The Research of Debris Flow Disaster Prevention and Response System in Taiwan

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Abstract. The Taiwan Disaster Prevention and Response Act had been issued and put into practice on June 30, 2000. Roughly, that the disasters prevention and response system with three levels, namely the organization of central, county, and township. Due to above plans, the Council of Agriculture, Executive Yuan, become the director organization for the debris flow disaster prevention, for this work promoting smoothly, the Council of Agriculture drawn up debris flow disaster prevention works from February 22, 2002, such as Operating Procedures for Debris Flow Disaster Evacuation, Operating Procedures for Collection and Reporting of Debris Flow Disaster Information, Implementation Guidelines for Debris Flow Disaster Prevention Education and Publicity, Operating Procedures for Forecasting and Warning of Debris Flow Disasters, and Operating Procedures for Prevention of Repeated Debris Flow Disasters and for Recovery and Reconstruction, in order to set up the implementation emergency practice mechanisms of debris flow disaster prevention and response system in each stages, and each kinds disaster prevention and response operation normalizing, combine, coordinate, and practice. Although that carry out already several years, but there were some cognitive problem between each level's organization exultantly. Thus this research synthetically sums up the experience of carrying out from the aspects of decree, organization, and operation, to inspect and offer the suggestion of making a self-criticism, improving, and defend for the reference of Regional Disaster Prevention and Response Plan.

1. Introduction

In 1996, Typhoon Herb hit the mountainous area of central Taiwan with heavy rain, causing debris flow disasters in many areas of Nantou County, submerging fertile farmlands and houses, destroying public facilities and leaving 27 people dead and 14 missing. So far, Debris Flow has become the focus of social concern. After Jiji earthquake in 1999, lots of loose earth and rock were accumulated in slopes or valleys, which increased the possibility of debris flow. In 2001, Typhoon Toraji caused many debris flow disasters in Hualien County and Nantou County with plentiful rainwater and left 70 people dead and 96 missing, which greatly shocked the society. In view of this, the government has made great investments to engage in debris flow research, establishment of debris flow disaster prevention system, debris flow disaster prevention emergency response plan and debris flow disaster prevention propaganda, hoping to reduce casualties in case of debris flow disasters.

In 2004, the debris flow disaster caused by Typhoon Aere in Taoshan Village, Wufeng Township, Hsinchu County, Mingduyou Tribe left 4 people dead and 2 missing, and the collapse in Tuchang...
Tribe left 9 people dead and 13 missing. After that, Typhoon Haima in that year also left 4 people dead in Wufeng Township, Hsinchu County due to the debris flow disaster. The Soil and Water Conservation Bureau (SWCB) of the Council of Agriculture therefore proposed the “Debris Flow Evacuation Standard Procedure” which was renamed as the “Operating Procedures for Debris Flow Disaster Evacuation” after many negotiations. Its purpose is to provide all disaster prevention and response units with the abilities to evacuate inhabitants smoothly and to guide inhabitants to safe refuges when debris flow disasters occur or are imminent, so as to strengthen the emergency response abilities. Moreover, it also aims at improving the public’s usual preparation and their abilities to respond to disasters, to reduce the threats of disasters to lives and properties, so as to build a regional disaster prevention and response system and to establish bottom-up concepts of disaster prevention and measures to avoid disasters.

However, it deserves a further discussion whether the promotion of debris flow disaster prevention at all levels has been appropriately combined with practical experience in disaster prevention and has been adjusted to function as expected since the regulations were implemented. In this paper, data of relevant literature were collected for summarization, self-criticism and analysis to explore the reference for future promotion.

2. Materials and Method

2.1. Basic theory of disaster prevention

2.1.1. Features of disasters

Based on Article 2 of “Disaster Prevention and Response Act”, “disasters” refer to the damages caused by the following catastrophes: natural calamities including wind, flood, earthquake, drought, chilling and debris flow; devastating fire, explosion, disaster of utility gas & oil pipelines and transmission lines, air crash, marine peril, traffic accident and toxic chemical hazard (Ministry of the Interior, 2000). Additionally, some scholars argued that “disasters” are the natural phenomena directly or indirectly caused harm or damage to human life, property and comfort (Wang, 1997). Generally speaking, the occurrence of disasters is not simple, but the threats caused by disasters to human society increase day by day. Therefore, for disaster prevention and response, it is necessary to understand the features of disasters (Chao, 1998):

- **Regional feature**
  The occurrence or the severity of disasters often varies from region to region, for example, the heavy rain with the same rainfall occurred in different regions will inevitably result in the disasters with varied severity, and the roads in the same size and with the same construction method passing through the areas with different geological conditions can also lead to different results.

