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Flood control and management for the transitional Huaihe River in China

WANG Kai[a,*], CHU Deyi[b], YANG Zhaohui[b]

[a]*Bureau of Hydrology of Huaihe River Commission, , Bengbu 233001,China*
[b] *Huaihe River Commission of Ministry of Water Resources, , Bengbu 233001,China*

Abstract

The Huaihe River Basin is a transitional river located in the transitional climate zone in China, and it has been frequently hit by big floods and suffered from flood disasters. Flood control and management of the areas are of vital importance of the Huaihe River Basin in its social and economic development. In this paper, pioneer works of summarizing the flood management has been done for the Huaihe River in China. It firstly introduces flood and flood disasters of the River basin, Moreover, the paper summarizes achievements in flood control and management. Furthermore, it discusses experiences and enlightenment in flood control and management and draws conclusions for the research.

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Keywords: flood management; flood control; the Huaihe River; transitional river

1. Introduction

The Huaihe River Basin is located in the transitional climate zone in China, which is known as the transitional river of China(Qian, 1992). It has been frequently hit by big floods and suffered from flood disasters, and the frequency of disaster is one time in 10 years roughly (HRC 1992; HRC 2006;HRC 2010a, 2010b). The critical issue is that about 2/3 of the middle and downstream of the major rivers are prone to floods, where is inhabited 13% of people of China, 12% of cultivated land area of China, 1/6 of food product of China, and 1/4 the food as commodity of China. Flood

* Corresponding author.
E-mail address: 43604772@qq.com

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control and management of the areas are of vital importance of the Huaihe River Basin in its social and economic development. Strenuous efforts have been made in fighting against floods, however, there is still a long way to go.

The paper is organized as follows: Section 2 introduces the study area of the Huaihe River basin; Section 3 presents floods and flood disasters of the River basin. Section 4 concerns achievements in flood control. Section 5 discusses experiences and enlightenment in flood control and management. Section 6 draws conclusions for the research.

2. Geographical Features

The Huaihe River Basin is located in the east China, with the Yellow River in the north and the Yangtze River in the south, and its catchment area is 270,000 square kilometers. Starting in the Tongbai Mountains of Henan province, flows from west to east, it has its upper reaches in Henan and Hubei Provinces, middle reaches in Anhui Province, and lower reaches in Jiangsu Province. Its trunk is about 1,000 kilometers long. The Huaihe River is divided into three sections: the upper reaches flow from the source to the mouth of Honghe River between Henan and Anhui provinces, with a total length of 360 kilometers; the middle reaches, from Honghe River to Hongze Lake, are 490 kilometers in length; and the lower reaches, with a total length of 150 kilometers. In the lower part of the Huaihe River Basin, there are four major outlets for floods, i.e. the Flood-way to the Yangtze River, the Floodway to the Yellow Sea, the Northern Jiangsu Irrigation Canal to the Yellow Sea, and diversion waterway from Huaihe River to new Yi River, then to the Yellow Sea.

The average annual precipitation of basin is about 883mm, of which 50%~80% precipitation is concentrated in the rainy season (June-September). Located in the north-south climate transition zone, with uneven spatial-temporal distribution of precipitation and the capture of the headwaters of Yellow river into the Huaihe River, Huaihe River flood disasters occurred very frequently. The basin-wide floods hit the Huaihe River in 2003 and 2007 of this century.

Due to the frequent flood disasters in the Huaihe River Basin, the State attaches great importance to harness of the Huaihe River. For nearly half a century, many flood control buildings has built, including 38 large reservoirs, 21 flood storage areas, 1716km embankment of level I, diversion rivers such as Huaihongxinhe canal, Ruhaishuidao canal (floodway to the sea), as well as large lakes such as Hongze Lake. In addition, non-structural measures such as communication systems, hydrological forecasting system, the remote monitoring system of flood control works, remote consultation system and flood control system have also been built. All these measures have played a positive role in the defense of floods.

