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THE FLOOD OF THE NENJIANG RIVER AND THE SONGHUA RIVER IN 1998 AND THE COMPREHENSIVE MANAGEMENT OF THE RIVER BASINS

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ABSTRACT: In the summer of 1998, an exceptionally serious flood, with the characteristics of high water level, large volume of flow, long duration and serious losses caused by the disaster, occurred in the Nenjiang River basin and the Songhua River basin. Greater flood peak occurred three times in the trunk stream of the Nenjiang River for the floods occurred in its tributaries one after another. At Jiangqiao Hydrometric Station, the water level was 141.90 m and the rate of flow was 12 000 m^3/s. The flood is ranged to a catastrophic one, which occurs once in 50 years. Ranged to a catastrophic flood at Qiqihar Hydrometric Station that occurs once in 400 years, its water level, 0.89 m higher than the former all-time highest, was 149.30 m and the corresponding rate of flow was 14 800 m^3/s. The water level that exceeded the all-time highest lasted for 7 days. At Harbin Hydrometric Station, the water level, 0.59 m higher than the former all-time highest, was 120.89 m and the corresponding rate of flow was 17 400 m^3/s. The water level that exceeded the all-time highest lasted for 9 to 10 days. The flood here is ranged to a catastrophic one, which occurs once in 150 years. The flood of the Nenjiang River damaged 456×10^4 ha of crops and 115×10^4 rooms and the direct loss of economy exceeded 40 billion yuan(RMB). The main reasons of the flood are great rainfall, long flood season, unreasonable land use, regional ecological environment degradation and lack of water control projects. It is obvious that the following measures are greatly needed: the comprehensive management of the river basins; the formulation of development planning of the river basins, especially the water control projects; the development of agriculture based on ecological security.

KEY WORDS: the Nenjiang River basin, the Songhua River basin, flood, comprehensive management of river basin, natural disaster

The Songhua River, one of the major rivers in Northeast China, has two sources: the north source is the Nenjiang River and the south source is the Second Songhua River. The trunk stream of the Nenjiang River, rising at the southern foot of the Yilehuli Mountain, is 1370 km long and its watershed area is 29.7×10^4 km^2. The Second Songhua River, rising from the Tianchi Lake on the Changbai Mountains, is 958 km in length, and has 7.8×10^4 km^2 of watershed area. The two rivers join at Da'an City, Jilin Province. The Songhua River flows eastward and empties into the Heilong River at Tongjiang City, Heilongjiang Province. The total watershed area of the Songhua River and its tributaries is 52.3×10^4 km^2, almost 60% of the total land area of Northeast China (Fig. 1). Below Xingdong Town, the Heilong River flows past the Sanjiang Plain, with broad valley, smooth current and widespread flood plains. Below the confluence point of the Songhua River and the Heilong River, the valley of the latter is 10– 11 km in breadth and a large area of marsh develop on the low and smooth banks.

