

# THE EFFECTS OF THE THREE GORGES PROJECT ON ECOLOGY AND ENVIRONMENT

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**ABSTRACT:** The impacts of the Three Gorges Project are summarized in this paper from the viewpoint of the whole Changjiang (Yangtze) River basin and system ecology. Among the impacts on aquatic ecosystem and fishery of the river basin, the emphasis is placed on the survival of certain precious and rare species, such as the indigenous River Dolphin, *Lipotes vexillifer*. The impacts on terrestrial ecosystem include the ecological changes of the inundated, agricultural land, and the carrying capacity of the land for the resettled population in the upper reaches of the river, and changes of the environment of lowland district and lowlying paddy fields in the middle and lower reaches. The impacts on the surrounding geology and safety of the reservoir area include mud-rock flow, land slide and earthquake. The impacts on estuarine ecology involves increasing salinization of water and soil, erosion of coastline, and the security of Shanghai City. The impacts on the cultural landscape of the Three Gorges area are also highlighted. Through the overall and systematic analysis, the conclusion is drawn that there are both advantageous and disadvantageous aspects in the effects of the Three Gorges Project on ecology and environment, but the disadvantageous effects are the greater.

**KEY WORDS:** the Changjiang River, Three Gorges Project, ecology and environment

## I. INTRODUCTION

The Changjiang River, with a distant source and a long stream, stretches over our country from west to east. The main river is about 6,300 kilometers long, with 3,600 tributaries connecting the south and north of the river. Richly endowed by nature, the river is known as "golden waterway". Its safety and prosperity are related to the destiny of hundreds of millions of people living in the basin and touched on the rise and fall of our nation nearly. As is known to all, the proposed Three Gorges Project is the key structure for harnessing and exploiting comprehensively the Changjiang River. Its synthetic benefits are

undoubtedly greater than that of other large and medium-sized water conservancy projects. In order to give full play to the project's synthetic benefits, numerous scholars have made comprehensive studies on the ecological and environmental problems of the project and many countermeasures have been put forward to abolish harmful impacts. Based on some research results made by numerous Chinese scholars<sup>[1-2]</sup>, some important problems about the effects of Three Gorges Project on the ecological environment are summarized as follows.

## II. THE EFFECT ON AQUATIC ECOSYSTEM OF THE CHANGJIANG RIVER

### 1. The Effect on the Biological Diversity

From the viewpoint of ecology, no influences on the ecology and environment caused by water resource exploitation of mankind are greater than the dam-building on large rivers and the water transfer works over basins. The normal pool level, dam-top elevation and total reservoir capacity of the Three Gorges Reservoir are 175m, 185m, 39.3 billion cubic meters respectively. The effect on the water ecology will be greater than that of the low head, river-run Gezhouba Project. There are many precious and rare species in the Changjiang River. The rich species and marked biological diversity have the Changjiang River become an important natural gene pool and one of the freshwater fishery bases in Asia or even in the world.

The fish diversity of the Changjiang River holds the first place in all of the rivers of China. Among eight hundred species of freshwater fishes in China, about three hundred species live in the Changjiang River. In addition to a large number of fishes characterized by East Asia geographical distribution, there are both fish species of the north, such as *Hucho bleekeri*, *Phoxinus*, and of the west frigid zone, such as *Schizothorax* and *Triplophysa*. Among more than two hundred species of fishes in the upper reaches of the Changjiang River, more than a hundred species are peculiar, and most of them like swift current circumstances. After the building of the Three Gorge Dam, the narrow course of 600km will become broad valley-type reservoir and the estuarine reaches of the tributaries, such as Xiangxi river, Longchuan River, Daning River and Wujiang River will also become the arms of the reservoir. In consequence the living environment of about forty species of special fishes in the upper reaches will be ruined. One of the countermeasures is to select one or two proper tributaries on which cascade development will not be carried out and their natural ecological environment will be protected, so that fishes whose existence is menace will have a suitable environment to live in, and the results of fish "emigration" will be achieved. In this way, part of the peculiar fish species in the upper reaches may be protected.

