



# Ecological Effects of the South-to-North Water Diversion Project on the Hanjiang River

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The middle and lower reaches of the Hanjiang River are the center of local economic development in the region. For a long time the mother nature's mighty force and mankind's infringement have led to a series of ecological problems, such as flooding and water-logging calamities, droughts, soil erosion & water loss, downgrade of environmental quality, shrinkage of wetland resources, posing threats to the

valley's sustainable development. The middle route of the South-to-North water Diversion Project will offer unprecedented opportune chances for the local development. However, it will reshape the flowing volume and seasonal distribution of the water resources in the River's main waterway downstream off the Danjiangkou Reservoir, imposing influences in varied degrees on the anti-flood water-works, water quality, riv-

erside industrial or farming undertakings and urban development.

To promote a sustainable development in the River's valley, the authors of this article suggest that efforts should be made to conduct a systematic and comprehensive evaluation on the project's impacts on the local ecological surroundings and socio-economic development, and to actively push forward a modern demonstrative model for water conser-



The giant dam at the outlet of the Danjiangkou Reservoir.



vancy in the valley.

The central route of the ambitious South-to-North Water Diversion Project is a center piece for the national efforts to transfer water from the humid south to arid north, a grand and strategic engineering initiative to meet the water demands of the north China. It is an urgent task to alleviate the water shortage in north China by readjusting the spatial distribution of water resources in Chinese heartland. Its operation will exert a far-reaching influence on China's sustainable development in the social and economic aspects. Because such a huge water shipment through different valleys is a complex and systematic project, its impacts on the water source region are an extremely complicated issue. Without the help of a long-time and systematic hydrological monitoring and related research, it would be difficult to reach a scientific conclusion about the impacts. The middle and lower reaches of the Hanjiang River are Hubei Province's breadbasket and hub of manufacturing industries, acting as a powerhouse for the economic development in the valley. The water-shifting project will change the annual run-off and seasonal distribution downstream off the Danjiangkou Reservoir, making impacts in various degrees on inland navigation, water quality, farming irrigation, industrial production and urban reconstruction, imposing a direct bearing on sustainable development of the valley in the new century.<sup>[1,2]</sup> So the water-shifting program will bring in both opportunities and challenges for the whole valley and needs a careful study.

## I. An Overview of the Valley

Originating from the Qinling Range in Shaanxi Province, the Hanjiang River is the largest tributary of the Yangtze, with a full length of 1,557 km and a drainage area up to  $15.9 \times 10^4 \text{ km}^2$ . Danjiangkou and Nianpanshan separate the river into upper, middle and lower reaches. Its valley is located on the transitional belt between arid north China and humid south China, serving as a linkage between the two regions. It is also a water transport passage, through which coal is shipped from the north to south and petroleum from west to east. It is expected to play a critical role in the all-round development of the central China for the new century.<sup>[3,4]</sup>

### 1. Natural environment

The middle and lower reaches of the Hanjiang River are situated in the low-lying heartland of Hubei Province. Its mainstream is 652 kilometers in full length, running through 28 counties and cities with a total drainage area of  $6.4 \times 10^4 \text{ km}^2$ , including  $4.6 \times 10^4 \text{ km}^2$  within the borderlines

of Hubei Province.

The valley is predominantly subject to a sub-tropical monsoon-dominated climate with 800–1,100mm in annual precipitation, which is usually concentrated in the period from May to September. The uneven spatial and temporal distribution of the rainfall makes the region vulnerable to various calamities such as flooding, water-logging and drought. It has a surface run-off trove up to  $137.1 \times 10^8 \text{ m}^3$  and underground water storage up to  $55.8 \times 10^8 \text{ m}^3$ . After the deduction of repeated calculations, its water resources yielded from the province itself has been registered to  $148.1 \times 10^8 \text{ m}^3$  while the annual average of water resources flowing in from other provinces comes up to a total of  $404.4 \times 10^8 \text{ m}^3$  with a relatively lower figures per capita and per hectare of water resources<sup>[5,6]</sup>.

### 2. Socio-economic development

The middle and lower reaches of Hanjing River are noted for their fertile and broad land mass, huge population, economic prosperity, and abundance in natural endowment. In



Danjiangkou Reservoir.



2000, the area yielded  $815 \times 10^4$  tons of grain and its industrial output value was 140.3 billion yuan, accounting for 45.8% of the provincial total. Its GDP reached 155.7 billion yuan, making up 36.4% of the province's corresponding figure.