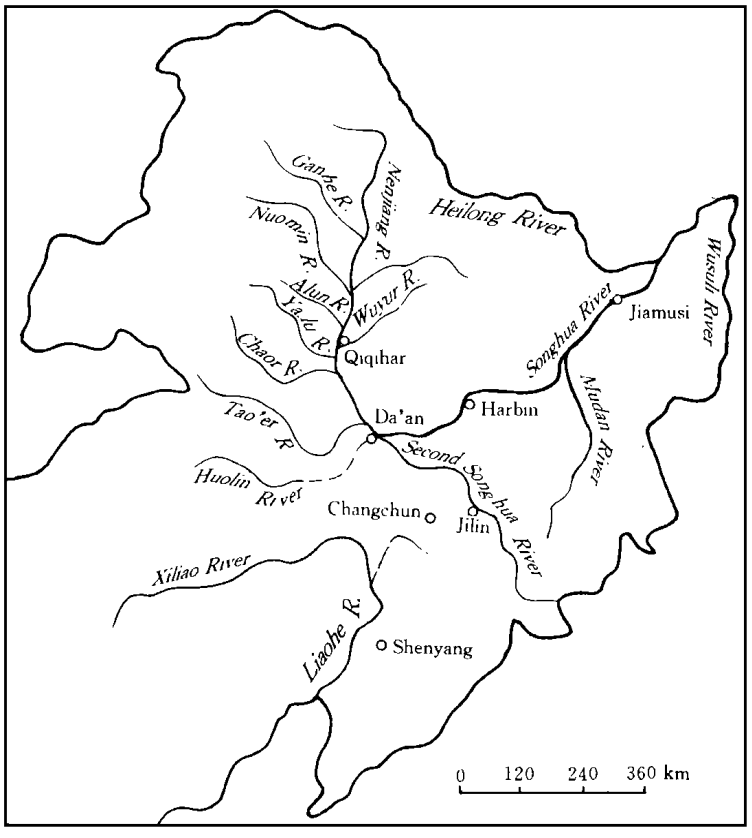

Fig. 1 The system of the Songhua River basin

In the summer of 1998, an exceptionally serious flood occurred in the Nenjiang River basin and the Songhua River basin. The flood caused heavy losses of economy. According to the interpretation result of the satellite images and the statistics before August 20, the flood hit 62 counties (districts), 778 towns and 6 485 villages. It damaged 456×10^4 ha of crops and 115×10^4 houses and affected 1132×10^4 people, among which 320×10^4 people were transferred peremptorily and 131×10^4 people were besieged. The direct loss of economy exceeded 40 billion yuan (RMB).

The flood occurred mostly because of natural causes, but human's irrational utilization of natural resources aggravated the flood damage. So, it is necessary to manage and plan the whole river basins comprehensively.

1 THE CHARACTERISTICS OF THE FLOOD IN THE NENJIANG RIVER AND THE SONGHUA RIVER BASINS IN 1998

The characteristics of the flood are high water level, large volume of flow, long duration and serious losses.

The major tributaries on the right side of the Nenjiang River are the Ganhe River, the Nuomin River, the Alun River, the Yalu River, the Chaor River, the Tao'er River, the Huolin River etc. Floods occurred in these tributaries one after another in flood season. The rate of flow at the Gucheng Hydrometric Station on the Nuomin River was 7 800 m^3/s, which occurs once in 500 years. The rate of flow at Nianzi Hydrometric Station on the Yalu River was 5500 m^3/s, once in over 1000 years. The rate of flow at the Chaor River was 5500 m^3/s, which occurs once in 200 years. The rate of flow at Taonan Hydrometric Station on the Tao'er River was 2000 m^3/s, which occurs once in 100 years. Great flood peaks occurred three times in the trunk stream of the Nenjiang River for the floods occurred in its tributaries one after another (Table 1).

The flood of the Nenjiang River arrived at the Songhua River in the late August. The water level at

Table 1 Three greater flood peaks in the trunk stream of the Nenjiang River

Flood peaks	Stations	Date	Water level(m)	Rate of flow (m^3/s)	Frequency
No. 1	Jiangqiao	July 3	140.71	7480	Once in 15 years
	Dalai	July 7	128.97	5390	
No. 2	Jiangqiao	July 10	141.27	9480	Once in 20 years
	Dalai	August 2	130.10	7850	Once in 15 years
No. 3	Jiangqiao	August 11	141.90	12000	Once in 50 years
	Qiqihar	August 13	149.30	14800	Once in 400 years
	Dalai	August 15	131.47	16100	Once in 100 years

Harbin Hydrometric Station, 0.59 higher than the former all-time highest, was 120.89 m from August 22 to August 23 and the corresponding rate of flow was 17 400 m^3/s. The water level that exceeded the all-time highest lasted for 10 days.

2 THE CAUSES OF THE FLOOD OCCURRENCE

2.1 Heavy Rainfall and Long Flood Season

The main causes of the flood are heavy rainfall and long flood season. The precipitation of the Nenjiang River and the Songhua River basins in the summer of 1998 and the average precipitation during the corresponding period in history (APCPH) are shown in Table 2.

