ECOLOGICAL CONCERN WITH WATER-RELATED DISASTERS

- Lessons from Flood of the Yangtze River in 1998 -

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Abstract

Extremely heavy flood of the Yangtze River in 1998 has caused great damage and concern in China. This paper intends to give a general analysis about the cause of the flood and the strategy for restoration of degraded ecosystems. It was discovered that the flood of the 1998 was caused both by natural factors as well as by unreasonable human activities including deforestation, overgrazing, sloping cultivation, reclamation of lake for agricultural cultivation etc. A series of measurements for ecological restoration were suggested. These include: to carry out integrated survey and assessment of land cover and land use in the watershed of the Yangtze River; to establish overall plan for ecological restoration under the general framework of sustainable development of watershed; to restore ecosystems by the preservation of natural forest in the upper reaches of the river, to enclose hills for natural regeneration; to establish shelter belts systems, to develop non-wood production, and, to conserve grassland ecosystems in high altitude, dry habitat and difficult for afforestation areas etc.

Keywords countermeasurements, flood, Yangtze River
INTRODUCTION

China is one of the countries in the world, which suffers most seriously from natural disasters. Over the past forty years, flood caused a great deal of economic losses with death tolls averaging thousands each year. Economic development, population growth, and ecological degradation, especially in high-risk areas, where there is high population density and intensive production, have led to escalation in the frequency, extent of effect and degree of risks of natural disasters. In some regions, these factors are seriously hampering long-term efforts to eradicate poverty.

The Yangtze River (Changjiang) is the longest river in China with the widest drainage area and the biggest water flow. It is originated from Qinghai-Tibetan Plateau and flows eastward across Qinghai, Xizang, Yunnan, Sichuan, Hubei, Hunan, Jiangxi, Anhui, Jiangxi, Anhui and Jiangsu Provinces and empties into the Pacific Ocean. It lies in the subtropical monsoon region of China with abundant precipitation. The Yangtze River has many tributaries, among which ten tributaries each have an annual mean flow of more than 1,000 cu. m. per sec. The water in the Yangtze River comes mainly from its upper and middle reaches, accounting for more than 90% of its total runoff (46.4 per cent from the upper reaches and 47.3 per cent from the middle reaches). While the water entering the river in the lower reaches accounts for only 6.3%.

The seasonal distribution of runoff in different sections of the Yangtze River is as follows: about 40 percent of the annual total on the upper reaches and 50 per cent on the lower reaches in summer; about 33 per cent in Autumn; less in Spring and the least in Winter. Compared with rivers in the North, this yearly flow is relatively even. The biggest flow occurs in summer when the summer monsoons move northward. In general, the earliest flood comes from the Dongting Lake drainage system, then from the main stream of Yangtze River west of Yichang and last from the Hanjiang River. If the high water from the main stream and its tributaries arrive at the same time, the flood may present a big menace to areas of middle reaches. For example, the flow at Yichang area in 1954 was measures at 69,000 cu. m. per sec., producing the worst flood in a century. In flood years, about 60 per cent of the total flow at Hankou comes from the main stream west of Yichang, 20-30 per cent from Dongting Lake system and 7 to 9 per cent from the Hanjiang River.
Table 1. Volume of flow of China’s Major River

<table>
<thead>
<tr>
<th>Name of River</th>
<th>Drainage area (sq. km.)</th>
<th>Length (km.)</th>
<th>Average flow (m$^3$.sec$^{-1}$)</th>
<th>Total volume (billion m$^3$)</th>
<th>Depth runoff (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yantze River</td>
<td>1,807,199</td>
<td>6,380</td>
<td>31,055</td>
<td>979,350</td>
<td>542</td>
</tr>
<tr>
<td>Yarluzangbu</td>
<td>246,600</td>
<td>1,940</td>
<td>3,699</td>
<td>116,652</td>
<td>772</td>
</tr>
<tr>
<td>Langcang</td>
<td>164,799</td>
<td>1,621</td>
<td>2,354</td>
<td>74,248</td>
<td>412</td>
</tr>
<tr>
<td>Nujiang</td>
<td>142,681</td>
<td>1,540</td>
<td>2,222</td>
<td>70,088</td>
<td>469</td>
</tr>
<tr>
<td>Hanjiang</td>
<td>34,314</td>
<td>325</td>
<td>942</td>
<td>29,710</td>
<td>866</td>
</tr>
<tr>
<td>Huanghe</td>
<td>752,443</td>
<td>5,464</td>
<td>1,820</td>
<td>57,450</td>
<td>76</td>
</tr>
</tbody>
</table>