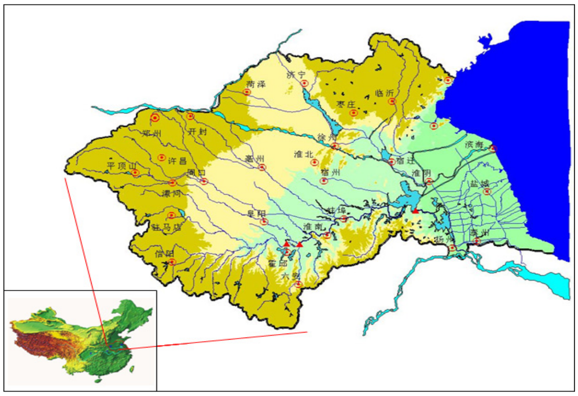

Fig.1 Location Map of the study area

3. Floods and Flood Disasters

According to statistics, during the 2256 years from 246 B.C. to 2010, totally 1946 flood and drought disasters had occurred in the Huaihe River Basin, among which, number of flood disaster is 1008 while number of drought disaster is 938, disaster almost happens every year. Number of basin-wide flood and drought disasters is 340 (number of flood disaster is 268 and number of drought disaster is 72), and frequency is approximately once every 6.6 years on average. From the diversion (capture) of the Yellow river into the Huaihe River in 1194, flood disasters became more frequently. From 13 century to 19 century there were 165 flood and drought disasters occurred in the HRB, one time in every 4.2 years on average.

Due to the unique natural features of the HRB, in recent years, large-area flood and drought disasters happen frequently and local flood and drought disasters happen annually. According to statistics, from 1949 to 2008, average annual flood disaster area of the HRB is 25.29 million mu, among which, number of annual flood disaster area above 30 million mu reaches to 15 accounting for 25% of the number of statistical years; number of annual flood disaster area higher than 40 million mu reaches to 11 accounting for 18.3% of the number of statistical years; number of annual flood disaster area above 50 million mu reaches to 8 accounting for 13.3% of the number of statistical years.

Table 1. The maximum flood discharge for major rivers in HRB(Unit m3/s)

River	**Station**	**area (km^2)**	**observed**	
			Discharge	**Year**
Huaihe mainstream	Wangjiaba	30630	17600	1968
Huaihe mainstream	Lutaizi	88630	12700	1954
Huaihe mainstream	Bengbu	121330	11600	1954
Huaihe mainstream	Sanhe	158160	10700	1954
Shihe southern major tributary	Jiangjiaji	5930	4550	1968
Pihe southern major tributary	Hengpaitou	4370	6420	1969
Shayinghe northern major tributary	Fuyang	36606	3310	1965
Guohe northern major tributary	Mengcheng	15475	2080	1963
Yihe major tributary	Linyi	10315	15400	1957
Shuhe major tributary	Daguanzhuang	4529	4250	1974

Table 2. Statistics of flood disasters in 1991, 2003 and 2007 in HRB

Year	Disaster Area (10^4 hm^2)	Affected people (10^4)	Destroyed houses (10^4)	Immigrant (10^4)	direct economic losses(10^4 RMB)
1991	401.6	5423	196	226.1	339.6
2003	259.1	3730	77	207	286
2007	158.7	2472	11.53	80.9	155.2

4. achievements in Flood Control

Since the foundation of the new China, for the purpose of effectively reacting to flood and drought disasters and reducing losses, under the guidance of “jointly considering storage and discharge of floodwater” principle for harnessing the Huaihe River, with 60-year continuous river harness, tremendous achievements have been made in engineering construction of the Huaihe River harness. Laws and regulations i.e. "Flood Control Law of The People's Republic of China", "Flood Control Regulation of The People's Republic of China", "Drought relief regulation of The People's Republic of China", and "Administrative regulation for flood storage and detention areas", have been established, and basin flood prevention and dispatching programs have been improved, all these play a vital role in reducing flood and drought disasters.

4.1. Flood and water-logging control ability has been strengthened, and disaster reduction mechanism has been established

(1) Structural measures

About 5700 reservoirs have been constructed, with a total storage capacity of 30 billion m^3, and 38 of them are large reservoirs, with a total storage capacity of 20 billion m^3 and a flood control capacity of 62 billion m^3. Seventeen flood detention areas and large lakes for controlling flood have been constructed, with a total storage capacity of 35.9 billion m^3 and a flood storage capacity of 26.3 billion m^3. Figure 2 illustrates the major structures in the Huaihe river basin.

Artificial channels have been constructed with a length of 2100 km. Different types of dikes have been constructed with a length of 50,000 km, and the length of key dike is 11,000 km. River channel discharge capacity has been significantly promoted, channel discharge capacity of the upper mainstream has been enhanced from 2000m^3/s to 7000m^3/s, channel discharge capacity of the middle mainstream has been enhanced from 5000m^3/s-7000m^3/s to 7000m^3/s-13000m^3/s, and channel discharge capacity of the middle mainstream has been enhanced from 8000m^3/s to 18270m^3/s.