Table 2 Precipitation of the Songhua River and the Nenjiang River basins in flood season of 1998

Month	Basins	Precipitation(mm)	APCPH (mm)	Difference (mm)	Anomaly(%)
June	The mainstream of the Heilong River	114.8	84.1	30.7	36.5
	The Nenjiang River basin	133.6	79.1	54.5	68.9
	The mainstream of the Songhua River	96.5	88.5	8.0	9.0
	The Second Songhua River basin	120.2	108.8	11.4	10.5
July	The mainstream of the Heilong River	79.8	113.5	-33.7	-29.6
	The Nenjiang River basin	241.6	144.5	97.1	67.1
	The mainstream of the Songhua River	106.3	145.2	-38.9	-26.7
	The Second Songhua River basin	177.5	181.4	-3.9	-2.1
August	The mainstream of the Heilong River	70.7	117.6	-46.9	-39.8
	The Nenjiang River basin	200.6	98.7	101.9	103.2
	The mainstream of the Songhua River	159.0	122.1	36.9	30.2
	The Second Songhua River basin	208.7	140.0	68.7	49.0

2.2 The Decrease of Forest Coverage

The evapotranspiration of plants results in 40% – 60% of the annual water losses in the forest regions (Kovner, 1956), and vegetation is an important adjuster of the river discharge. The decrease of vegetation can cause the increase of the stream runoff amount and the decrease of evaporation capacity (Hewlett *et al.*, 1961). The experiments proved that the storm flow amount increased by 11% and the peak discharge increased by 7% after the vegetation were cleaned out (Hewlett *et al.*, 1970). The cutting pattern of forests greatly affects the surface runoff. The proportion among the surface runoff of the clear cutting slash, selective cutting slash and primeval forest is 11◇2◇1, that is, the primeval forest is more effective than the clear cutting slash in regulating the hydrological process. The proportion among the amount of silt erosion of the clear cutting slash, selective cutting slash and primeval forest is 1◇4◇10 (Chen, 1995). The forests of the Da Hinggan Mountains, the Xiao Hinggan Mountains and the eastern mountains account for 97% of the

forest in Heilongjiang Province. In the early part of this century, the forest area of Heilongjiang Province was 3300×10^4 ha; the total forest storage was 40×10^8 m^3; the forest coverage was 70%. In the middle part of the 1980s, the forest coverage was 36.4% and the total forest storage was 12.7×10^8 m^3 due to overcutting, fire and gold mining. The forest area and the total forest storage decreased about 3.3×10^4 ha and 90×10^4 m^3 per year, respectively (The Editorial Committee of Chinese Natural Resources Series, 1995). The decline of the forest area result in the decline of the capability of the forest to reduce the flood peak and regulate runoff. It also results in soil erosion and deposition in the riverbeds, which give rise to slow flood discharge.

2.3 The Decrease of the Wetland Area

Wetlands play an important role in regulating stream runoff and reducing flood peaks. The experiments indicate that the coefficient of swamps to regulate flood is similar to that of lakes (Chen *et al.*, 1982). The swamp soils have tremendous capacity of holding water, so it is called "the biological reservoirs". In the experiments in the Sanjiang Plain, the saturation moisture capacity of peat horizon is 500% – 800%, even up to 900% and that of the grass root layer is 300% – 800% (Zhang, 1981). The runoff modulus and the runoff yield of precipitation of the swamps is less than that of the farmlands (Chen, 1988). The annual dropping rates of the meadow marsh soil (0– 16 cm in depth) and the muddy marsh soil (0– 10 cm in depth) are 7.36% and 6.22%, respectively (Ma *et al.*, 1996).

In the middle and upper reaches of the Songhua River, over-reclamation results in the loss and degeneration of some lacustrine and palustrive wetlands. There are lots of wetlands on the Songnen Plain, an alluvial plain, due to low and gentle terrain and ineffective drainage system. Many wetlands are distributed in the lower reaches of the Nenjiang River, 50– 60 km from north to south and 170– 180 km from west to east. There are a lot of palustrive wetlands in the lower reaches of the Wuyur River, the Namoer River, and the Yalu River, too. The total area of lakes in the Songnen Plain, which is one of the largest lake regions in China, is about 2570 km^2, which is equivalent to 6% of the land surface (Lu *et al.* 1998). The main beaches of the lakes are desertified beaches, meadow wetland beaches, and marsh beaches. The area of wetlands in the Songnen Plain was 254.2×10^4 ha (Liu, 1997), accounting for 20% of the total area of the plain (Liu, 1998).