- **Timeliness**
  The conditions or severity of disasters is easily affected by time, and the disasters with the same conditions occur at different times may cause different damages. For example, the earthquakes in the same size occur at rush hours and at late nights must cause different disasters.

- **Chain reaction**
  The disasters occur in one region may create chain reactions in other regions, and may even expand to large-scale ones from a line to a surface. This chain is easier to stand out in the modern society in which the information, transportation and network systems are highly developed.

- **Accumulation**
  Most disasters are produced by factors accumulated over years, for instance, disasters such as earthquake, typhoon or heavy rain all suddenly strike and take people by surprise. However, if precautions can be taken at ordinary times to strengthen the anti-seismic or flood prevention
measures, the disaster degree will be greatly reduced even with sudden attacks. Nevertheless, most of the terrible disasters are caused by years of accumulations. For example, most of the building collapses in mountains are caused by improper soil and water conservation and over-exploitation. The accident happened in Lincoln Residence, Xizhi, Taipei County is a deadly lesson.

- Complexity
The losses caused by disasters may be multiple and widespread and such characteristic can be easily shown in massive earthquakes or floods. For example, earthquakes will cause not only the primary house collapses but also the extending fires and even casualties; and water pipe burst may contaminate the drinking water, massive deaths of people and animals may cause infectious diseases, or the collapse of large numbers of buildings at the same time may lead to a halt in business activities and then turn into the social disasters of prolonged economic depressions.

2.1.2. Disaster management
Although various prevention and management measures are taken to achieve the goal of zero disaster, due to various factors such as human errors or natural phenomena, disasters are inevitable. Therefore, the disaster management procedure can be divided into the following four major steps: disaster reduction, preparation, emergency response and reconstruction.

The purpose of disaster management is to integrate the disaster plans and activities of all departments, so as to expand the applications of disaster preparation and emergency response resources of all departments. In order to effectively support and integrate the disaster management of the governments at all levels and to establish an integrated disaster processing system, it is necessary to introduce disaster management into the diversified target management guidance.

The structure of disaster prevention and response system of Taiwan mainly follows that of Japan, and the concept of the whole structure and plan is comprehensive and complete. However, people found that it failed to work as effectively as the disaster prevention system of Japan after having been tested by many disasters in recent years (Shih, 1998).

The structure of disaster prevention and response system of Taiwan is divided into two major parts of organization and plan, and organization can be divided into three aspects including meeting, emergency management center and disaster emergency response task force, and the disaster prevention and response system is firmly established as three levels such as central government, municipality and county government and township office. Figure 1 shows the whole structure of disaster prevention and response system.
2.1.3. Debris flow disasters in Taiwan

Debris flow refers to the “natural phenomenon” that the fluid generated from the mixture of the materials such as mud, sand, gravel and rocks with water under the influence of gravity flows from high to low along slopes or ditches, but the circumstances of casualties, damages to buildings, bridges and public utilities, and loss of life or properties caused by debris flow is called as debris flow disasters (SWCB, 2004).

- Progress of debris flow survey
  - From 1992 to 1996, the Council of Agriculture completed the first debris flow survey. At that time, there were totally 485 streams with the potential risk of debris flows in Taiwan.
  - After Jiji earthquake in 1999, the SWCB conducted a new survey in 921 reconstruction area, and the streams with the potential risk of debris flow in the reconstruction area increased to 370. After the data of the first survey was added, at that time, there were totally 722 streams with the potential risk of debris flows in Taiwan.
  - From 2001 to 2002, geological conditions were changed due to the successive attacks from Typhoon Toraji and Typhoon Nari, so the SWCB conducted a new survey and completed the second national survey, and there were totally 1420 streams with the potential risk of debris flows.
  - Since 2003, the major debris flow disaster occur frequently during typhoon and heavy rain, that is addition of new potential debris flow stream, this there were totally 1725 streams with potential debris flow in 2018.