In order to relieve the Yangtze River flood menace, large-scale work have been done since 1949 to manage the river. Great work has been made along its course in the flood prevention, irrigation, power generation and navigation. Dykes along its main stream and its main tributaries have been repaired, raised or strengthened. The Jingjiang flood diversion project, the Hanjiang flood diversion project and other flood-storage projects have been built along its middle reaches, the area often hit by the unusual floods. Many lakes have been dredged, and this has increased the capability of the Yangtze River to prevent flood.

Extremely heavy flood of the Yangtze River in 1998 has caused great damage and concern of the whole country. This paper intends to give a general analysis about the causes of the flood and the strategy for restoration of degraded ecosystems. It was discovered that the flood of 1998 was caused both by natural factors as well as by unreasonable human activities including deforestation, overgrazing, sloping cultivation, reclamation of lake for agricultural cultivation etc. A series of measures for ecological restoration were suggested. These include: carry out integrated survey and assessment of land cover and land use in the watershed of the Yangtze River; establish overall plan for ecological restoration under the general framework of sustainable development of the watershed; restoration of ecosystems by preservation of natural forest in the upper reaches of the river; closing hills for natural regeneration; establish shelter belt systems, development of no-wood production; conservation of grassland ecosystems in high altitude, dry habitat, and difficult for afforestation areas etc.
1 FRAGILE ENVIRONMENT AND CLIMATE ABNORMITY ARE NATURAL FACTORS RESULTING IN FLOOD

1.1 Abundant rainfall with uneven distribution in the Yangtze River Basin
The Yangtze River is the longest river in China, having many tributaries that form a vast drainage system. Ten tributaries each have an annual mean flow of more than 1,000 m$^3$.s$^{-1}$. The Yangtze River basin lies in the subtropical monsoon region of China. The precipitation is abundant and the distribution of it is uneven. 80% of the rainfall is concentrated in August and September. The water in Yangtze River comes mainly from its upper reaches, which account for more than 90% of its total runoff. The biggest flow occurs in summer, sometimes early and sometimes late, depending on when the summer monsoons move northward. Roughly speaking, the earliest flood comes from the Dongting Lake drainage system, then from the main stream of the Yangtze west of Yichang and last from Hanjiang river. If the high water from the main stream and its tributaries arrives at the same time, the flood may occur, presenting a big menace to land areas along the middle reaches of the Yangtze River. Due to the influence of phenomena of Elneno and Nolina. In summer of 1998 the worse situation occurred. Flood in upper and middle tributaries met together and the flood peak occurred repeatedly. This is an important climatic factor resulting in flood.

1.2 The landform and the relief as well as the fragile environment of the upper reach of the Yangtze River accelerate soil erosion process
In the upper reaches, the landform mainly consists of high mountains with deeply dissected valleys. In the fragile environment, in conflict with gravity and geologically tectonic movement, the upper reaches is the area where earthquake, landslide, and debris flow frequently take place. It is also the most severe area of soil erosion. When the river runs through the Three Gorges, the river gradient ratio is fairly low so that sediment is deposited and water flow is blocked.

2 EXCESSIVE CULTIVATION OF LAKE AND CONSTRUCTION IN FLOOD-DIVERSION AND FLOOD STORAGE AREAS
Decades ago, a series of flood-diversion areas and water storage areas were planned and constructed. These infrastructure engineering had played important role in mitigating flood in
1954, when the flood was as much as it was in 1998. However, due to population growth and economic development, these flood waterway and flood-diversion areas were not only cultivated but also was occupied by many permanent buildings, factories and project facilities. It can not be used for flood mitigating. If during the flood season in 1998 the waterways were used for flood discharge, a great deal of economic loss will definitely be resulted in. That is why the central government had to decide to fight against flood and tried the best to reduce the loss from flood discharge. This was resulted to raise the level of flood and a high risk was faced during 1998. Thanks to the heroic spirit and joint efforts of millions army and people we created historical miracle and had won the flood control in 1998. However, this also gave us a deep lesson and experiences for future flood control.