## 2. The Effect on the Rare and Precious Species

In addition to abundant fish diversity as described above, the reasons why the Changjiang River have become the treasure house of hydrobiological species resources in China or even in the world are that some rare, specious and dying species have been living in the Changjiang River, for example the indigenous River Dolphin, *Lipotes vexillifer*, belong to "dying species in the world". In order to make the River Dolphin immune from dying out, the study on the artificial breeding of River Dolphin should be strengthened. *Psephurus gladius* (Martens ) is another national first-class protected animals living in the Changjiang River. The body length (the longest record is up to 7 meters ) occupies the first place in all of the freshwater fishes. It is one of the two survived species only living in the Changjiang River. After the construction of the Three Gorges Project, it is obviously impossible to supply fish resources to the middle and lower reaches from the upper reaches. When cascade developments on the Jinshajiang River are carried out progressively, the spawning areas will be destructed completely and *Psephurus gladius* will become extinct. *Myxocyprinus asiaticus* is also a large half-migratory fish, belonging to national second-class protected animals. The weight can be up to dozens of kilograms. The spawning grounds are in the upper reaches of the river. New spawning fields have been formed in the downstream of the Gezhouba Dam, but the scope is very small. *Myxocyprinus asiaticus* resources will have a tendency to decrease for the building of the Three Gorges Dam.

The artificial breeding of *Myxocyprinus asiaticus* have achieved success, but that of *Psephurus gladius* remains to be broken through. These two species of rare and precious fishes should be protected by putting them in a suitable place to breed.

*Acipenica sinensis*, one of national first-class protected animals, is the river-sea migrating fish. In the past it migrated to the upper reaches to spawn and breed. Now new spawning ground has formed. The impacts of the Three Gorges Project on the *Acipenica sinensis* may come from two aspects. During the breeding season (Oct. and Nov.), the Reservoir is filled with water just in time, so the water stage at Yichang falls, and the river course will become narrow, which is unfavorable to breeding. Another aspect lies in increased boats and more frequent shipping, which would interfere ecological environment for the sexual gland development and regain the *Acipenica sinensis*. In order to more effectively protect and regain the *Acipenica sinensis* resources, the existing artificial release measures must be strengthened and good-quality sturgeon seedling be bred and put into the Changjiang River so that the resources can be propagated.

### 3. The Effect on the Fishery Resources of the Changjiang River Basin

After completing the Three Gorges Dam, the 600-kilometer upstream narrow stream of dam-site, Sandouping, will become a broad valley-type man-made lake, and the surface area will increase by  $6.67 \times 10^4 \text{hm}^2$ , so the fish production capacity will go up. But from the viewpoint of the whole basin, the possible negative influence on the fishery resources and production still exist. The sources of fry in the middle and lower reaches will reduce greatly for the construction of the Three Gorges Project.

The Changjiang River is the natural productive place of the "Four Major Farm Fish" (black carp, grass carp, silver carp and bighead) and its fingerling in our country<sup>[3]</sup>. After the building of the dam, all of the eight spawning places (the spawning scale accounted for 24 percent of the whole river) within the reservoir area will be inundated. The most important breeding reaches in the Changjiang River is from Yichang to Chenlingji, where there are twelve spawning places, and the scale accounted for 45 percent of the whole river. The breeding season of the "farm fish" is from May to August. The reproductive capacity in May and June made up 70–80 percent of the whole year. Flood rising and falling are the preconditions of the farm fish breeding. Because of the reservoir regulation, the flood peak was cut and the rising magnitude was reduced, which would restrain and even stop the breeding processes of these fishes. At the same time, the water temperature should not be lower than 18°C when the farm fish breed. During the season of fish propagating, if the water temperature is below 18°C owing to cold water outflow from the reservoir, the small changes of the water temperature will do harm to the fish propagating, making the spawning process postponed, which will be harmful to the quality and quantity of fry and unfavorable to the growth of fry and the increase of natural farm fishes resources. In order to provide the water rising process necessary to the normal breeding of the farm fishes, the remedial measures can be taken by man-made flood peak in the regulation of the reservoir. The question of cold water calamity can be solved by installing different layers of draw-off devices regulating the outflow temperature.

