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THE CONSTRUCTION OF MONITORING AND WARNING SYSTEM FOR FLASH FLOOD MANAGEMENT IN CHINA

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Abstract: Flash floods often happen suddenly with little warning and also likely to induce secondary disasters such as landslides and debris flows. The work of flash flood defense is full of challenge because of the complex process of flash flood formation. In recent decades, flash flood disasters are increasingly witnessed in China due to the imbalance between rapid urbanization and outdated structural and non-structural measures. Chinese government, recognizing the problems, has directed its attention to more inputs on the study of flash flood defense. After some endeavors in recent years, a set of non-structural measures on flash flood defense has been established featuring Chinese characteristics. In these measures, monitoring and warning system is a core. This paper initiates with a general introduction of basic situation of flash flood disasters in China and follows with a detailed discussion of the monitoring and warning system. This work would provide merits and references to other countries and regions facing flash flood problems.

Keywords: flash flood; non-structural measures; monitoring; warning; China

INTRODUCTION

The flash floods often occur after heavy local rainfalls, especially in small mountainous basins. They are characterized by a quick rise of water levels causing a threat to the lives of those exposed. Flash floods often induce occurrence of landslides and debris flows leading to severe damages and casualties in local areas. At the same time, the forecasting of flash flood is full of challenges because of its complexity. Flash flood prevention is a worldwide problem many countries are facing.

Many developed countries carried out the flash flood prevention works earlier. For example, in 1970s, the number of deaths caused by flash flood disasters has been the most among all natural disasters related to severe weather condition in the United States. In order to reduce casualties and property losses due to flash floods, the U.S. government developed a national program for flash flood early warning and simultaneously carried out the works of flash flood forecasting and pre-warning[1]. The EU set up a special project called EU-FLASH to study the new technology for the pre-warning of flash flood [2].

Compared to western developed countries, the works of flash flood defense in China started relatively late affected by national conditions. In recent years, flood control standards of major rivers have been significantly improved; however, flood problems of medium and small

rivers, especially the problems of flash flood hazard in the small mountainous watershed, have become more and more serious. Therefore, Chinese government has increased investment in the flash flood prevention and control work according to the serious conditions and explored a set of effective non-structural measures in recent years.

SITUATIONS Of FLASH FLOOD PREVENTION AND CONTROL IN CHINA

Mountainous and hilly areas account for 2/3 of the land area in China, among which the prevention and control area of flash flood disaster reaches to 4.63 million km2, involving in the population of 560 million. According to the statistic data, from 2004 to 2011, the proportion of death toll caused by flash flood disaster to that caused by all flood disasters in China is shown in Fig. 1. It can be seen that in the deaths caused by all kinds of floods, the proportion of deaths caused by flash flood is the highest and has an increasing trend. Therefore it is imperative to strengthen the work of flash flood prevention and control.

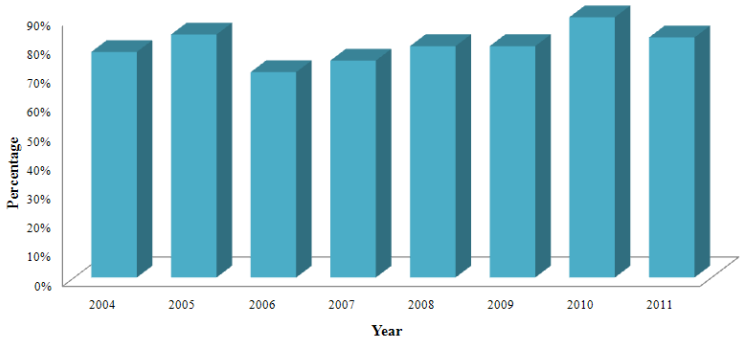

Figure 1. Proportion of deaths caused by flash flood disasters compared to those caused by all flood disasters in China

Chinese government has been directing substaintial attention to the problems of flash flood. In October 2006, the State Council officially approved the National Flash Flood Prevention and Control Planning, Covering 2058 counties in 29 provinces within China. In February 2009, the Chinese government set special funds in the budget for pilot development of non-structural measures on the prevention and control of flash flood disaster in 103 pilot counties in 29 provinces (autonomous regions and municipalities). On the basis of the pilot project, in November 2010, the Ministry of Water Resources, together with the Ministry of Finance, the Ministry of Land and Resources and China Meteorological Administrative officially initiated the programme of non-structural measures development for the prevention and control of flash flood disaster at county level nationwide. The major content of the non-structural measures construction for flash flood disaster prevention is as follows: Comprehensive investigation of flash flood disaster, Risk assessment and risk area delineation, determination of warning indicators, such as critical rainfall or water level, construction of monitoring equipments, such as automatic rainfall and water level monitoring instruments, construction of warning system platform at county level, equip with necessary warning facilities, establish a community-based defense system for disaster prevention, etc. The mentioned contents are interrelated, and rely on each other, which together form the non-structural measures system for flash flood control. More detailed information pertaining to the matter is described in reference [3].

