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Climate, Ecosystem and Migration: The Three Gorges Dam Study

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Abstract: The Three Gorges Dam, known as one of the biggest project items throughout the history, is a milestone for the development of China. Since it was completed in 2006, the dam has been persistently supplying ample electricity to the southern and eastern part of China. Despite its impressive output and benefits notwithstanding, we have to objectively pay our attention to the long-term impact that the Three Gorges Dam leaves to the place where we live, especially the influence on the climate, the ecosystem and the migration pattern of the reservoir area.

Key words: Three Gorges Dam, migration, settlement, geologic hazard, biodiversity, local climate.

1. Introduction

The conception, construction and activation of the Three Gorges Dam has always been one of the most controversial water conservancy projects in China. In 1919, Sun Yat-sen proposed the idea of erecting a dam in the upper reaches of the Yangtze River, particularly the stream segment in Yichang. According to his book *The General Plan of National Construction*, he wrote "Sluices should be constructed to block the flow of water, hence the boat can travel against the water current, and water can be accumulated and used as hydro power." [1].

2. The Historical Dispute of Project

Early as the proposal was, it failed to be implemented due to wars and unrest in China. In April, 1944, the plan was re-conducted and submitted by G. R. Parshall, an American consultant, to the Chongqing Kuomintang government. G. R. Parshall suggested in the report that hydraulic power plant together with fertilizer plant be built in the Three Gorges via the nine hundred million US dollars' loan provided by the U.S. government, and China would refund the debt by exporting chemical fertilizer to the U.S. [2].

In May, 1944, John Łucian Ꞩavage, a civil engineer, was invited to the Three Gorges to verify the feasibility of erecting the Three Gorges Dam. After the on-the-spot investigations for three times, Savage wrote the report *Yangtze Gorge and Tributary Project*, also known as *Savage Plan* [3].

Since the establishment of the People's Republic of China in 1949, the arguments had always existed about whether to build the Three Gorges Dam or not [4]. The in-depth investigation did not set out until 1978 [5, 6] signifying the end of the ten-year-lasting Great Cultural Revolution from 1966 to 1976 [7]. Deng Xiaoping, in July, 1980, inspected the Three Gorges and Gezhouba basin. Showing great concern to the people and the crops in Jingjiang basin, he approved the advantages brought by the Three Gorges Dam in terms of energy output, navigation access and flood protection, and he stated that the aforesaid advantages could reduce economic loss and environmental issues.

The decision of water level went through a range of stages as well. The initial design was to restrict the

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maximum water level within 200 m. In 1984, the Chongqing government suggested to the central government that the water level be 180 m so as to allow ships of ten thousand tons to travel past Chongqing. The dissent against 180 m primarily supported the water level under 160 m because fewer migrants were involved, sediments in the backwater zone were easier to deal with, and the composite economic results were maximized. During this period, Huang Wanli, Dai Qing and Li Rui, on behalf of the opposition, persistently oppugned the project due to concerns about migration, sediment accumulation, ecosystem damage, dyke breaching and the inundation of the upper reaches. Despite of the opposition, the decision was finally made on April 3rd in 1992, indicating the approval of the project. After voting, the height of the dam was unanimously consented to be 185 m, and normal water level would be 175 m.

3. Local Climate and Biodiversity

The erection of the Three Gorges Dam has brought a variety of influences in the reservoir area, and a significant impact is observed on the modes of life and relation to their environment.

The first alteration is the local climate of the reservoir area. As the river basin is artificially modified by the construction of the project, the storage of water is different from what it used to be, which, in turn, triggers changes on the local climate.

From 1988 to 2007, the average annual temperature of the Three Gorges reservoir area was 17.3 to 18.8 ℃. After retaining water in years between 2004 and 2007, the temperatures of those channel segments had increased compared with the average annual temperature. The average annual temperature of the Three Gorges reservoir area was 17.8 ℃ from 1988 to 2007. Among these years, the lowest temperature was 17.2 ℃ in 1989 and the highest one was 18.8 ℃ in 2006. There was an uptrend in terms of the change of the average temperature over the years. Before 2000, there was a relatively large difference between the year-round value and the average annual temperatures, and they presented the up-and-down fluctuations. However, from 2000 onwards, it was the situation that the average annual temperatures were constantly higher than the year-round value by a small degree except for the year of 2006 when the average annual temperature greatly went beyond the year-round value. The average annual temperature in 2007 reached 18.3 ℃, higher than the year-round value by 0.5 ℃. Together with the data after the year of 2000, it could be concluded that the erection of the dam does cause influences on the temperature of the reservoir area.