- Distribution of streams with the potential risk of debris flows
  The distribution of 1725 streams with the potential risk of debris flows announced by the SWCB so far is shown in Table 1.
Table 1. Distribution of streams with the potential risk of debris flows

| County and city     | Number of debris flows | Percentage | Potential degree | Continuous observation |
|---------------------|------------------------|------------|------------------|------------------------|
|                     |                        |            | High  | Medium | Low  |                  |
| Nantou County       | 262                    | 15.19%     | 118   | 85     | 55   | 4                 |
| Miaoli County       | 80                     | 4.64%      | 30    | 20     | 21   | 9                 |
| Taichung City       | 110                    | 6.38%      | 44    | 39     | 23   | 4                 |
| Changhua County     | 9                      | 0.52%      | 2     | 4      | 2    | 1                 |
| Yunlin County       | 13                     | 0.75%      | 0     | 8      | 5    | 0                 |
| Taoyuan County      | 53                     | 3.07%      | 2     | 16     | 25   | 10                |
| Yilan County        | 150                    | 8.70%      | 13    | 33     | 88   | 16                |
| Taipei City         | 50                     | 2.90%      | 0     | 3      | 19   | 28                |
| Keelung City        | 34                     | 1.97%      | 0     | 8      | 4    | 22                |
| Taipei County       | 235                    | 13.62%     | 52    | 51     | 115  | 17                |
| Taoyuan County      | 87                     | 5.04%      | 30    | 37     | 16   | 4                 |
| Hsinchu County      | 77                     | 4.46%      | 36    | 20     | 17   | 4                 |
| Hualien County      | 169                    | 9.80%      | 41    | 52     | 64   | 12                |
| Tainan County       | 48                     | 2.78%      | 10    | 8      | 29   | 1                 |
| Kaohsiung City      | 111                    | 6.43%      | 58    | 29     | 19   | 5                 |
| Pingtung County     | 71                     | 4.12%      | 18    | 26     | 21   | 6                 |
| Taitung County      | 166                    | 9.62%      | 35    | 49     | 50   | 32                |
| Total               | 1725                   | 100.00%    | 489   | 488    | 573  | 175               |

2.2. Research Materials and Method

The authors of this paper all attended the operation of the central or local disaster prevention in recent years and understood well that communication and coordination are important in disaster prevention promotion. Furthermore, every minute counts for disaster prevention and emergency response, but the pressure from the public and social opinion requires improving the accuracy, which often makes disaster prevention and emergency response at a loss. Therefore, based on the central and local laws, regulations and operation procedures (such as Disaster Prevention and Response Act, Operating Procedures for Debris Flow Disaster Evacuation, and Operating Procedures for Collection and Reporting of Debris Flow Disaster Information) implemented at present, this paper conducted summing-up, self-criticism and analysis and provided suggestions for the relevant director organizations to refer to in studying relevant regulations and measures.

3. Results and Discussion

In recent years, many disasters in Taiwan have caused heavy casualties and losses, which has severely tested the disaster prevention and response system of Taiwan, and the reasons have been investigated to be the lack of communication among all disaster prevention units, the undefined implementation and promotion mode of disaster prevention and response as well as imperfect laws and regulations (Chen, 1998). In order to strengthen the disaster prevention and response function and to ensure the safety of people’s lives and properties, a disaster prevention system shall be established for special
disasters to strengthen the measures related to natural disaster prevention and to effectively carry out disaster rescue and rehabilitation, and educational training and propaganda shall be strengthened to improve the people’s abilities to respond to disasters. A sound disaster prevention plan can help to provide immediate rescue in the event of disasters, so a set of disaster prevention and response system from central to local levels shall be established; and all disaster director organizations shall be responsible for directing, supervising and coordinating all relevant director organizations and local governments to implement all tasks related to disaster prevention and response. The debris flow disaster prevention system is discussed from the following three aspects, such as laws, organizations and operation.