At present, flood control standard of the mainstream in the upstream is once-10-years, and flood control standards of the key flood protection areas and important cities in the middle and lower reaches were promoted to once-100-years. Flood control standards of the important tributaries can reach to once-20-years to once-50-years.

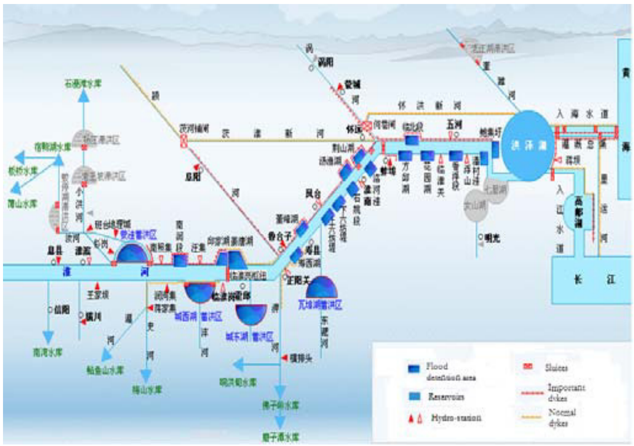

Fig. 2. Simplification of major water conservancy projects of the Huaihe River

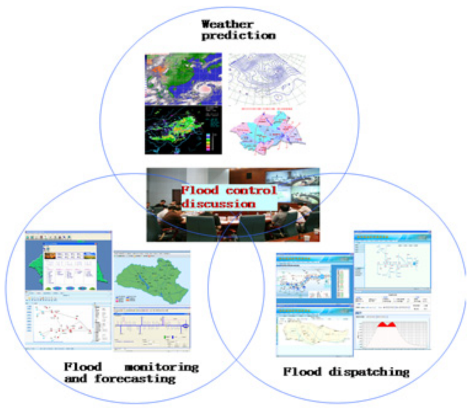

Fig. 2. Integrated system of flood monitoring, forecasting and warning system

(2) Non-structural measures

So far non-structural measures of flood prevention regulation command system jointly form system mechanism for flood prevention and disaster reduction.

(a) The flood monitoring system

Hydrological information and flood forecasting are the basis of flood fighting during rainy season. As of 2014, there were 329 hydrological stations (measurement of rainfall, water level and discharge), 220 gauge stations and 2,488 rain gauges, 1,489 water quality monitoring stations, 324 moisture stations and 3,024 ground water monitoring stations which constitute the hydrological network and also the flooding monitoring system over the Huaihe River Basin. Part of the above stations (1,250) are mandated to report/release hydrological information during flood period regarding the hydrological elements at a regular time interval as stipulated on the basis of the requirement of flood forecasting for the river system (The Huaihe River commission, 2014).

(b) Information transmission

The hydrological information is transmitted through the telecommunication system of the country. For those reporting stations in remote areas where the telecommunication system may not be covered, the special transmission line is established. In accordance with the regulation laid down by the government, the hydrological information transmission during the flood period is regarded as the high priority task of the telecommunication department.

For those river reaches and water projects of special importance, short wave radio stations were established to ensure more effective information transmission. Furthermore, data collection, processing, storage, retrieval and distribution have been computerized in the real time flood forecasts for the major rivers.

(c) Flood forecasting and warning

Flood forecasting and warning were made by the Flood Fighting and Drought Defying Headquarters (FFDDHS) at various levels, i.e. the central government, the river basin commissions, the provinces/autonomous regions/municipalities under the central government and prefectures. In case of critical situation, i.e, a given water level is surpassed, the FFDDHS will issue warning via government at different levels, all parties concerned and also the media (radio, TV, news papers) to the public. The flood fighting schemes are prepared prior to the flood season, annual meeting of FFDDHS at different levels is held to review the preparatory work. The large reservoirs both completed and under construction also made flood forecast for their own operation. In addition about 1,000 hydrological stations also conduct river flood forecast as requested. The modeling technique has been developed since early 1950s, on the basis of the conventional methods in runoff yield analysis and flood routing, Xinanjiang Model developed by Chinese experts has been widely used in large river basins, other models like Sacramento and Tank model are also used in many river basins. A computerized flood forecasting system has been established with real time adjustment leading to high precision in the flood forecasting (Jiang 2009; Li et al. 2008; Ma 2014).

In summary, an integrated system of flood monitoring, forecasting and warning system, includes weather prediction, flood monitoring and forecasting, flood dispatching and flood control discussion, has been preliminarily established in the Huaibe River Basin (Fig. 3), which plays a vital role in basin flood control. However, system for flood risk management, e.g. probability flood forecasting system, flood risk dispatching models for reservoirs and hydro-junction, still stay at a starting stage.