Apart from Fengjie and Zigui, the relative humidity around the reservoir area had all decreased compared with the year-round value. Overall speaking, the relatively humidity of the west reaches was highest, especially the part from Chongqing to Wanzhou whose relative humidity could reach 80%. The middle reaches had the lowest relative humidity which was around 68% to 71% along the channel segments of Fengjie to Zigui. The east reach of Yichang had a relative humidity of 75%, higher than that of the middle reaches but lower than that of the west reaches. The average annual relative humidity of the reservoir area was 76.4%. From 2003 to 2007, the decrease of relative humidity had been very significant as water was retained during this period of time.

Among the reservoir area, all channel segments were ample in terms of the amount of precipitation. From Fengjie to the west, the amount of precipitation was relatively high. From Wushan to Zigui it was relatively low, but it became high again in Yichang, east of Wushan-Zigui channel segment. The amount of precipitation was overall high in the reservoir area. From 1998 to 2007, the mean annual precipitation reached higher than 1,000 mm, among which Wanzhou ranked 1st with 1,129 mm. However, after retaining water, the annual precipitation began to fall except regions of Chongqing, Yunyang and Badong, and there was a downtrend of the amount of precipitation.

In terms of terrestrial biodiversity, there had also been noticeable changes. Due to climate, food, environment, human activities, pests and the retaining of water in the reservoir area, occurrence of forest pests had been predicted to increase fiercely. Albeit the increase of forest coverage from 26.7% in 1996 to 27.3% in 2000, vegetation cover was still at a level of degrading. Among all types of vegetation, the shrubbery accounted for the greatest proportion, and its varieties and functions were least affected by the effect of inundation. However, for the area of grasslands and their quality, the structures had been changing, showing a trend of degradation. The completion of the reservoir would also make this region the largest constructed wetlands on the upper reaches of the Yangtze River, which would largely affect the constitution of the number of birds and the type of birds. Comparing the period before and after retaining water, 11 species of birds declined noticeably. In all, there were 6,088 types of advanced plants in the reservoir area. The most direct effect of storing water to the terrestrial plant was that the sphere of activity would decrease due to inundation. Three hundred (300) types of terrestrial plants were affected by inundation, and 6 of them were rare or endangered species. As for terrestrial animals, there were 575 types of species. From the examining report during 1997 to 2008, the biodiversity was maintained at 575 types, and the returning of the grain plots to forestry and preservation of habitats contributed to the protection of animal species.

In relation to the aquatic biodiversity, there were changes as well. As the rate of water flow decreased, the self cleaning capacity of the reservoir area decreased, so types of algae increased from 79 to 151, triggering impact on the ecosystem of the area. As with algae, plankton species increased as well as a result of the lower rate of water flow. In 1980s, there were 196 types of fish. After storing water in the reservoir area, the habitat of fish was greatly affected. During construction, the types of fish were as low as 63, but types increased after 2003, although still lower than the figure of 196 [8].

4. Water Soil and Geologic Hazards

Some changes were on the land use of the reservoir area. After the construction and the completion of the Three Gorges Dam project, the reservoir area had shown such significant features: large increase of water areas and relative decrease of terrestrial areas. The impact of the construction on the land use mainly took place after water storage. Area of cultivated land decreased from 38.16% in 1995 to 36.98% in 2007. From 1995 to 2007, water area increased from 1.41% to 1.76%. The proportion of forest increased as well, slower rate notwithstanding. It increased from 46.99% to 48.64%.

Water loss and soil erosion had been a problem for the reservoir area since very early days, but effort had been paid to reduce the situation. In 1980s, the area affected by the problem was 38,823 km^2, but it was effectively reduced to 29,559 km^2. Since 1998 onwards, projects of conservation of water and soil were conducted on the upper reaches of the Yangtze river, preservation of natural forests and returning of the grain plots for forestry were supported too. Hence, effect had been significant on protecting plants species, decreasing water and soil erosion, blocking sediments and storing water.

The ecosystem of the Three Gorges Dam reservoir area had undergone huge changes, so had the water environment. Damming the river on the upper reaches largely alters the river flow and the characteristics of the hydrology and sediment. Moreover, due to the deficiency of regulations, enormous amount of sewage was discharged directly into the Yangtze River, deteriorating its self cleaning capacity and its water quality.

Affected by global warming, the annual runoff of the Yangtze River had shown the tendency of gradual fall. From 1998 to 2007, notwithstanding fluctuations, the volume of runoff constantly fell year by year.

However, as water had been stored since 2003, the volume began to increase by small scale gradually except the drought taking place in Chongqing and Sichuan in 2006. As for the sediment runoff, it continuously dropped from 707 million tons in 1998 to 52.7 million tons in 2007. As with the sediment runoff, the sediment delivery modulus demonstrated a downtrend from 1998 to 2007 as well.