3.1. Discussion from the legal aspect

3.1. 1. Debris Flow Disaster Prevention and Response Operation Plan
The Debris Flow Disaster Prevention and Response Operation Plan is drawn up by the Council of Agriculture to meet the prevention and response needs of natural disasters caused by debris flows, according to Article 19 of the Disaster Prevention and Response Act. the purpose of improving the debris flow disaster prevention and response system, strengthening the measures related to debris flow disaster prevention and response, implementing debris flow disaster reconstruction and promoting debris flow disaster prevention educational training and propaganda, so as to enhance the emergency response abilities in debris flow disaster prevention and response, to mitigate disaster losses and to be used as the basis for developing Regional Disaster Prevention and Response Plan.

3.1. 2. Regional Disaster Prevention and Response Plan for Debris Flow Disaster Operation Plan
Municipal and county execution units of disaster prevention and protection meeting shall develop the sections about debris flow disasters involved in the regional disaster prevention and protection plans, by referring to relevant matters and potential features of regional disasters stated in Part 2 “wind and flood prevention and response measures” and Part 5 “key points of regional disaster prevention and protection plan” of the basic disaster prevention and protection plan as well as the “Debris Flow Disaster Prevention and Response Operation Plan” issued by the Council of Agriculture.

3.1. 3. Operating Procedures for Debris Flow Disaster Evacuation
The debris flow disaster prevention measures can be divided into the strong control measures to prevent the destruction of debris flows from breaking out and the soft prevention measures to provide prior warning on disasters, to inform the people in the dangerous areas of emergency escape and to reduce the losses caused by debris flows (Yu et al., 2001).

Therefore, after Typhoon Haima in 2004, the SWCB convened all central ministries and committees, all county governments and the officials from the townships affected by debris flows develop the Operating Procedures for Debris Flow Disaster Evacuation according to Article 24 of the Disaster Prevention and Response Act as well as Section 4, Chapter 1, Part 2 of the Debris Flow Disaster Prevention and Response Operation Plan. Its contents include 10 items such as establishment of disaster prevention database, evacuation plan development, disaster prevention preparation, warning and monitoring, disaster analysis and study, debris flow warning area announcement, control area definition, inhabitant evacuation and shelter, report on evacuation status, and forecast and warn clearance.

3.1. 4. Debris Flow Disaster Prevention and Evacuation Program
The Debris Flow Disaster Prevention and Evacuation Program is developed according to Article 7 Appendix of the Operating Procedures for Debris Flow Disaster Evacuation, with the purpose of ensuring the safety of inhabitants’ lives, and avoid chaos in debris flow disaster prevention and evacuation and enabling inhabitants to voluntarily take actions of disaster prevention, so as to reduce losses with the assistance of guidance.
During disaster response, the local village chief who understand the actual situations shall act as the commanders to make the best decisions; when it is necessary to help the protected targets to evacuate from the range affected by debris flows, the major tasks shall be carried out by the self-defense forces formed by local communities. Hence, as for the Debris Flow Disaster Prevention and Evacuation Program, the rudiment of the community disaster prevention and response system has been established.

3.2. Discussion from the organizational aspect
In recent years, many disasters in Taiwan have caused heavy casualties and losses, which has severely tested the disaster prevention and response system of Taiwan, and the reasons have been investigated to be the lack of communication among all disaster prevention units, the undefined implementation and promotion mode of disaster prevention and response as well as imperfect laws and regulations (Chen, 1998).
In order to clearly divide the responsibilities of all units, to strengthen the vertical and horizontal ties and integration, and to implement the tasks of disaster prevention and response, the debris flow disaster prevention, protection and response organization includes 4 parts such as level administrative system, debris flow disaster prevention operation regulatory authority, disaster rescue units and independent disaster prevention organizations in local communities. The organization chart of debris flow disaster notification and response is shown in Figure 2.

Figure 2. Organization chart of debris flow disaster notification and response (modified from Chang, 2002).