3 UNREASONABLE LAND USE ACCELERATING THE VIOLENCE OF FLOOD DISASTER

3.1 Illegal cutting and deforestation
Forests play an important role in conserving water and regulating runoff. Forests take the advantage of multiple vertical structure to intercept rainfall, redistribute rainwater and weaken soil erosion to ground soil. But the function of conserving water is quite different in different kinds of forest stands. Human-destroyed, low-aged artificial forests have low growth rate and low capacity of keeping water and conserving soil. China’s forest resources are mainly distributed in Northern China and Southwestern China, just located in the areas, in which severe flood disaster occurred in 1998, of the upper and middle reaches of the Yangtze River and the Songhuajiang River. For a long time, these areas were the major ones for timber logging and producing. Forest resources have been destroyed severely. In 1960s, the policy of building industry in remote mountain areas aggravated deforestation in natural forest areas. Now the area and stock volume of forest resource reduce 50% compared to that of 1950s. For example, more than 50 counties in the upper reaches of the Yangtze River have forest coverage less than 3% - 5%. Some forest enterprises have no forest resources for logging.

3.2 Unreasonable exploitation of wetland and lakes, including drainage, enclosing cultivation and reclamation
Wetland, including lakes, marshes, turf, coastal belts, mangroves and coral reefs, is water sink and water regulation pool. Wetland plays an important role in flood storage and drainage,
watershed water balance, and pollutant decomposition, so enjoying the good fame of „Kidney of the Earth“. There is 25 million hm² of wetland in China, accounting for 2.6% of the total territory area, now almost degraded. The lakes in the 500 km length of reaches from Zhicheng to Wuhan were almost enclosed for cultivation. The capacity of flood regulation and storage has been weakened greatly. For example, Dongting Lake is the only one having good water regulating and storage capacity. The area of lake region shrank from 4350 km² in 1949 to 2691 km² in 1978 and water capacity decreased from 29.3 billion in 1949 to 17.4 billion in 1978, reducing 38.2% and 40.6% respectively. On the average, the bottom of lake rose 3.6 cm per year, and the area of beaches amounted to 120000 hm², with 666.7 hm² of annual expanding speed. Under the condition of enclosure for cultivation and sand deposition, the loss of water capacity occupied 1/5 of the total. This enhanced threats of flood.

3.3 Irrational cultivation on purpose to excessively pursuing food production

The Sichuan branch of the upper reaches of the Yangtze River is an agricultural region where rural population accounts for 85.6 percent of the local total. In the region cultivation is intense. For example, in western Sichuan Province, the landform is mainly composed of high mountains and steep slopes. Local residents have to cultivate along riversides. In the upper reaches of the Yangtze River, 70% of the arable land is cultivated without any measures of soil conservation. Furthermore, slope land over 25 degree is commonly cultivated.

4 STRATEGY AND MEASURES FOR PREVENTION AND MITIGATION OF FLOOD

In order to relieve the Yangtze flood menace, large-scale work has been done since 50s to control the river. Great achievements have been made along its course in flood prevention, irrigation, power generation and navigation. Dikes along its main streams and its main tributaries have been repaired, raised or strengthened. The Jingjiang flood-diversion project, the Hanjiang flood diversion project and other flood-storage projects have been built along its middle reaches, the area usually hit by unusual floods. Many lakes have been dredged, and some bending in the river course has been straightened. All of these provide an important basis for further work in protection against disasters, in mitigating their effects and in increasing capability to preventing flood.
For further preventing and mitigating floods a complex of measures should be taken. This include:

a. Promoting the Establishment of flood Prevention and Mitigation Systems
b. Improving flood control Management
c. Reducing floods caused or aggravated by Human Factors

4.1 Promoting the Establishment of flood Prevention and Mitigation Systems
Flood management involves a combination of activities, including legislation, planning, organization, coordination, intervention and engineering, which are carried out by the government, appropriate agencies and social organizations for the prevention and mitigation of disaster. This is at the core of the disaster mitigation system, and permeates all actions associated with it.