### III THE EFFECT ON THE TERRESTRIAL ECOLOGICAL ENVIRONMENT OF THE RESERVOIR AREA

The Three Gorges Reservoir area is densely populated. The population per square kilometer is 256, among which the farmers account for 89 percent. The cultivated land area that each person possesses is about  $0.07 \text{hm}^2$  on an average, and 70 percent of which are sloping fields, and the slope gradient of 25 percent of fields is greater than 25 degrees, some of them greater than 40 degrees. The rate of land reclamation is 17.2 percent (10 percent for the country). In short, the features of this region are more population, less land and over

reclamation. The ratio of forest cover decreases day by day, and the water loss and soil erosion increase with time, environmental conditions are getting worse. The relations among population, cultivatable land area and grain yield become more and more inconsistent and conflict. It is difficult to control the ecological disturbance effectively. The ecological system was in the vicious circle.

Six hundred and thirty-two square kilometers of land will be inundated by Three Gorges Reservoir, in which the cultivated land is  $2.74 \times 10^4 \text{hm}^2$  and the orange growing area is  $0.5 \times 10^4 \text{hm}^2$ , involving 19 counties, 140 villages and 657 enterprises. Eight hundred thousand citizens and farmers will emigrate (when the project is finished in 2008, the emigrant will be more than one million and one hundred thousand). Therefore whether the Three Gorges Project is constructed or not, the agriculture situation in the reservoir area is severe. After the building of the dam, most of inundated areas are smooth islets and beaches, or the first and second grade terraces (platform) and hilly lands, where the grain, vegetables and other cash crops yields are high and stable in the local regions. Most of the cultivated land that will not be drowned are poor steep slope where the gradients are bigger than 15–25, or even 30 degrees. The water loss and the soil erosion are serious. The production capacity of about three times of these kinds of slope area can be equal to that of the first or second grade high productive cultivated lands.

After the construction of the reservoir large quantities of cultivated lands will be inundated. Millions of emigrants will need land to live on, many removed enterprises will need land to rebuild. The contradictions among the population, cultivable land area and grain yields will be intensified further. It is an arduous task to make emigrants live and work in peace and contentment. The ecological environment is so fragile in these regions that is as though treading on thin ice to solve the cultivable land inadequacy and grain self-sufficiency only by extending reclamation. In order to relax the inconsistency between the population and the cultivable land, it is necessary to take synthetic measures and give special aids to the emigrants. That is one of the keys to the success or failure of the Three Gorges Project.

#### **IV. THE EFFECT ON THE LAKES AND LAKE DISTRICT ENVIRONMENT OF THE MIDDLE REACHES OF THE CHANGJIANG RIVER**

Lake is important land resources of our country. The lake ratio and the average amount of fresh water that one person possesses are lower than those of the world. The areas of lakes are reducing and the environment of lake areas is getting worse because of the natural evolution, especially the effect of human activities. Since the 1960s, the reclamation land area of lakes has been more than  $133.3 \times 10^4 \text{km}^2$ , and the area of the lake that have

lost is more than the sum of the five lakes (Poyang Lake, Dongting Lake, Taihu Lake, Hongze Lake and Chaohu Lake).

The lakes and their environments in the middle reaches of the Changjiang River Basin are greatly related with the Changjiang River. After the construction of the Three Gorges Project, the changes of the channel situation and the hydrological, sedimentary properties in the middle reaches of the Changjiang River will lead to the change of the relation between the river and the lake directly or indirectly, which could affect the ecological environment of lakes and lake.