3.2.1. Three-level administrative system
“The top-down support and disaster protection system and the bottom-up disaster prevention and evacuation system” are the key points and the target to promote debris flow disaster prevention and response at present (Wang, 2002). Disaster prevention organizations are divided into three levels: Disaster Prevention and Response Council, Disaster Emergency Operation Center, Disaster Emergency Action Team. They are briefly described as follows:
- Disaster Prevention and Response Council at all levels
In order to integrate the administrative disaster prevention and response system and to coordinate and contact affairs related to disaster prevention and response, the central to local governments shall hold disaster prevention meeting regularly each year. However, in the disaster prevention and response council and disaster emergency operation center at the township level, the local chiefs usually act as the conveners or commanders. But due to insufficient knowledge of the disaster prevention system operation and lack of crisis awareness, or due to formalism, or due to failure to develop the suitable regional disaster prevention plans according to the actual local features, the local chiefs often supervise, direct and coordinate the tasks in person. As a result, in case of disasters, weak response always leads to failure to implement the disaster prevention and response system (Shih, 1998).

- **Disaster Emergency Operation Center at all levels**
  The disaster emergency operation center is the central nervous system of the disaster prevention and response system and also the most important leader of the whole organizational system (Cheng, 2001). In order to deal with disaster and emergency response issues, governments at all levels shall establish disaster emergency operation center according to the Disaster Prevention and Response Act, and have their own establishment ways and tasks. The disaster protection organization system often operates by top-down orders or mobilizations, but the functions of a truly sound organizational system shall be strengthened from the bottom. In other words, the lower disaster prevention and response organizations shall have the more flexible functions of disaster prevention and response and the more targeted disaster contents and scopes, so as to respond immediately (Yang, 2001).

- **Disaster Emergency Action Team**
  In response to debris flow disasters, in the central government, the Council of Agriculture shall establish the debris flow disaster emergency action team and the chairman of the Council of Agriculture shall act as the convener and assign the commanders. Its tasks are to cooperate to establish the central disaster emergency management center, to assign officers to perform duties and conduct staff work and supervision, to direct, supervise, coordinate and deal with all disaster response measures according to the Debris Flow Disaster Prevention and Response Operation Plan and understand all situations of disasters, to transmit the disaster information immediately, to notify relevant units to respond to the disasters and of disaster protection manpower, to dispatch supplies and to provide supports.

### 3.2.2. Disaster Prevention Operation Regulatory Authority
As the central director organization of the disaster prevention operation regulatory authority, the Council of Agriculture is responsible to direct, supervise and coordinate all administrative organs and public institutions related to debris flow disaster prevention and response to perform all emergency response measures of debris flow disaster prevention and post-disaster reconstruction, and has the disaster emergency response task force for prevention and response.
  Its tasks are collecting disaster condition, dealing with emergency response, monitoring real-time rainfall information released by the Central Weather Bureau and relevant field data announced by the debris flow observatory, and timely issuing the warning notification of debris flows, to provide reference to the disaster emergency operation center at all levels to give evacuation orders.

### 3.2.3. Disaster protection unit
However, it can be found from all previous cases of major debris flow disasters that the rescue of debris flow disasters is to dig victims or to search for the missing. Debris flow disasters are preventable, so we shall think about how to use the primary-level disaster prevention system and the community disaster prevention and response organizations to help the protected targets in the range affected by the streams with debris floe potential to evacuate to the safe refuges before debris flow disasters.
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3.2.4. Community disaster prevention organization

The independent community disaster prevention organizations can not only improve the public awareness of disaster prevention but also achieve the effects of disaster reduction, disaster prevention and instant disaster protection based on the bottom-up spirit.

The disaster prevention communities participate in and learn, with professional and administrative assistance, analyze the problems in community safety and disaster prevention. Their purposes are to equip communities with disaster prevention and response functions and disaster risk management capabilities.

3.3. Self-criticism from the operational aspect

In order to strengthen debris flow disaster management, to establish the response practice mechanisms to be implemented at all stages of the debris flow disaster prevention and response system, to standardize the integration and coordination of disaster prevention and protection operation, and to carry out the promotion of the debris flow disaster prevention and response operation, from disaster prevention education and propaganda, disaster forecast and warn, disaster prevention and evacuation, and disaster condition collection and notification to debris flow extending disasters control and reconstruction, the operation procedure related to debris flow disaster prevention and response is developed (Chen, 2003), as shown in Figure 3.