4.2 Comprehensive planing
Establish an overall plan for flood control based on sustainable development principles. To make an overall plan for the whole river watershed as an integrated system combine engineering with vegetative measures and take the whole ecosystem into consideration in terms of natural, ecological and economic aspects. Manage the whole ecosystem and regulate in macro-scale. In the near future, the mechanism of section management should be changed and establish a institution of watershed management and comprehensive regulation to coordinate and supervisor key ecological construction and water conservancy construction.

4.3 Implementing comprehensive watershed management
Taking watershed as a unit, and combining environment protection with economic development to carry out vertical planning and comprehensive development is one of the successful experiences in the field of mountain ecosystem restoration and management. It is also the research objective of landscape ecology. This experience should be promoted the rehabilitation and restoration in mountain ecosystems.

4.4 Withdrawing unsuitable cultivated land for reforestation and lake
The key to stopping cultivation for reforestation and lake is to arrange the surplus manpower to service and processing industry and settle the problem of food supply for them. In the place where slope more than 25, cultivation should be forbidden. The cultivated land should be withdrawn as soon as possible for afforestation. In the moderate slopes where soil and water
conditions are better, the land should be planned comprehensively and agroforestry should be promoted. The natural beaches should be controlled strictly for cultivation in order to maintain its function of regulating and storing floodwater.

4.5 Developing rangeland for animal husbandry
In the areas of slope mountains and alpine meadows, and in the arid valleys, rangeland should be developed for animal husbandry. It is an effective way to shake off poverty and promote sustainable development.

4.6 Strengthening forestry reconstruction
The forest resources are mainly distributed in Northeast and Southwestern China, in the upper and middle reaches of the river in which flood occurred. The forest resources are destroyed severely due to more deforestation and low conservation. So the following suggestion should be attached more attention:

a. Intensifying natural forest conservation
There is plenty of biodiversity in natural forest. The natural forests play an important role in conserving water, soil and sustaining ecological balance. It is the precious treasure of China. Natural forest resources are now limited, especially in the upper reaches and along riversides in huge rivers, the natural forests should be protected as water conserving forests. Natural forests should be categorized to manage according to scientific classification. I suggest that permanent water conserving areas should be established in the river banks in the extent of 10 km and ban for deforestation.

b. Closing hills for natural regeneration and transforming secondary forests
Closing hills for natural regeneration is an effective measure for mountain greening. This measure should attach more attention on closing hills and in combination with management and fostering young trees. The air-seeding forests and young forests in fragile area should be strictly closed and prevent destruction from animal and human activities.

c. Encouraging public greening projects
In the areas of difficult to restore vegetation, such as limestone mountains, red soil hills and sandy areas, more investment should be input to ensure vegetation restoration. In areas with deep soil layer and withdrawing cultivation for afforestation, economic forests can be afforested. In economic forests with low benefit of protection, biological hedgerows should be combined to enhance the benefit. The afforested species should be deep-rooted, flourishing-
branched, fast sprouting and fast-grown and productive trees. The shelter belts should be multi-functional mixed forests.

d. Enhancing investment and expanding money-raising channels
In addition to the investment from central government and local institutions, more channels should be expanded to attract financial support. Ecological compensatory mechanism should be established to meet the need of afforesting commonwealth forests.

4.7 Promoting wetland conservation and rational utilization
The status and tendency of wetland degradation should be quickly investigated and ecologically evaluated. This is the basis for finding sustainable utilization models and bringing the role of flood peak reduction, water storage and runoff regulation into full use.

4.8 Establishing eco-economic accounting system and ecological benefit compensatory system
Now the State Council is formulating forest accounting and forest benefit compensation mechanism. This is not only beneficial to enhance the enthusiasm of managers but also a new conception for benefit evaluation.

4.9 Carrying out education of laws and regulations and improving environmental consciousness
Legislation and related regulations should be consummated, execute the law and boost propaganda in order to publicize the consciousness of environment protection. Natural forests should be protected strictly and ensure the forest resources in the upper reaches of large rivers not to be destroyed.

4.10 Reinforcing scientific research and technology application
Summarize and promote scientific achievements for demonstration. As regard to resource protection and scientific and technological issues, especially watershed sustainable development, ecosystem ecological service and watershed management models and its evaluation, resource accounting and management techniques of water and conserving forests, should be the key points of research project. Dynamic remote sensing system on the base of land use and geographical information in the Yangtze River should be established to build up database and monitoring systems in order to forecast storm and flood.