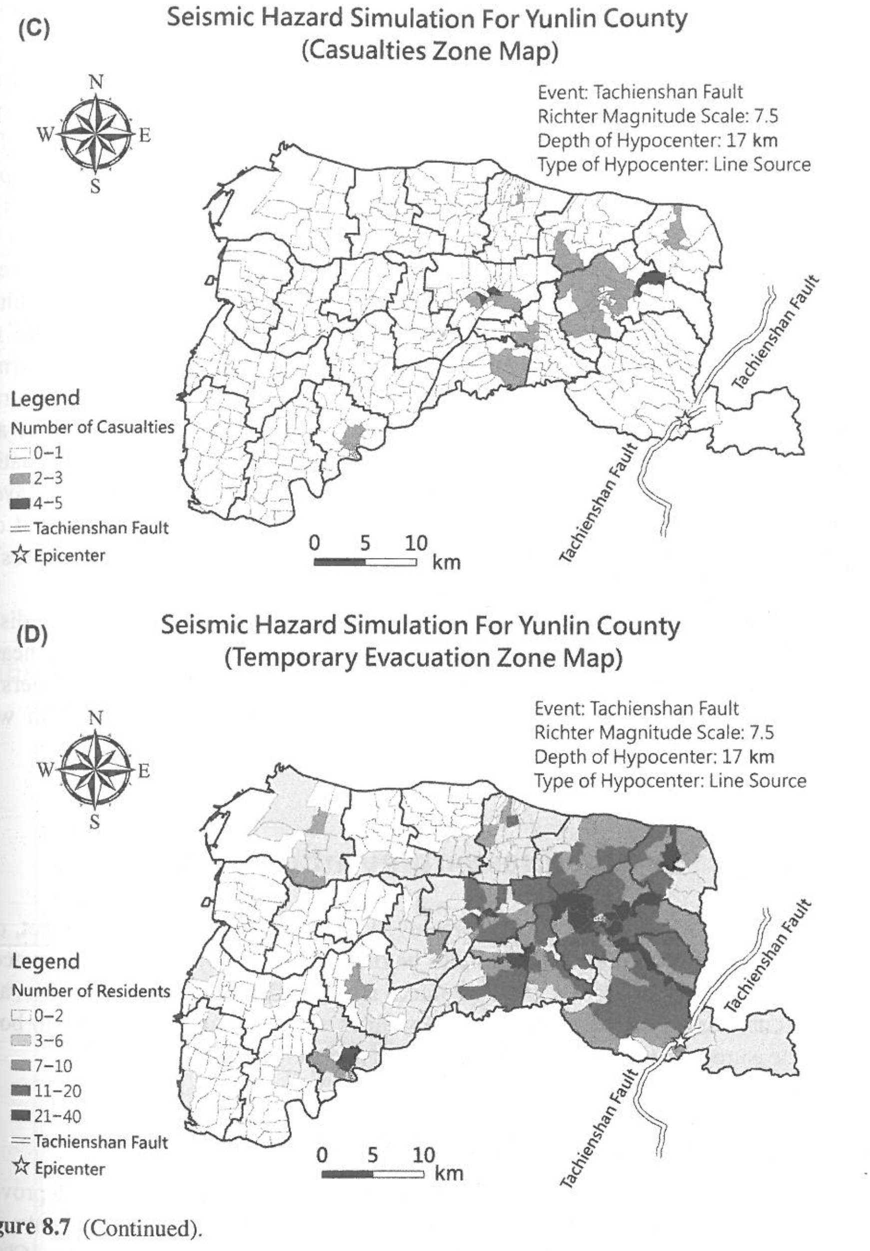

Figure 8.7 (Continued).

nonexperts may navigate in a simpler website, like Google Earth, to search for disaster management information.

There are many types of hazard maps such as the disaster potential diagram (Fig. 8.8A), the disaster prevention and protection resource diagram, and the simple evacuation map (Fig. 8.8B) (Chiayi City Government Fire Bureau, 2016). The Information shown in each diagram is depended on what it is needed to be presented. It may also show important local landmarks or characteristics, as well as other related disaster information.

The SWAN Research Center has provided assistance and counseling to several authorities for hazard map drawing in 2015 and 2016. Considering the difficulties of drawing, they were taught to draw simple evacuation maps that contain the administrative division location, emergency numbers, disaster prevention information websites, information for shelters and legends. The main portion of a diagram as such includes the village range, disaster rescue institutions (Police, Fire, and Medical Departments/Units), locations that are used as shelters and evacuation directions. The most efficient way to prepare an evacuation direction is to avoid high disaster potential regions. After the simple evacuation map is finalized, it can be printed for the local populations, and/or it can be saved in online databases as digital diagram files for future downloading.

Other types of hazard maps may also be used for decision-making when a disaster EOC is involved. The officer in charge may establish rescue facilities near a disaster potential region in advance in order to reduce the effects of disasters or may organize suitable shelters and command storage areas to supply them with goods for those in need.