From 1998 onwards, huge effort was made on conservation of water and soil, natural forest protection and returning the grain plots to forestry. These activities effectively enhanced the efficiency of the Three Gorges Dam construction, and water environment was also preserved to a great extent. As a result, the sediment charge and the erosion area were reduced in the reservoir area, hence improving the water quality in terms of water transparency.

According to the result of the detection data, the water quality of the main stream of the Yangtze River had always remained at a relatively high level. After retaining water since 2003, the water quality has shown a tendency of improving. The main sources of pollutants in the river are petroleum substances, CODMn (permanganate indices), ammonia nitrogen, total lead and mercury. As time proceeded, the amount of pollutants also showed the tendency of dropping since water has been retained in 2003. Total nitrogen and total phosphorous are always important index for determining the water quality of a body of water.

The nitrogen and phosphorous pollution showed an uptrend from 2003 to 2005 but then showed a downtrend from 2005 onwards. The amount of total nitrogen from 2003 to 2007 remained high, indicating high level of pollution. However, the amount of total phosphorous was relatively less, meaning less pollution.

Different from the main stream, tributaries performed poorly in terms of the water quality. Due to the poorer self cleaning capacity compared with the main stream and the close distance between highly polluting enterprises, the storage of water led to greater impact on the tributaries. Sanitary wastewater and industrial effluent were all discharged into the tributaries of the Yangtze River without sewage treatment, therefore causing decrease in water flow rate and causing eutrophication, further shifting the rivers into lakes and degrading the water environment and water quality [8].

The main geologic hazards in the reservoir area are earthquakes, landslides, collapses and mud flows. Many factors contribute to the occurrences of hazards, for example, the rise and fall of the water level, tectonic movements, intense rainfall, etc. Those hazards, in turn, lead to damage and instability to the ecological condition of the reservoir area [9].

Some monumental events can effectively substantiate the increase of geologic hazards. In November, 1996, the damming project had officially started. By that time, there were 125 earthquakes below magnitude 2.0, 41 earthquakes between magnitude 2.0 and 2.9 and 7 earthquakes between magnitude 3.0 and 3.9, and this number remained relatively stable until May, 2002, when cofferdams in the upper reaches were bombed. By that time, there were 153 earthquakes below magnitude 2.0, 57 earthquakes between magnitude 2.0 and 2.9 and 4 earthquakes between magnitude 3.0 and 3.9. However, in June, 2003, when the storage of water had been officially started, the number of earthquakes below magnitude 2.0 dramatically rose to 507, while the number of earthquakes between 2.0 and 2.9 and between 3.0 and 3.9 were 33 and 1 respectively. As the migrants were gradually settled, the generator sets were started step by step and the water level progressively reached 156 m, the frequency of earthquakes rose as a result. In 2008, the number of earthquakes had reached its peak. In total, there were 2,001 earthquakes below magnitude 2.0, 105 earthquakes between magnitude 2.0 and 2.9 and 14 earthquakes between magnitude 3.0 and 3.9. Although the number of earthquakes had been intentionally controlled since 2008, the number still exceeded that

before the Three Gorges project was started, and the lowest number recorded was 403 earthquakes below magnitude 2.0 and 10 earthquakes between magnitude 2.0 and 2.9 in 2011 [10].

5. Power Station and Migration

The Three Gorges hydroelectric power station is one of the largest hydro-power stations in the world, and together with its function of water storage, an estimation of 1 million local residents were forced to migrate as their residences were either inundated or removed for construction purpose.

This process of construction, inextricably, involved migration and the impact on the migrants. Thus, an investigation was done in Chongqing, Sichuan Province, Shandong Province and Shanghai since 2007 August to 2008 May so as to further discuss the conditions of the migrants after migration and influences left on them. The investigation focused on 41 migrants, among which 20 were males and 21 were females. The oldest interviewee was 75 years old while the youngest was 17, and the average age of the interviewees was 48. Besides, 15 government officials from different destinations responsible for the settlement of migrants were interviewed to appraise the migration from another point of view.

Among all the interviewed migrants, a majority of them mentioned that they were currently at a poor state of physical condition with illnesses of different degrees for different individuals. High blood pressure, heart disease, apoplexy, bronchitis and backache are common illnesses, according to the interviewees. Although some migrants said that illnesses had been troubling them before migration, there were still a number of people ascribing the cause of illnesses to the forced migration. This phenomenon, however, contradicted with the words of most government officials who stated that the physical conditions of migrants remained well or even improved after arriving at the destinations overt time.