After the Three Gorges Reservoir gives play to regulation, the changing magnitude of water rising or declining will decrease in a year. During the flood season there will not be large floods and during the drought season, not very dry. The medium water stage will last for a long time, so will the waterlogging time of the basin. Year after year, paludification will develop further in the four lakes regions of Hubei Province. About  $13.3 \times 10^4 \text{ km}^2$  low-lying rice fields would be lost. The original ecological environment problems, such as waterlogging, harmful insects etc. would be getting worse.

The sediment deposits seriously in Dongting Lake at present. The lake area is reducing rapidly and about 82 percent of sediment flowing into the lake ( $1.093 \times 10^8 \text{ m}^3$ ) are from the Changjiang River. After the construction of the Three Gorges Dam, the sediment flowing into lake from three entrances would reduce, by which the development of the delta in the tree entrances region would be restrained, and the lake extinction process would be delayed, so that Dongting Lake may be restored from the view point of long time.

The area of Poyang Lake in Jiangxi Province is  $3,283.4 \text{ km}^2$ , with basin area of  $16.2 \times 10^4 \text{ km}^2$ . It receives water from five rivers (Ganjiang, Fuhe, Xinjiang, Xiushui and Pojiang rivers). The water volume flowing into the Changjiang River at the outlet, (Hukou Lake outlet), is up to  $1,457 \times 10^8 \text{ m}^3$ , which is 15.9 percent of the mean annual runoff of Datong Hydrological Station ( $9,150 \times 10^8 \text{ m}^3$ ), exceeding the runoff sum of the Huanghe (Yellow) River, Huaihe River and Haihe River, and playing an important part in the flood regulation in the middle and lower reaches of the Changjiang River. The flood and drought situation, and the scouring and depositing of Poyang Lake are controlled by the interaction between the Changjiang River and the five rivers.

According to the numerical dynamic simulation of water movement at the middle reaches of the Changjiang River, the water stage at Hukou Station would rise 0.6–1.0m in the drought season if the outflow of the Three Gorges Reservoir increases by  $1,000\text{--}3,000 \text{ m}^3/\text{s}$ , the affected area only being limited within the region of north of the

Xingzi, at most as far as the Duchang, 80km from the Hukou Station. But in flood season, the water stage changes in the Changjiang River have greater effect on the lake. If the outflow of the Three Gorges Reservoir increases by  $5,000-7,000\text{m}^3/\text{s}$ , it would lead to a series of impacts on the ecological environment of the lake. In the case of releasing clear water, channel erosion would intensify, which would lead to sediment deposit in the reaches near Hukou and the sand barrier would develop further. Because the entrance to the Changjiang River became narrow, the water current flowing into or out of the lake was blocked, the hydrological situation and the scour and silting law of the lake area would change, so the influences would be much greater.

Because the Three Gorges Project will reduce enormously the fry source of the four farm fish in the middle and lower reaches of the Changjiang River, and the serious destruction to the spawning places by Wan'an Hydroelectric Power Station in the Ganjiang River, the fish resources will be on the decline in the lake area.

In every autumn and winter, with the river level falling, large places of wetlands in Poyang Lake formed, which attract thousands of precious birds, and become the overwintering habitat. Some of the birds, such as white crane, belonging to the first or second class protected precious and rare birds in China, were concerned by people at home and abroad, including Britain, prince, Philip. In Poyang Lake region, about  $224\text{km}^2$  at home habitat were designated as national natural protective area. After the construction of the reservoir, if the outflow decreased, the water stage at the habitat would fall correspondingly, which would make different wetlands appear ahead of seven to fifteen days. In the case, it is not beneficial to the protection of the rare and precious birds.