The area is a national base for developing comprehensive and environment-friendly farming production and diversified economies in the countryside as well as main producers of cereal, cotton and edible oil in China. Out of the 100 top cereal- and cotton-yielding counties across the country, nine and 15 are in the area respectively. Its fresh water aquaculture is well-known for its fish-farming potential and now becomes one of the largest inland aquatic bases throughout the country. Because of

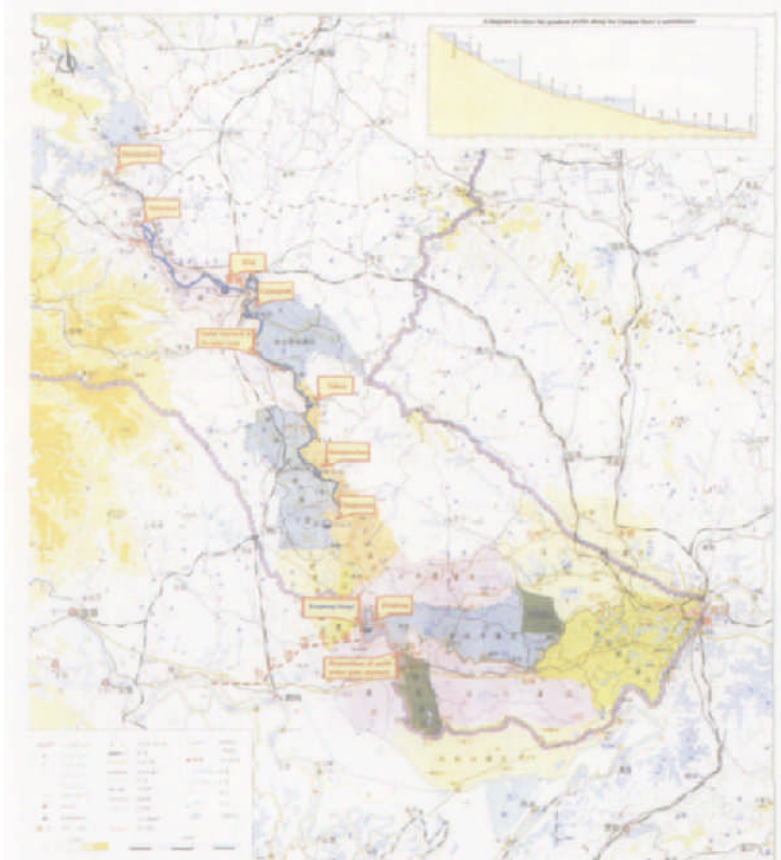
its urbanization and industrialization of farming yields processing at the national frontline, the Hanjiang River valley now acts as a powerhouse for the Province's economic development. The region along the river's mainstream between Wuhan, capital of the province, and Shiyang city is a flourishing belt of the automobile manufacturing industry.

Thanks to the half-a-century strenuous efforts, an engineering system capable of bringing floods and water-logging calamities under control takes its initial shape, featuring its riverside embankment and Danjiangkou Reservoir. Including the flood-diversion area at Dujiatai and 14 civilian reserves for flood storage in a rainy season, the system now can stand against the worst deluge

once in every 20 years. In addition, an accessory network is put into operation for regulating the geographic layout of the water resources, which is composed of 1,471 reservoirs in varied sizes, totaling  $63.7 \times 10^8 \text{m}^3$  in aggregate storage capacity. Its irrigation culverts and riverside water gates can supply  $128 \times 10^8 \text{m}^3$  of the river's water to farmlands each year. So, in a normal year, the system is able to meet the demands for water consumption of industrial or farming undertakings in the area. Along the river's mainstream, a cascade-shaped engineering system is designed to conduct an all-round exploitation of the water resources in the valley, functioning as a key project of water conservancy for hydropower generation, inland navigation and water supply. Its inauguration will lay a solid foundation for the rational utilization of the valley's water resources and modernization of the whole area.

## II. Major Eco-environmental Problems

The sustained development of the water resources is a precondition to the whole area's sustainable development. In the wake of the rapid progress scored by the local socio-economic development, the pressure on the carrying capacity of the local environment and resources is on rise, leading to a variety of ominous developments in the area, including higher frequency of flooding, water-logging and drought events, intensified soil erosion and water loss, water quality degeneration in the area's hydrological setting, shrinkage in the



A diagram showing the gradient profile along the Hanjiang River's mainstream.



area's wetland resources and snagged management system. This has become a restrictive factor for the valley's sound development.

