Problems of Flood and Drought in a Typical Peak Cluster Depression Karst Area (SW China)

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Abstract Flood and drought are typical hazards in karst areas, especially in the peak cluster depression karst area of Southwest China. In this study, some karst areas prone to flooding and drought area are mentioned; and the flooding and drought problem in Mumei subterranean river system in Yunnan Province is discussed in detail. There are multiple reasons for the problems, including uneven precipitation in a year, a complicated underground river system, intensive human engineering activities, deforestation and unreasonable land use. Some solutions to the karst flood and drought cycles could be returning farmland to forest and some engineering measures. Because flood and drought threaten the limited land resources and also human life, they should have more attention.

1 Introduction

Flood and drought are the most outstanding natural hazards in the world. People have paid much attention to these (Jones 1990; Liu et al. 2005; Singh 2001). But most of studies focused on non-karst areas. In China, flooding in karst terranes is frequent, as is drought. Together, these natural hazards cause damage to property, businesses and life. In the karst mountain areas, besides line distribution of surface rivers, another landform which is easily impacted is a blind valley, or a trough valley in long strip distribution and depression which can be either erose (jagged) or nearly rotundity. This negative landform acts as a separate hydro-unit which collects

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surface water. Pooling of water enters to the underground through sinkholes developed in depressions, then discharges to an adjacent river via the conduit. Flooding occurs when a sinkhole's drainage capacity is not adequate to transfer the storm water runoff to the underground. Because depressions contain the most concentrated areas of local people and farmland distribution, but are rather flood-prone, the importance of this issue can not be underestimated. Floods can lead to the formation of cover-collapse sinkholes and groundwater pollution. Human beings' activities may increase the runoff rate to a sinkhole so that the rate of recharge exceeds the acceptance capacity of the sinkhole drain (Zhou 2007).

Drought is another hazard in karst areas. As a result of extensive distribution of karst surface features, such as karst windows and sinkholes, rain water usually discharges the underground system quickly. And because the infiltration coefficient is large, rain water easily leaks underground. So in dry seasons, it is difficult to find drinking and domestic water for the local people. They obtain water from far away by carrying containers on their shoulders or by horse. When the land resources are too dry, the people can not feed themselves, which contributes to reoccuring poverty.

2 Flood and Drought in Karst Area of Southwest China

Flood and drought are serious phenomena in the karst area of Southwest China, especially in the peak cluster area in Guizhou Province, Yunan Province and Guangxi Zhuang Autonomous Region (Li and Wang 2001). For example, about 94% of the areas are occupied by carbonate rocks in the east Mashan County, Guangxi Autonomous Region (Li et al. 2008). The karst depression and valley are well developed and flooding occurs quite often. According to the survey, there are more than 170 depressions with flooding, and the area frequently submerged by water is 1400 ha, accounting for 74% of the 189 thousand ha. Banwen subterranean river system. One of the largest underground rivers, Hongshuihe River in Guangxi, is often flooded. One flooding event in 1993 resulted in a flooded area of 12.35 km^2 and affected 6671 farmers, with a direct economic loss of more than 700 million yuan (Xie and Pei 2002). Drought is also an outstanding problem. According to statistics in 1997, Yunnan, Guizhou, Guangxi Province with 800 million people has severe drinking water problems.

3 Flood and Drought in Mumei Subterranean River System

The Mumei subterranean stream is situated in the boundary of Guangnan and Funing county, Yunnan province, China. The catchment covers an area of 308 km^2. The discharge point of Mumei subterranean stream is located in Mumei village, Babao town. The Mumei catchment is characterized by a humid subtropical climate, and is heavily influenced by the monsoon regime of Southwest China. Two distinct seasons can be observed in the area: the dry winter lasting from November to April, and the rainy summer from May to October. The yearly mean temperature is 17 °C in the study area, the mean annual precipitation is 1410 mm.

The hazards of flood and drought are frequent, occuring seasonally almost every year. As everybody know, groundwater in karst is plentiful, whilst there is a shortage of surface water. The subterranean river system has characteristics of surface river and underground river alternation. When the conduit can not discharge the runoff timely, groundwater will backflow from karst windows or resurge from portals connected with the conduit. Although there are usually sinkhole in the depression which can discharge the water, the depression will submerge due to the rate of backflow being larger than that of discharge. The submerge time is related to rain features such as intensity or duration. Table 1 shows the submerge time and depth of some typical depressions in the Mumei subterranean river system.