The effect on the lowland paludification and gleization in the middle reaches of the Changjiang River basin is another important question. There are cultivated land of  $1,133 \times 10^4\text{km}^2$  in the river-net plain of the middle reaches of the Changjiang River basin. The enclosed tide lands, islets and beaches can be found everywhere because of long term reclamation and lake deterioration, Nanjing Institute of Soil Science, the Chinese Academy of Sciences, made estimation about the possible maximum scope of this effect based on the investigating results now available. In the four grand lake areas (i.e. Dongting Lake, four lakes, east Hubei Province and Poyang Lake), and the shoaly land and beaches along the Changjiang River, the proto-swamp type and gley paddy soil area that may be affected is about  $66.7 \times 10^4\text{hm}^2$ . Because the rising and the lag lower water table, the influenced cultivated land area is about  $30.6 \times 10^4\text{km}^2$ . On condition that the water stage of the river is high and the rainfall amount is more than 300-400mm from January to May, it is hard to avoid the influence of the Three Gorges Project upon the farm land in these regions. But in many aspects of the question, the opposite conclusions have been reached, based on its own de-

tailed investigations, by the Bureau of Changjiang River Water Resources Protection.

## V. THE EFFECT ON ESTUARINE ECOLOGY AND ENVIRONMENT

Estuarine is a sensitive ecological system. From Datong, Anhui Province (tidal compartment boundary line during dry season), downstream to the front of underwater delta, the Changjiang River estuarine is about 700km long. It is a large-scale, medium-strength, branching tidal estuary that has abundant water volume and sediment. The scope of the mouth has been enlarging and the coast extends at the speed of 50m per year. The 10m isobathic line of the seacoast extend yearly 40m, on an average, in the last a hundred years. After the construction of the Three Gorges Reservoir, the changes of the estuarine hydrological condition and sediment transportation will have effect on the river estuarine development and ecology and environment.

The coast line is 450km long in Shanghai City, in which the eroding coast line accounts for 48.44 percent, and the silting one 37.94 percent, rest 13.62 percent being at the state of score and silting equilibrium. The sediment of the river mouth come mainly from the upper reaches of the Changjiang River (Chuanjiang River in Sichuan Province). The formal record of mean annual sediment discharge at Yichang Station is  $5.3 \times 10^8$ t, in which  $4.68 \times 10^8$ t of sediment flow into the East Sea. After the building of the Three Gorges Dam, the sediment discharge flowing into sea will have a tendency to decrease, which will lead to the results that the coast erosion around the Nanhui district would aggravated. So will the other coast bands of Shanghai City. Therefore, the effect on the coast safety of Shanghai City can not be underestimated.

Sea water intrusion endangers industrial and agricultural production and people's health. It is harmful to the coast of the river mouth, especially to Shanghai City. According to the planning reports of the Three Gorges Project, the reservoir outflow will increase from January to April every year. It is no doubt that this will be useful to avoiding sea water intrusion in the tidal estuary region. But every October are the storage time of the reservoir. The outflow discharges reduce by several thousand cubic meters per second, which will result in Shanghai City and tidal estuarine region being in the danger of sea water intrusion. If we consider the South-to-North Diversion Project (from the Changjiang River near Shanghai to Beijing) will reduce the Changjiang River discharge flowing into the sea, the problems that the sea water intrusion in every October during reservoir storage time can't be neglected.

The another problem connected with sea water intrusion is soil salinization within the river mouth region and the coastal area. It is estimated that the possible maximum affected



range is about  $2,000\text{km}^2$  from the viewpoint of long-term and potential influences. The variable environment factors and fragile ecological system have formed under the interaction between the Changjiang River runoff and the sea current, the saline water and fresh water. After the building of the dam, the downstream discharges will be controlled by man. Therefore the natural state of the runoff flowing into the sea will change to some extent, which will affect the growth and decline relation among the Yellow Sea water, Taiwan warm current and the Changjiang River fresh water, as well as the scope and position of the central fishing ground. There are both advantageous and disadvantageous aspects in these effects.