### 1. The uneven precipitation distribution leads to an increase in floods and droughts

Since the 1950s, the area has been hit by seven disastrous floods. As the standards for the anti-flooding engineering projects were not high enough, a 581-km-long substandard embankment in the area failed to reach the designing requirements. Most riverside reserves for flood diversion could not work properly when put in operation. The result was huge economic losses inflicted by the flood diversion. In the middle reaches of the river, there are many knolls or hilly districts, where the lack of a well-functioning setting for water storage led to their unfavorable climatic conditions and exotic landforms. After a downpour, it was very difficult to make use of the runoff as the latter is running away very soon or leaks beneath the ground while the underground water table is quite low and its volume is few in quantity. As the topsoil vegetation is poor in water conservation, the area is vulnerable to serious droughts when the precipitation becomes lower than the annual level in average and the evaporation is so strong and just because of these reasons, seven disasters of drought have struck the area over the latest 50 years. The most disastrous one occurred in 2000 when a drought spell possibly to attack the locality once in 100 years hit the middle and lower reaches of Hanjiang River, leading to



A map showing the central route for the national water diversion program.

local people forced to drill wells for their survival and the River's branch Dongjinhe had its normal flow dried off temporarily. The socio-economic losses were enormous.

### 2. The water loss and soil erosion are not under control while the environment is seriously polluted

The total area affected by water-and-soil losses in the middle and lower reaches of Hanjiang River reaches  $1.2 \times 10^4 \text{ km}^2$  and the eroded soil totals  $2,500-4,900 \times 10^4$  tons per year. Middle or low elevation hilly areas are the main victims of the scourge with the main nutrients such as nitrogen, phosphorus and their salts

immediately slashed down into the River as pollutants while the majority of the urban sewage and industrial wastes are pouring into the River flows without treatment, causing the serious pollution of the nearby water bodies. In 2001, the total discharge volume of waste water in the whole region reached  $7.196 \times 10^8$  tons and the figure for chemical oxygen demand (COD) was  $22 \times 10^4$  tons, accounting for more than 30% of the province's total. Among the 19 water quality monitoring sections in the eight major branches of the River's lower reaches, 17 failed to meet the standards for the functions of its division, and the water quality in different river sections in Xiangfan, Wuhan and



other urban centers mostly reached its critical value. In 1992, 1998, 2000 and 2003 respectively, Hanjiang River was hit by the outbursts of the algal bloom with increased frequencies and enlarged areas.

### 3. Wetland shrinkage and ecosystems depletion

The middle and lower reaches of Hanjiang River used to be noted for their flourishing wetland systems dotted by streams & creeks, ponds, marshlands, paddy fields and aquatic farms. Because of the intensive efforts of creating farmlands by reclaiming the lakeside wastelands during the period from the 1950s to 1970s, the original taxonomic structure, faunal or floral population's composition in the pristine riverside surroundings were reshaped, leading to drastic reduction of the migratory fishes, depletion of waterside ecosystems, and deterioration of the hydrological setting in the region. The aftermath is calamitous, including the more frequented disasters, soil erosion at water heads and drought spells. As a result, both structure and function of the once sound wetland ecosystem become more vulnerable to external pressure and its bio-diversity declines in an accelerated way.

### 4. Poor management of water resources

The management of water resources in the middle and lower reaches of the Hanjiang River is plagued by rampant departmentalism and unclear definition among the different authorities. The lack of a workable regional statute and advanced

managerial means gives rise to many institutional snags and ill-conceived policies. What is worse, outmoded equipment, backward technology and poor operation lead to low exploitation and utilization rates. At a residential center, the aged water-supplying pipeline is too old to prevent the water waste through dipping, leaking, draining and over-rimming. At the same time, the residents show little frugality in daily water consumption.

## III. Impact of the Water Diversion Project on the Region

The middle route project is planned to shift a total of  $130 \times 10^8 \text{ m}^3$  each year from humid south China to the arid north. The figure is  $95 \times 10^8 \text{ m}^3$  in its first-phase enforcement. The shifted amount accounts for about one third of the total runoff at the outlet of the Danjiangkou Reservoir. This will change mainstream influx and seasonal distribution in the middle and lower reaches of the Hanjiang River, leading to a series of secondary changes in varied degrees in the following aspects: anti-flooding situation, river route sedimentation, water quality, navigational activities, farming irrigation, industrial production and urban development.