Table 1 Submerged areas and depth of some typical flood depressions

No.	Flooding area (m^2)	Flooding duration	Water depth (m)
1	32.66×10^3	May to November	20
2	367.32×10^3	submerging all the year	10
3	390.45×10^3	April to August each year	5
4	102.94×10^3	one month after heavy rain	10
5	188.72×10^3	May to August each year	15
6	100.91×10^3	several months in a year	2
7	75.80×10^3	several times each year, 7–15 days once	12
8	8.83×10^3	April to November	10
9	31.30×10^3	May to August each year	40
10	75.44×10^3	May to August each year	10

Drought always occurs in dry seasons. All of water tanks and epikarst springs are dry. People have to get water from karst windows which still have water. Because the transportation is poor, it may take a day to get water from the farthest water sources. In some place a karst window will supply 40 villages from the surrounding area. Drought brings to reduction of output of crops. Many people can only live by relying on almsgiving.

4 Cause of Flood and Drought

Meteorological Factors. Although there is plenty of rain in the Mumei subterranean river drainage area, it is uneven. About 83% of precipitation is distributed between May and October, and only 17% falls in the dry fall and winter season. The amount of precipitation has a tendency to decrease from south to north spatially.

Hydrogeological Conditions. The Mumei subterranean stream lies in the slope area of Yunnan-Guizhou altiplano and Guangxi plain, with highland parts in the west and south, and with lowland in the east and north. The highest peak has an altitude of 1,851 m (a.s.l.). The altitude of the Mumei discharge point is 1150 m. Surface water is normally absent in the study area. Only several intermittent streams emerge in the mid-section or in the downstream part of the subterranean water-courses. The system has a complex conduit network. Four tributary conduits (I, II, III and IV) of the Mumei subterranean stream have been identified, which show a parallel channeling in the catchment. Water in conduit I, II, and III is mainly discharged by the Mumei outlet. In the rainy season the water is discharged at Jiaba intermittent stream synchronously (Guo et al. 2009). The average discharge of Mumei subterranean stream is 5.37 m^3/s.

Jiaba depression is one of the easily waterlogged depressions in the system. Because it is a converged area for several conduits with plenty of water outlets, it is very important to understand the groundwater status of it when the distribution of groundwater in the basin is discussed. Jiaba depression is divided into two parts, namely Shangba and Xiaba. Jiaba village lies in Shangba. From south to north along Shangba depression, there are eight water points including No. 1 to No. 8. All of water gathers into the open flow, and it flows to the north continually. It accepts three water points when passing Xiaba depression, which is No. 9, No. 10 and No. 11.

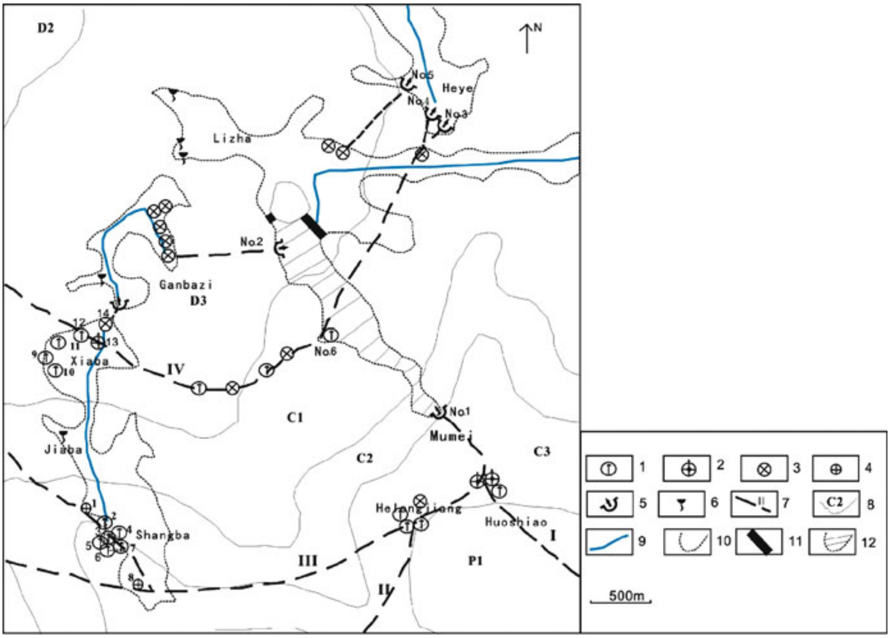

Fig. 1 Groundwater distribution in Jiaba-Mumei. 1. spill hole; 2. karst window; 3. sinkhole; 4. swallow-spill hole; 5. underground river outlet; 6. seasonal spring; 7. conduit; 8. stratum boundary; 9. surface water; 10. karst depression; 11 reservoir dam; 12. Babao reservoir

Then it turns into groundwater between Jiaba and Ganbazi depression. After that it outcrops in Ganbazi depression, then it enters into ground in the other side of the depression. Finally it discharges at No. 2 of Mumei outlet (Fig. 1). The discharge, water chemistry and physical properties were monitored to better understand the relationship among them. They showed that there were some similar features in water chemistry of water point in Shangba, and those in Xiaba too. But there are different character between Shangba and Xiaba, indicating they have different sources.