MONITORING AND WARNING SYSTEM

Among flash flood management works, construction of monitoring and warning system is the essential part of the project, which consists of monitoring equipments, warning platform at county level and warning facilities. The values of rainfall and water level measured by the monitoring equipments are delivered to the warning platform in real time. At the same time, the monitoring information of weather department and land and resources department is also delivered to the platform. If the cumulative rain-fall or real-time water level exceeds the preset threshold values, the warning platform will automatically notify the association officials, who will discuss and confirm the actual situation instantly. Once the information is confirmed, warning information is transferred to the people in the affected locations through radio broadcast or telephone, fax, cell phone, etc. The detailed warning process is depicted in Figure 2.

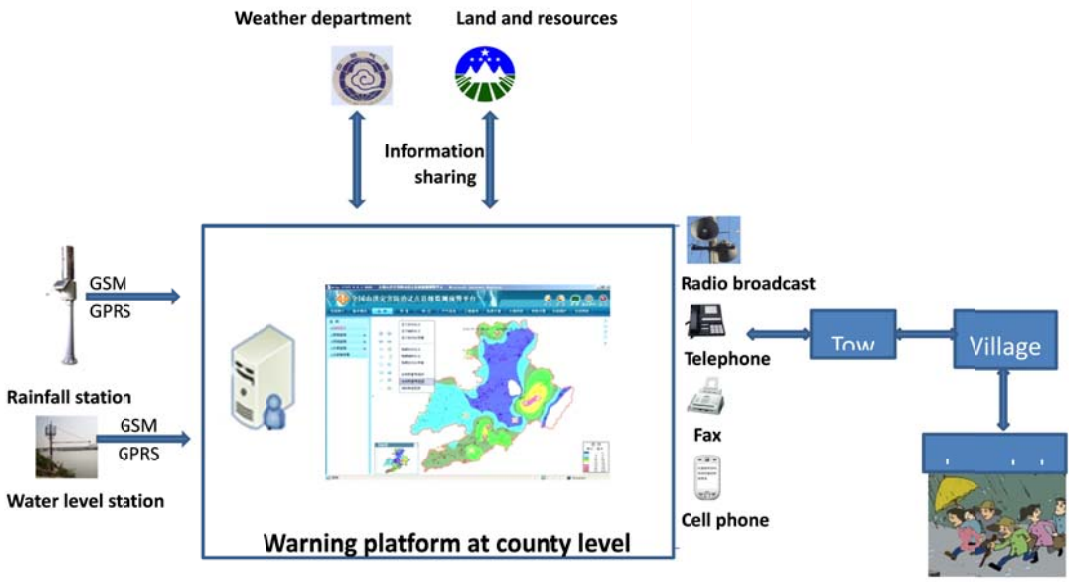

Figure 2. Warning process of flash flood defense

1.1 Monitoring equipment

Automatic monitoring equipments mainly refer to the automatic rain gage stations and stream gage stations located in the project areas of non-structural measures construction for flash flood control. At present, most of the automatic rain gage stations adopt the tipping bucket rain sensors and mainly include the following items: rain sensors, remote terminal units (RTU), communication modules, solar panels, charge controllers and batteries, etc, which is shown in Figure 3.

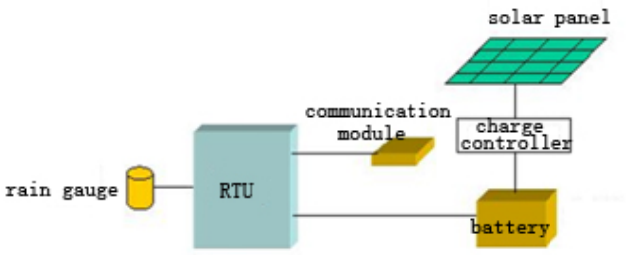

Figure 3. Schematic of automatic rainfall station

According to their shape, the rain gage stations can be divided into integrated stations and split stations. For the so-called split rainfall stations, the rainfall sensors and the transmission equipments (RTU, communication modules) are separated. On the contrary, the integrated rainfall stations integrate all the parts together, which ease of installation and construction, meanwhile reducing construction costs.