5. Achievements in Flood Control

5.1. Experiences in flood management

Flood disaster, which occurred suddenly and inevitablely, is different from the general emergency disasters. It is determined by the natural conditions of the Huaihe Basin. By review of the Huaihe River flood regulation, it is found that the keys of success are still dependent on the following factors:

(1) The complete flood control structural system is the foundation of flood regulation and management. The standard and quality of the flood control works are directly related to flood management and projects operation. Although the standard of the flood control system in Huaihe Basin is not high enough, it is compounded by a wide range of works with high correlation. Their operation is very flexible, especially the flood regulation of detention basins and diversion channels like Huaihongxinhe canal and Ruhaishuidao canal (floodway to the sea), plays a vital role in flood control. In future we should strengthen the construction of structural system for flood prevention and increase the flood control standard appropriately.

(2) Accurate hydrologic forecasting is the prerequisite of the flood regulation. The forecast accuracy and the lead time will directly affect the correctness and timeliness of the flood regulation decision. In recent years, the extreme weather events have increased significantly from global perspective. The sudden strong rainfall is unforeseeable, and it becomes a new issue for flood prevention work. In the future, we should continue to strengthen early warning system, to optimize flood forecasting model and to improve forecast accuracy and quality. Particularly, there is an urgent call for constructing an ensemble flood forecasting system integrating with numerical weather models, distributed hydrologic models, hydraulic models and real-time control models.

(3) Scientific analysis and judgment of the flood is the key to flood regulation. Flood regulation should consider all factors as an integrated system, including upstream and the downstream, both sides of river, global and local, flood control and drought relief, as well as economy and society. To balance different interests is a hard nut to crack in decision-making. In future, we need to continue to strengthen the flood management and risk management, to resolve the problems in laws & regulation, mechanism, technology and other issues.

(4) Advanced technology and perfect plan are the effective support for flood regulation. Huaihe River floods in 2003 and 2007 are not only a test of the flood structural system, but also a full inspection of the Huaihe River non-structural system. All of advanced technology and comprehensive plan of flood monitoring and forecasting, flood control scheduling, emergency management mechanism and the joint regulation of the flood engineering system play an important role in joint operation of flood control structural system. In future, we should learn from domestic and international flood management experience, promote the application of high technology, constantly improve the flood control and strive to reduce disaster losses.

5.2. Outlook on flood management in the Huaihe River Basin

In the future, we have to change from flood control to flood management, and finally achieve the goal of flood risk management.

(1). Room for River. In terms of river planning and training, it is necessary to make more room for flood and formulate relevant schemes and measures by comprehensive analysis of flood. Based on the structural system comprising of reservoirs, dykes and flood detention areas, we have to enlarge passageway for small and middle magnitude floods in river harness for the purpose of releasing such kind of floods. To construct flood detention areas to receive extra floods that exceed the river channel capacity, aiming to solve the big flood issues.

(2) Live with floods. To harmonize the interrelationship between man and nature, it should be considered that: ①A credible flood control system and more integrated flood management system are the basis of and precondition for living with floods; ② In view of China current situation, with huge population and limited availability of land resources, the harmony between man and flooding should be represented as a sharing of floodplains and deriving maximum net benefits from the floodplains; ③Structural measures that are taken to meet the demands of reducing to an affordable risk and sustainable development for the whole system but not to bring the maximum benefits to the local residents, should be supported by means of some non-structural measures, such as legislation, administration, economics, finance and education.④Human activities should be regulated effectively to avoid accretion of flood risk over time and diversion of flood risk to neighbors. ⑤ Normalizing flood control and operation activities into a rational approach. It is to stress more rational planning, designing, construction, maintenance and operating of flood control structural systems to realize their joint benefits.

(3) **Flood risk management.** We do not have to control all floods of different magnitude, and we cannot bear enormous flood disaster risk. We have to avoid risks actively, take prevent measures as high priority, live far from flood disasters and control flood disaster risk to a certain extend. We have to determine reasonable flood protection standards, and the standards should not be too high or too low. We have to classify function of flood structures in a reasonable way, because flood disaster risks could propagate if function of flood structures is not classified correctly or properly. We have to share risks. Construction of flood structures can absolutely cause risk propagation, and therefore we have treat risk propagation in a right way, different regions have to share flood risk and construct flood risk compensation mechanism and flood insurance system.

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