## **VI. THE EFFECT ON THE ENVIRONMENTAL GEOLOGY OF THE RESERVOIR AREA**

The Three Gorges region cuts across parallel valleys in the east Sichuan Province and mountainous lands in the west Hubei Province. There are always many landslips and mud-rock flows and weak earthquakes in these two large geomorphologic units. Within the reservoir area there are as many as 214 large and small rockslides and landslide events, and the summed volume is about  $13 \times 10^8\text{m}^3$ . Among these events, the large and extraordinarily serious landslides occurred at 36 places, the land volumes were  $7.5 \times 10^8\text{m}^3$ . During the last two thousand years, there were over a hundred bank caving events in which the serious events were more than forty. Sometimes the channel was blocked. During the last twenty years, the landslide and rockslide in the Three Gorges reaches were in the active period. After the building of the Three Gorges Project, the scope of the inundated area within the reservoir area will expand. The scouring action during the high level, the dynamic hydraulic pressure and the soaking action will enhance, which will accelerate the slip or result in revival of the ancient landslip bodies and make these successive geologic disasters occur more frequently.

It is necessary that hundreds of thousand of people or even up to millions people move their residences. Therefore the human activities will intensify promptly within short time. This is also one of the important reasons that give rise to mountainous disasters. At the dam site, Sandouping belongs to a weak earthquake area, there is not geological structure that will lead to violent earthquake. But there are conditions inducing earthquake at the reservoir area. One of the regions where earthquake may be induced to happen is from Miaohe to Xiangxi, another is from Niukou to Xinling Town, Badong County. The grade of earthquake is below ( $M < 6$ ). If the earthquake in the Three Gorges Reservoir bring about the earthquake in Gezhouba Reservoir, it will threaten the security of the Yichang City<sup>(5)</sup>. In a word, after the construction of the Three Gorges Reservoir, the original state of adverse surrounding geology may get worse further. Close attention must be paid to the encounter of the different kinds of disasters.

## VII. OTHER EFFECTS

With respect to human health, *Oncomelanta stchuan* are separated from the *Oncomelanta hupensis* at the present time in the reservoir region. After the building of the dam, whether they would combine together or not and the blood fluke epidemic disease be prevalent in the reservoir region should make further investigation and prevention.

After the storage of the reservoir mercury and other heavy metals and radioactive pollution in the deposits of the reservoir will increase. The sediment accumulation and the water pollution near Chongqing Port should be paid attention to.

The Three Gorges of the Changjiang River is one of the ten famous scenic spots of China. After the building of the dam, the extremely excellent scene will weaken to some extent. The Three Gorges region is the home town of Ba-Chu culture. There are a large number of invaluable cultural relics and places of historic interest from the Stone Age to today, more than five thousand years. For example, the famous Daxi ruins, the ancient graves from Zhangou to Tang, Song dynasties; Zhangfei Temple, Shibao mountain stronghold, ancient plank road built along the face of a cliff, coffins in the cliffs etc. from the Eastern Han Dynasty to the Ming and Qing dynasties. They have formed a long historic cultural veranda. After the building of the dam, many cultural relics and historic sites, such as the underwater forest of Steles in Fuling "stone fish", which reflect the hydrological history of the Changjiang River, will be inundated forever. Only part of cultural relics may be removed and saved, for which, a high price will be paid.

## VIII. CONCLUSIONS

In sum, building a large dam on the middle reaches of the Changjiang River will break the continuity law of a river as the original pattern of river ecological environment in each reach of the Changjiang River. The ecological and environmental problems of the Tree Gorges Project are extremely important and complicated. The construction of huge water conservancy project on the Changjiang River will lead to widespread and profound influence on the whole river basin. It is true that "pull one hair and the whole body is affected". Some impacts are obvious and realistic but the others are potential. Among them the problems of the biological diversity and "a million emigrant" are extremely important.

Through the overall systematic analysis, the conclusion is drawn that there are both advantageous and disadvantageous aspects in the effects of the Three Gorges Project on ecology and environment, but the disadvantageous effects are the greater.

The great importance have been attached to the ecological environment problem of the Three Gorges Project. The strict and thorough scientific demonstration of the project is unprecedented in the water conservancy history of China. During the construction of the project and even after completion, it is necessary to make further continuous investigation on the ecological environment problems and take proper measures, thus, the biggest synthetic economic benefit may be obtained. In this way, the Three Gorges Project, the studies and the countermeasures on the ecological environment problems will synchronously step into advanced level of the world.

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