Another question is how both muddy water and clear water discharge happens. Some of water points in Jiaba have clear water, while some emerge as muddy water. Two water points outcrop closely with different water colors, what is the reason? The possible cause is that they belonging to different sources, or maybe some independence layer in one underground river system receives more direct runoff. Upward layers are closer to ground surface, and with the characteristics of surface and underground river interphased, groundwater may take a large bedload of sediment. Lower layers further away from surface have less probability of pollution. For example, water in Shangba is clear, and has fish, indicating water source is far and it is a real groundwater in saturated zone. Water in Dapingzi (No. 6, No. 7) has a short duration time, with large seasonal variation, and is often muddy, indicating it is groundwater in seasonal variation zone. Water systems in Shangba and Dapingzi have no contact relationship although their discharge points are closely positioned, further showing the characteristic of heterogeneity of karst development in the vertical direction.

Human Factors. Intensive human engineering activities, deforestation and unreasonable land use, are the direct cause of serious damage to the ecological environment, which leads to vegetation reduction, enhanced surface runoff, and serious soil erosion. The formation of the mountain torrents of rainfall brings mud sands as waste deposition, with silting in the mouth of sinkhole, resulting in reduction of flow cross sections, lowered discharge capacity of conduits, and then flooding. In recent years, the affection of ecological destruction has gradually increased, and durations of floods are more prolonged. The rock desertification in Mumei underground river basin is serious. According to an investigation from 2003 to 2004, out of 308 km^2 in Mumei, there are 231.9 km^2 of moderate and severe rock desertification, 47.8 km^2 of mild degree rock desertification, accounting for 75.2% and 15.5% of the total area respectively (Jiang et al. 2005).

5 Solutions to Karst Flood and Drought

Solutions to karst flooding requires knowledge of the unique characteristics of karst systems and regulatory control of human being's activities in sinkhole areas. There is an intimate relation between surface water and groundwater in karst aquifers. A flood-prone depression is not an isolated geologic feature, rather a source or sink that connects to the whole karst system.

Returning Farmland to Forest. Vegetation can conserve water. It reduces surface water runoff and water from blind valley and depressions. Returning farmland to forests or grasslands work should be speeded up in the steep slopes above 25°. Through returning farmland to forests or grasslands, karst source material which leads to pipeline blockage can be reduced. Resultingly, the epikarst springs will retain more usable water, which will be a good measure in solving the problems of drought.

Engineering Measures. Before the implementation of flood disaster management, hydrogeology investigations and evaluations should be done. Delineation of the karst basin may require a comprehensive investigation using specialized techniques such as tracer tests, geo- or hydrogeo-physics, and long-term groundwater monitoring. After systematic analysis of the causes of karst floods, effective and economical measures may be proposed. Expanding the groundwater import, such as creating additional sinkholes or swallow holes by artificial blasting, may accelerate the discharge rate in depressions. The most favorable topography and geological conditions of the terrain will need to be selected for excavating drainage tunnels. Adjusting the water flow between different drainage areas can also control or alleviate the flooding. For example, Tingzhai karst blind valley in Xianfeng county, Hubei Province, China, was made to adjust the water to Tangyan river drainage area by excavating a drainage tunnel. Its creation solved the long-term problem of devastating flood (Su et al. 2008). For the Mumei system, flood water can be collected in a selcted depression, which will alleviate water content pressure of other depressions. If a mini-type reservoir can be built in the west of the drainage area to collect allogenic water, it will have two good effects, one is reducing flood flow, the second is intercepting mud and sand to better protect water quality for irrigation.

6 Conclusions

Flood and drought are key environmental problems in karst areas of southwest China, which results from water imbalance between recharge and discharge. The unique geology and hydrology background of karst determinate this. Human being's activities further increase the probability and severity of flood and drought in some areas. Some measures such as engineering projects often can be used to change this situation, but they should be based on understanding the characteristics of karst aquifers. Locations for the incident depressions to control flooding should not be considered as single independent areas; they should consider the whole karst system as part of the scope of work.

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