![Flow chart of the operation procedure related to debris flow disaster prevention and response measures (Chen, 2003)](image.png)

3.3.1. Implementation Guidelines for Debris Flow Disaster Prevention Education and Publicity

Disaster prevention education and propaganda is the beginning of disaster prevention preparation, with the purpose of establishing the correct concept of disaster prevention for the public, improving the awareness of disaster prevention, educating the public to understand disasters, and establishing the correct concept of risk, so as to raise the inhabitants’ crisis awareness, to train inhabitants to save themselves and others, and to improve emergency response abilities.
3.3.2. Operating Procedures for Debris Flow Disaster Evacuation

Its purposes are to work together on preventive measures of regional disaster prevention, avoidance and reduction through drill plans and evacuation drill guidance and review, in order to enhance the public’s ordinary preparation and disaster response abilities and to reduce the threats of disasters to lives and properties, and then to improve the regional disaster prevention and response system and to build a bottom-up concept of disaster prevention and measures of disaster avoidance. The debris flow disaster prevention and evacuation drill is mainly to implement the debris flow disaster prevention and evacuation results, and to combine with the social resources to simulate the situations of debris flow disasters in county governments, township offices, police units, fire control units, health care units, community self-defense forces and among the local people, so as to protect people’s lives and properties and prevent the expansion of disasters if disasters occur or are imminent.

3.3.3. Operating Procedures for Forecasting and Warning of Debris Flow Disasters

Its purposes are to learn the information and signs of debris flows, to study the disaster possibility, to raise the public’s alertness by issuing forecasts, and to issue alarms to evacuate the people in dangerous areas when necessary, so as to achieve the effects of disaster reduction. The implementation procedure is to enable all disaster prevention and response units to smoothly issue forecasts and warns if debris flow disasters occur or are imminent.

Debris flow disasters are preventable, so forecast and warn are very important. At present, the SWCB releases the debris flow disaster forecast and warn according to the weather forecast and rainfall data (once every 10min) provided by the Central Weather Bureau, study the disaster possibility in cooperation with its established debris flow warning baselines (the cumulative rainfall of up to 200 to 350mm), will release the notification of the debris flow warning area to the county and township disaster emergency management centers, and the township disaster emergency management centers will evacuate the protected targets from the areas at the risk of debris flows to refuges.

3.3.4. Operating Procedures for Collection and Reporting of Debris Flow Disaster Information

Its purposes are to establish a perfect notification system and a sound emergency response system, to quickly learn the disaster conditions, and to immediately notify and transmit the disasters with the expectation of collecting the information related to disasters quickly and contacting with all parties for assistance.

At present, the debris flow disasters are mainly reported by the public, notified by village chief and police units and reported by the media, and then the disaster emergency operation center at all levels can get the disaster information. After that, the township disaster emergency operation center assign officers for disaster protection and confirmation, and notify the actual disasters to the county disaster emergency operation center. The county disaster emergency operation center dispatch relief workers and equipment for rescue.

However, in 2004, the instantaneous soil collapse in Tuchang Tribe, Wufeng Township, Hsinchu County caused heavy casualties, and the disaster was not confirmed until two days later because the tribe is located in a remote mountainous area. When the typhoon came, their general external communication system was damaged and only the police notification system could be used for external contacts. Unfortunately, the local police station has been buried at the moment of soil collapse, so that the communication of the tribe was completely cut off and the outside world was unable to know the disaster. Hence, in order to prevent a recurrence of such events, in early 2005, the SWCB entrusted the academic institutions to set up the debris flow volunteer specialist in all areas at the risk of debris flows, hoping to add a notification system from outside the administrative notification system, so as to avoid repeating the embarrassment that the whole external communication channel was completely cut off in case of major disasters.
3.3.5. Operating Procedures for Prevention of Repeated Debris Flow Disasters
Its purpose is to pay special attention to the prevention of repeated debris flow disasters, because the loose geological structure and the large volumes of rainwater arising from earthquakes, typhoons and floods are usually the key to causing debris flow disasters. For debris flow disasters often carry a lot of sands and the immense destructive power often threatens the midstream and downstream people; in addition that the disaster prevention and protection shall be planned and improved at ordinary times, more importantly, the possible extending disasters shall be prevented. After disasters, special efforts shall be made to investigate and control mountains and rivers. The implementation procedure is to prevent the debris flow extending disasters and to strengthen the mountain management.