8.3 Innovations in disaster prevention technologies

During the last decades, Taiwan has achieved a lot in disaster prevention; yet, due to climate change, there are a lot more to be done. Different types of disasters occur more often than before; it is vital to promote not only disaster technologies but also disaster education in a very transparent approach so to be followed by all, to boost safety measures, and to improve the life quality of the populations.

8.3.1 Turning cities into "disaster prevention smart cities"

IBM Smarter City concept is an initiative of IBM Smarter Planet, created to provide hardware, middleware, software, and service solutions for city governments and agencies. Following this dogma, the emphasis is given to Internet of Things, Cloud Computing, Mobile Internet, Intelligent Terminal, etc., that can be applied to networks for electricity, traffic, facilities, pipelines, industries, organizations, residences, and lifestyles. By adjusting such innovations to people's lives, they can improve besides the quality and efficiency, their surroundings as well as the environment.

(A)

(B)

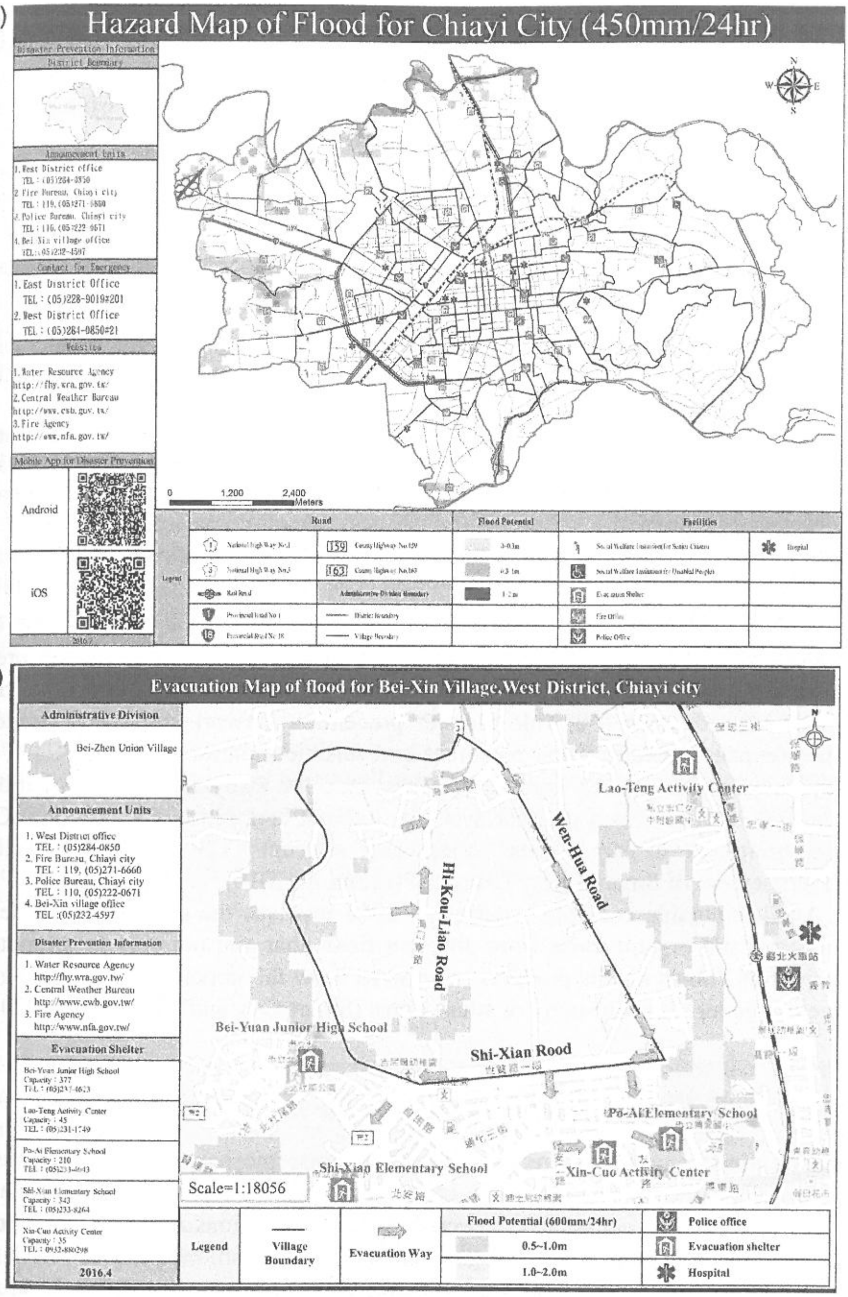

Figure 8.8 (A) Disaster potential diagram (flood). (B) Simple evacuation map (Bei-Hsin village in Chiayi City). Types of hazard maps.
Source: SWAN Research Center.

Due to the increasing consequences of climate change, industries and organizations of Taiwan in August 2015 completed a report regarding smart cities and disasters. Furthermore, all the local governments in Taiwan started using new technologies more frequently for all the phases of disasters, for example, early warning system networks (Smart City and Io T Website, 2016).

According to the fifth chapter of "Ide@ Taiwan 2020" that is related to smart country strategies (Ide@ Taiwan 2020, 2016), Internet efficiency is a trend of international disaster prevention; therefore, Taiwan should promote smart disaster prevention technologies by strengthening Internet and information technologies, creating developed user interfaces and sharing disaster prevention information.