Through the investigation, it was found that a great number of migrants were troubled by psychological problems. Most concerns about life concentrated on economic pressure, the education of their children, employment issues, health problems and problems of adaption. In terms of the officials, they deemed that many migrants had exorbitantly high expectations to the restitution of migration. Besides, many of them had problems of imbalance, complaints, reliance and agitation. Also, they were exclusive and they regarded themselves as the priority, according to the officials.

The housing conditions had greatly changed for migrants. Migrants who were satisfied with the new residences were mostly migrants who only migrated a very short distance from their sources. However, migrants in Tongliang village located in Chongqing and migrants in Shandong Province complained that the housing conditions were poorer in terms of the housing quality, the housing area, and the housing relief.

Half of the migrants mentioned that the security was poorer compared with their sources. Thefts and robberies became more common as they reached their destinations.

As for the aspects of traffic, medical service and education, most migrants were satisfied, though very few migrants complained that the distances between their kids' schools and their homes were far.

The migration greatly influenced the sources of income for the majority of the migrants. Only a few migrants continued earning a living via agriculture. For migrants who moved over very short distances, their land resources declined compared with the past, so the younger generations in the family chose out-migration for work, which was one of the main sources of income. Additionally, their identities of farmers were switched into urban dwellers. For the elder generations, they had to rely more on their children. Apart from those changes, the farming method had also altered for migrants who still went in for agricultural production. Human farmers were replaced by machines, and tradition farms were transformed to feed lots.

Many migrants mentioned that the level of consumption of destination areas was too high despite some migrants reaching Shanghai and enjoying higher living standards. The problem focused on short-distance migrants. Although they migrated over short distances, the storage of water caused decrease of their land resources, and the construction of new houses in destination areas may add burdens to their savings, income and life quality.

The problem of adaption existed mostly among migrants who migrated over long distances. Adapting to the dialects, the custom, the food and the climate were reported to be challenging, but most migrants managed to overcome the problems and successfully adapted to the new environment.

After migration, almost all migrants kept in touch with friends and relatives in the sources areas by phone calls or occasional visit to their sources. Migrants could maintain a friendly relationship with one another, and most migrants developed a friendly relationship with people in the destination areas. Some migrants had very few contacts with the people in the new environment. Few migrants mentioned that they had a feeling of being discriminated, and very few migrants had big conflicts with people in the destination areas.

Some other problems were listed as the investigation went deeper. One major issue was the decline of resources for those migrants who only migrated within the village, town or city. This problem was further intensified by the deficiency of restitution. Beside this issue, as some farmers were switched into the identity of urban dwellers, they lost land and the welfare that could only be enjoyed by farmers. Employment could trouble those migrants as they reached a new environment. Moreover, it was common to see that many migrants felt unfair about their current situations, hence they were considered as the latency which could cause insecurity in the society [11].

6. Conclusion

In conclusion, the erection of the Three Gorges Dam is one of the biggest projects throughout the world regardless of any aspect [12]. While the eastern and the southern China are enjoying more than one hundred billion kilowatt-hours of electricity each year from the Three Gorges Dam, it is extraordinarily important to keep in mind about the influence of the project on the geologic condition, the water environment, the ecological system, the movement of migrants and the distribution and planning of the settlements in the reservoir area. As a whole, the development of one region should never sacrifice the future of the other. Although the project has been completed long before, the subsequent care to the people, to the animals and to the environment still has a long way to go. Thanks to the improvement of infrastructure, China is undergoing steady process of development, but eliminating poverty and ecological damage is equally indispensable if an advanced society is the ultimate goal.

Disputes about the validity of the project ought to come to an end. Humans now have possessed power, which is greater than ever before, and then we have shifted from roles merely obeying the natural laws to challengers daring to change the environment surrounding us. While this decision seems to be the result of a random voting from Chinese officials, it is indeed an inextricable step for China to approach the standard of the developed countries. From this point of view, the construction of the Three Gorges Dam is reasonable and inevitable. After all, achieving progress and acquiring higher standard of living should be the pursuit of every human being, and building this dam perfectly suits this beneficial goal. Nevertheless, the forthcoming future is certain and irreversible that the weather is becoming hotter, and the living conditions of the human civilizations are deteriorating. As long as human beings still exist, the question revolving around us and the land where we live would never stop to be mentioned. Therefore, it is crucial to make meticulous consideration before making every decision on our homes and to show

solicitude for every subsequent outcome so as to protect where we live. Every single behavior at present determines the future of our next generation, and we, human beings, shall be the bravest species persistently overcoming difficulties for the sake of survival.

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