3.4. Comprehensive self-criticism
In recent years, many natural disasters in Taiwan have caused heavy casualties and losses, which has severely tested the disaster prevention and response system, and the reasons have been investigated to be the lack of communication among all disaster prevention units, the undefined implementation and promotion mode of disaster prevention and response as well as imperfect laws and regulations.

- From the legal aspect
  To draw up a perfect disaster prevention plan and conduct the whole task of disaster response well at any time shall be recognized at the present stage. Appropriate organizations shall be established from the central to the local levels to be responsible for disaster management, implementation of disaster response plans, and disaster prevention & protection education and training, be equipped with advanced rescue equipment and facilities, and strengthen disaster mobilization and command, so as to withstand the sudden disasters.

- From the organizational aspect
  The command and decision-making system for disaster prevention and response have not been fully established. The central and local governments have rapidly set up the disaster emergency operation center, but other relevant units are not active in stationing. It is true that, limited by manpower, experience and finance, the structures of the participant organizations in primary-level township offices are incomplete and formalistic, with the addition of a shortage of equipment, staff and technology, the disaster prevention and response is even more stretched.

- From the operational aspect
  The degrees of disasters are often different due to different space and time, and disaster management shall be sustainable and requires long-term planning and implementation. The tasks at ordinary time and before, during and after disasters are interlinked, so a complete standard disaster prevention and response operation procedure shall be established to avoid the impacts of inadequate preparation at ordinary time on disaster prevention and response. Hence, it is urgent to establish a standard debris flow disaster prevention and response operation procedure.

4. Conclusion
The overall concept of disaster prevention and operation promotion have been considerably improved since the Disaster Prevention and Response Act was issued and implemented on June 30, 2000, there into, depending on planning, coordination and assistance of the SWCB, the debris flow disaster prevention and response are highly effective in a very short time. However, in recent years, many natural disasters have still caused heavy casualties and losses, which has severely tested the disaster prevention and response system. The reason has been investigated to be that debris flow disaster prevention and response is closely related to all operation units and it remains to be one of the tasks of overall disaster prevention and response, but there are various problems in present disaster prevention and response, such as different degrees of knowledge about disasters at all levels, lack of communication, the undefined implementation and promotion mode of disaster prevention and response, and imperfect laws and regulations.
In this paper, the central and local acts, regulations and operation procedures currently implemented are summarized and reviewed, and relevant literature and reports are collected and analyzed to draw the following conclusions:

- In Taiwan, debris flow is one of the disasters often accompanied with typhoons and heavy rain. In order to prevent such disasters, a perfect disaster prevention and response plan shall be developed to complete the overall disaster response at any time.
- Appropriate organizations shall be established from the central to the local levels to be responsible for disaster management, implementation of disaster response plans, and disaster prevention & protection education and training, and be equipped with advanced rescue equipment and facilities, so as to strengthen disaster mobilization and command.
- Although debris flow disasters are preventable, the representativeness of rainfall data and the determination of debris flow warning baselines are still controversial and shall be revised and clarified in the future.
- The disaster prevention and response is stretched because of insufficient manpower, experience and financial resources for disaster prevention and response at the primary level, incomplete structures of the participant organizations, and a serious shortage of equipment, professionals and technology.
- The degrees of disasters are often different due to different space and time. Disaster management shall be sustainable and community staff are often changed, so it is suggested that the central government shall consider the financial burden of local governments and continue to provide subsidies for local governments to strengthen their abilities in disaster prevention and response.