1. *Strengthening Internet and information technologies*: by defining disaster warning systems through surveys and monitoring and by providing accuracy and efficiency, especially for the monitoring data.
2. *Creating developed user interfaces*: via open-access websites and applications, that provide big data of disaster prevention information, in which users can update data in various ways; for example, using mobile phones to report an incident, its location, and to provide photographic material.
3. *Sharing disaster prevention information*: by enhancing the use of social media for database analysis and for creating crisis maps, in order to predict the occurrence of a disaster and to provide critical information rapidly.

Both public and private sector work well together in matters of disaster prevention technology. The Chunghwa Telecom, the largest telecommunications carrier in Taiwan, has developed a wide disaster prevention network in several territories. This company operates water resources and seismic monitor systems, CCTV, low-frequency radio, disaster warning systems, etc., for analyzing the information by means of high-precision monitor systems, Internet connection stability, and Cloud Computing, as a part of the smart city concept (The Chunghwa Telecom Advertisement of Smart Safety Disaster Prevention, 2016).

Another notable example occurred in 2014 involves the cooperation of several industries and organizations from different fields that aim not only to promote the Internet of Things and its products but also to show the importance of working well together under the philosophy of smart cities (Smart City and Io T Website, 2016).

8.3.2 Disaster prevention schemes for residences

Once a disaster occurs, there are national-response mechanisms that are activated besides the self- and local-response ones. Regarding the self-response mechanisms, major goals include self-survival, disaster prevention actions and properties' protection. For the local response, vital goal is the collaboration. People assist each other when needed, they establish local organizations and cooperate with local businesses, Fire Department, and volunteers. For the national-response mechanisms, great responsibility of the authorities is to provide comprehensive services for all four phases of a disaster; mitigation, prevention, response, and recovery. In 1995, the Great Hanshin earthquake occurred in Japan. This catastrophic phenomenon leads the authorities to establish disaster educational and training programs for volunteers. The disaster response and relief systems in Japan are, nowadays, noteworthy and they used as example models worldwide (Hashimoto Shigeru, 2016).

It is widely accepted that local and isolated communities must be part of any disaster prevention schemes. The Global Platform for Disaster Risk Reduction conference (UNISDR) that was held on 2013 in Geneva is focusing on this action. Furthermore, they have released the "Post-2015 Framework for DRR" in which it was stated that disaster risk reduction and building resilience for communities are imperative for any future development agenda globally (UNISDR, 2013).

In Taiwan, attention is given to flood and landslide prevention programs that involve local communities. Educational institutions participate in this action by providing assistance in education and training. By adopting the role of "Bousaisi", a person/unit that promotes and informs about disaster prevention and education, the government hopes communities to be educated and trained more effectively (Central Disaster Prevention and Rescue Council and Water Resources Agency, 2008).

Additionally, local governments provide brochures for disaster prevention aiming to inform the majority in large regions such as Taipei, New Taipei City, Taoyuan, Hualien, Tainan, and Kaohsiung. These brochures are mostly sketched, using less but equally important information in order to become understandable by people of different ages and educational background. This idea, designed by the SWAN was first applied in Chiayi City in 2016 with great response and enthusiasm by the communities. This brochure also includes disaster prevention information for communities, actions for prevention and response, evacuation maps and locations first aid information and emergency call numbers. Up to now, authorities in Chiayi City continue providing this brochure to all the residents of Chiayi City, hoping it can educate, train, inform, sensitize, and reduce casualties and damages caused by disasters (Chiayi City Government, 2016).

8.4 Conclusion

The "Disaster Prevention and Protection Act" was first drafted after the national tragedy of the Chi-Chi Earthquake in 1999 and announced officially in 2000. This Act includes authorized institutions of various disasters as well as actions for every phase of disaster management. Furthermore, this Act regulates governments and their programs regarding disaster prevention and protection technology while they emphasize disaster education, training, and promotion. It is hoped that the disaster prevention and protection technologies based on this Act and its regulations boost the positive influence to future development works constantly.

Both central and local governments aim to provide funds and manpower to upgrade disaster prevention and protection technologies, in order to control or minimize, even prevent disasters before they spread. This era, the era of information, social media, network applications, and instant communication, demands lighting fast response. Adjusting to these circumstances, the NFA educates personnel of local governments and promotes disaster prevention and protection programs since 2005. While this action started with just few counties, in 2009 it managed to involve 135 township offices. After 2015, these programs included 368 township offices nationwide. Due to the success of this action, the works and programs for the communities will be further expanded and enhanced after 2018. While the regulatory authorities execute such programs to promote disaster prevention strategies, the Executive Yuan created the "Program on Applying Science and Technology for Disaster Reduction" in order to cooperate with industries and schools for similar issues. Thus far, all the procedures taken by the governments in Taiwan are based on the maxim "Prevention is better than cure"; yet, more actions need to be taken in order to prepare even more effectively against any further threats and cultivate the Taiwanese people with this ideal philosophy, regardless of their age or status.

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