Automatic stream gage stations are composed of water level sensors, RTUs, communication modules, scholar panel, charge controller and batteries etc. Water level sensors can be divided into two categories: contact sensors and non-contact sensors. Contact water level sensors can be divided into pressure type and float type, and non-contact water level sensors are mainly two types: ultrasonic and radar.

Various types of water level sensors have advantages and disadvantages. The pressure type water level sensor does not require the construction of monitoring well, as long as the sensor is placed in water body. However, the pressure balance pipe of pressure type sensors is easily blocked because of condensation; sensors are susceptible to siltation in the sediment and are likely to expose and easy to be damaged when the water level draws down. Ultrasonic type water level sensors are sensitive to the temperature and humidity. Radar type water level sensors have good stability and accuracy; however, the price is relatively high. Float type water level sensors are inexpoensive, reliable, and free from the influence of the water body and surrounding environment; therefore, they are widely used in China. The inadequacy of float type sensors is that the water level wells with high project cost are needed.

Automatic rain gage stations or automatic stream gage stations transfer the data to the warning platform through the commonly used wireless transmission, such as GSM/GPRS, ultra-short wave (UHF/VHF) and Beidou satellite. The existing public communication resources should be surveyed clearly and be made full use of. For the areas covered by public network, the GSM/GPRS method is selected to use. For the areas not covered by public network, the Beidou satellite or ultra-short wave method is adopted in general. For the very important stations, two different communication methods can be used simultaneously to achieve mutual backup and automatic switching, to ensure the stability of the data transmission.

1.2 Warning platform

According to the requirements of flash flood warning decision-making, the technical means, such as communications, GIS, computer networks, video, databases etc, are used to develop the warning platform for flash flood control at county level. The modules of information collection, information services and warning information release etc are included in the warning platforms which are developed in the B/S and C/S structures. The monitoring data of rainfall and water level are transmitted to the platform by the wireless method, the platform will manage the data in real time and store the data in the database. The data from Meteorology Department and Land and Resource Department are also transmitted to the platform, and they are also stored in the database after treatment complying with the uniform format.

When the values of water level or rainfall reach the predetermined critical threshold value, the icon flashes with warning beep is appeared in the corresponding township or a small watershed on the map of the platform. The staff on duty will check the data in the first time and then warning level and scope is determined after consultation with the flood control headquarters. The warning message will be released by a variety of ways, and the feedback information of the responsible persons will be also received simultaneously.

In addition to the warning platform at county level, the platforms at the municipal level, provincial level and country level are also developed in order to share the information timely and improve the information level for flash flood control.

1.3 Warning equipment

The departments of Flood Control Headquarters at county level release the warning message to each town through SMS platform, telephone, fax, radio broadcast, television or other forms. In case of emergency, the warning message can be released to each village directly. When the town governments receive the warning message, they will release the data to villages or groups via telephone, fax, radio broadcast and SMS etc. Country or groups are equipped with necessary warning facilities. In addition to traditional ways, such as a certain amount of hand cranking alarms, gongs and whistlse, radio broadcasting is also needed in some important areas. The radio broadcasingt uses a combination method of GPRS/GSM public network and wireless FM technology to realize the warning information transfer to the end nodes.

CONCLUSION

Flash flood disasters occur frequently over a broad area in mainland China. Due to the features of sudden occurrence and severe damages, as well as difficulty in pre-warning and prevention, flash flood leads to significant damages on personnel livs and safety, infrastructure and eco-environment. The Chinese government attaches great importance to flash flood disaster prevention, and the non-structural construction project for flash flood control have been carried out in 2058 counties comprehensively.

Since May of 2011, Hunan Province has been hit by two heavy rainstorms. Anhua County, Pingjiang County and Yuanling County of Hunan Province located in the center of rainstorms utilized the monitoring and warning systems for flash flood control to release more than 1300 warning messages. As a result, approximately 12800 people escaped to the safe place timely. It proves the systems can effectively reduce the death number caused by flash flood, and they are a set of effective technical system for the prevention and control of flash flood disaster. It can be predicted that the capacities on preventing and defending of flash flood disasters will be further improved comprehensively with the implementation of the non-structural measures for flash flood control.

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REFERENCES

[1] H M Mogil, J C Monro, H S Groper. NWS’s flash flood warning and disaster preparedness programs. National Weather Service, NOAA, 1978, 59 (6):690-699.

[2] C Price, Y Yair, A Mugnai, K Lagouvardos, M Llasat, S Michaelides. FLASH: a new EU project related to Mediterranean flash floods. Geophysical research abstracts, 2007.

[3] D Y Sun, D W Zhang, X T Cheng. Framework of national non-structural measures for flash flood disaster prevention in China. Water, 2012,4:272-282.