Before the 1960s, the area of reed swamp in the Songnen Plain was 28.7×10^4 ha. After the 1970s, the reed swamp degraded greatly and its area decreased by some 10×10^4 ha because of continuous drought and ill-management (Niu *et al.*, 1988). Recently, many wetlands have been reclaimed into farmlands. According to the investigation, the wetland area decreased by 50% or more, and the lake area did by 30% or so. So, droughts and floods often occurred alternately and flood level within the dikes rose while the fields outside the dikes were very dry.

2.4 Few Water Control Projects in the Nenjiang River and Songhua River Basins

At present, there are few middle-sized reservoirs and only one large-sized reservoir in the Nenjiang River basin. Because of the lack of water control projects, it is difficult for us to regulate and control the water resources. In addition, the low standards of flood control for the rivers and reservoirs, the lack of conveyance system, disrepair of the riverbeds also decrease the capacity of preventing floods.

3 THE MEASURES FOR COMPREHENSIVE MANAGEMENT AND THE SUSTAINABLE DEVELOPMENT OF THE RIVER BASINS

3.1 Planning of Resource Exploitation and Environment Protection Within the Basins

The comprehensive management of the river basins possess obvious holism and synthesis. Holism

means to view natural conditions, ecological environment, natural resources, and social economy as interacting factors, and to take the upper, middle, and lower reaches of a river as a whole. Synthesis means to pay attention to the synthetic benefit of preventing flood, generating electricity, irrigation, shipping, water supply and eco-environment and to avoid merely emphasizing single benefit. For example, recognizing the importance of preventing flood while ignoring to prevent drought, and neglecting shipping while damming and sluicing. In addition, the comprehensive management of river basins is a long-term task. We should consider not only the benefit of the present generation but also that of the following generations.

There are abundant forest resources, land resources, and water resources in the Nenjiang River and Songhua River basins. They are important timber and merchandise grain bases in China. In the comprehensive management of river basins, we should consider not only the coordination of the upper, middle, and lower reaches of the rivers but also the sustainable utilization of water resources, land resources, and biology resources. We should protect the forest resources and raise the forest coverage in the upper reaches of the rivers, in the meantime making rational use of the wetland resources in the lower reaches of the rivers. We should also strengthen the study on the sustainable utilization of the water resources and plan the flood-relief and store districts rationally. We must carry out environmental impact assessment before developing and constructing the river valleys.

3.2 Strengthening Water Conservancy Projects

There are abundant land resources in the Songnen Plain, which is one of the most important commodity grain bases and livestock farming bases in China, but the water supply there is in a natural situation and often cannot satisfy the demand for the lack of water control projects. By building water control projects, we can not only raise the flood control standard but also make full use of the water resources. For example, the Ni'erji Reservoir, the recent planning of pivotal projects in the middle reach of the trunk stream of the Nenjiang River, will control 6.64×10^4 km^2 land. Its total storage capacity is 83.74×10^8 m^3, including 13.38×10^8 m^3 of storage for preventing flood and 58.54×10^8 m^3 of storage for irrigation.

Besides building water control projects, we should also construct conveyance systems, dredge up the watercourses, reinforce the dykes, and repair the watercourses, and strengthen the design and construction of key water-control projects in the mainstreams and their tributaries especially

3.3 Developing the Agriculture Based on Ecological Security

The agriculture based on ecological security is sustainable agriculture that maintains the health of the regional eco-environment. Developing the agriculture based on ecological security means to regulate the crop distribution and planting structure. It also means to carry out landscape ecological planning and design according to the landscape structure, that is, to make unified planning of the forests, grasslands, and fields, lay out the dry land and irrigated field rationally, and reserve water and palustrive wetlands in certain proportion.

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