References

[1] Jhiih-Yong Wang, 1997, The Formation Factors and Categories of Earthquake Disaster. Information of the Insurance, 146:40-44.
[2] Shu-Yi Wang, 2002, The System of Debris Flow Disaster Mitigation and Disaster Resistant Community (Master’s Thesis), Department of Soil & Water Conservation, National Chung Hsing University, 78P.
[3] Chang-Tai Ciou, 2000, The Disaster Management Science— Earthquake, Angle Publishing Company, 368P.
[4] Ministry of the Interior, 2000, The Disaster Prevention and Response Method, Republic of China: Committee of Disaster Prevention and Rescue of Ministry of the Interior.
[5] Council of Agriculture, Executive Yuan, 2002, The Debris Flow Disaster Prevention and Rescue Business Plan, Republic of China: Soil and Water Conservation Bureau, Council of Agriculture, Executive Yuan.
[6] Council of Agriculture, Executive Yuan, 2004, The Provisions for the Evacuation of Evacuation and Shelter for the Debris Flow, Republic of China: Soil and Water Conservation Bureau, Council of Agriculture, Executive Yuan.
[7] Soil and Water Conservation Bureau, Council of Agriculture, Executive Yuan, 2003, The Debris Flow Annual Report 2003, Republic of China: Soil and Water Conservation Bureau, Council of Agriculture, Executive Yuan, pp.10-21.
[8] Soil and Water Conservation Bureau, Council of Agriculture, Executive Yuan, 2004, The Debris flow annual report 2004, Republic of China: Soil and Water Conservation Bureau, Council of Agriculture, Executive Yuan, pp.1-13.
[9] Wei-Yi Li, 1995, Review and Improvement of Japanese Disaster Prevention Policy – Learning from the Great Hanshin Earthquake, Taiwan Architect, 21(3):111-114.
[10] Hsiao-Mei Li, 2002, The Crisis Management Research on the Natural Disaster-the Case Analysis of Typhoon Xangsane in Keelung (Master’s Thesis), Master for Eminent Public Administrators, National Chengchi University, 229P.

[11] Kuang-Shiung Wu, 1997, The System of Disaster Management In SerZ Island (Master’s Thesis), Graduate Institute of National Policy and Public Affairs, National Chung Hsing University, 126P.

[12] Sheng-De Lin, 2000, The Establishment of Emergency Disaster Management Mechanism (Master’s Thesis), Graduate Institute of Public Administration, National Chengchi University, 153P.

[13] Ruenn-Rong Lin, 2005, Public Servant Attitude Research of Township Office Government Disaster Prevention and Dealing with Emergency for the Debris Flow in Taitung Area (Master’s Thesis), Graduate Institute of Forestry, National Pingtung University of Science and Technology, 104P.

[14] Bang-Jhui Shih, 1998, Review and Recommendation of the Disaster Prevention System, The 2nd International Disaster Prevention Conference Collected Papers, pp.75-90.

[15] Kai-Lien Chen, 1998, Analysis on The Emergency Response Action of Local Governments in Disaster Prevention and Mitigation, -A Case Study of the Disaster which caused by Wenney Typhoon in Ling-ken Community (Master’s Thesis), Graduate Institute of Building and Planning, National Taiwan University, 87P.

[16] Shu-Cyun Chen, 2003, Compilation and Teaching Training of Manuals and Teaching Materials Related to the Disaster Prevention and Rescue of the Debris Flow, Republic of China: Research and Result Report Authorized by Soil and Water Conservation Bureau, Council of Agriculture, Executive Yuan, pp.2-9.

[17] Te-Kuei Chen, 2002, A Study on Operation Mechanism of the Third Level Local Governments in Disaster Prevention and Protection System of Taiwan (Master’s Thesis), Central Police University Graduate Institute of Fire Science, 114P.

[18] Sing-Jyuan Liang, 2001, A Study of Emergency Response System Reconstruction--A Case of System Operation in 921 Earthquake (Master’s Thesis), Graduate Institute of Public Policy and Administration, National Chi Nan University, 137P.

[19] Yong-Nian Yang, 2001, The Establishment of A Disaster Rescue Organization System with Local Government as the Main Body – The Comparison between the 921 earthquake and the two sides of the Bazhang River, Republic of China: Police Science Quarterly, 32(3):245-268.

[20] Jin-Gu Chang, 2002, The Status and Future of the Debris Flow Disaster Prevention and Rescue Business, Republic of China: The Debris Flow Prevention and Response Strategies Conference Collected Papers, pp.9-14.

[21] Yu-Chung Tsai, 1999, A Study of Disaster Management in Connection with the Planning of Disaster Prevention of Local Governments (City, Town, and Villages) (Master’s Thesis), Graduate Institute of Civil and Disaster Prevention Engineering, National Taipei University of Technology, 133P.

[22] Gang Jhao, 1998, Disaster Crisis Management, Republic of China: Research Report, 43(2):50-66.