### 1. The changes in the flood management situation

When the water diversion program is put into operation, the number of days when the water flow is up to  $800\text{--}1,000 \text{ m}^3/\text{s}$  in the middle or lower reaches of the Hanjiang River

will decrease by about 20 days each year while the figure for water flow up to  $1,000\text{--}3,000 \text{ m}^3/\text{s}$  by 100 days a year. So, the silting situation of river water will undergo changes, causing negative impact on flood mitigation efforts. On the other hand, with the dam height of the Danjiangkou Reservoir to be increased, the reservoir's storage capacity will be going up accordingly and the anti-flooding norms set for the middle and lower reaches of the River will be uplifted from the effective containment of a deluge occurring once for 10-20 years to that once for 100 years. Hence the anti-flooding status for protecting the whole valley's socio-economic development will be greatly improved and the 14 civilian river-side enclaves previously designated for flood diversion will be out of work. Because of the reservoir's water storage increase in addition to a new project to diverting water from the Yangtze to Hanjiang, the flowing flux discharged from the reservoir will be growing up dramatically during a dry season, balancing the yearly distributive layout of the water resources across the whole valley.<sup>[5,9]</sup>

### 2. A drastic change in the mainstream's ecosystem

After the completion of the water diversion program, it is expected the runoff volume in the middle and lower reaches of the River will decrease by 16%, and the total capacity of the region's water environment will see a slight drop, leading to an uphill situation for the prevention of water pollution and ecological protection. Since the River's water flows see a



drop downstream the city of Xiangfan, the speed of water current will be retarded and the water level stabilized. This new hydrological condition will weaken the river water's capability of self-dilution and self-purification, resulting in outbreaks of the algal bloom due to eutrophication of the water quality. This will also give rise to a declining impetus to the local fisheries and native hydrological setting, rendering economic losses to the related production departments. In addition, the initiative will lower the average water level in the valley's water routes by 0.29–0.51m and hence, the water consumption cost will be going up. In the wake of the heightened water level in the reservoir, the discharged water temperature will be lowered, causing an unfavorable influence on the flora and fishing resources in the waterways. If the water quality cannot be ameliorated effectively, the aquatic life populations will be further decimated. Another long-standing scourge in the valley is the desertification which is well-known in south China. So far the desertified land in the valley has reached 1,300 square kilometers in total area. With the lowered water level in the River, an additional area of newly emerging beach lands, sand bars and shoals is estimated to ap-

proximate 1,200 square kilometers. With some of the Yangtze currents brought into the Hanjiang mainstream as a result of the enforcement of the new water diversion plan, the River's influx will have half to be replaced by the Yangtze water in its section downstream Gaoshibe in Qianjiang County and its water quality will be worsened as the Yangtze River has a more inferior water quality in comparison with that in the catchment basin of the Hanjiang River. <sup>[3,10]</sup>

### 3. Influences on farming irrigation, industrial production, urban development and inland navigation.

The lack of water to irrigate the farmlands in a dry season in the middle and lower reaches of the Hanjiang River has become one of critically restrictive factors to the local agriculture. What is worse, the demand for water will be increasing in the future when more water resources are to be consumed by industrial undertakings, and water-irrigated farmlands will be further expanding. At the same time, more water from the Hanjiang River is to be pumped up to make up the mounting deficiency due to the shrinkage of reservoirs and lakes in the valley while the existing network of the farming irrigation has few, if not, water resources

to meet the demands. In this way, the Hanjiang River will be burdened more heavily as a water source. Upon the completion of the water transfer program, the Danjiangkou Reservoir will supply less water to the River's mainstream, lowering its water level. As a result, less water will be supplied to the riverside farmlands and navigational transport will be further reduced due to the water shortage. In addition, both the urban centers and local populations are densely distributed in the middle and lower reaches of the River and the well-developed industries along the two banks of the River need more water. With the reduction of the navigational lanes' depth, both their width and curvature will change accordingly and more beaches will be surfaced in the water routes. All of these will make the maintenance work for the inland water transport more difficult to perform. <sup>[1,2]</sup>

### IV. Suggestions for Rehabilitation

The implementation of the water diversion program poses both chances and challenges to the region. In order to mitigate the unfavorable influences caused by the program, the national authorities arranges four accessory projects for rehabilitation, i.



A soil and water conservation engineering project in the Valley.



e., water diversion from Yangtze to Hanjiang, Xinglong Pivot Project, Partial Channels Renovation, Partial Sluice Station Renovation. At the same time, the Hubei Provincial authorities made a suggestion for a trial demonstration of the waterworks modernization in this region and making the pre-construction schemes for it. All of these initiatives provide some hard-sought opportunities for the building of a harmonious society. Following the strategic deployment and its enforcement in the drive to enable central China to take off, the middle and lower reaches of Hanjiang River will enter a new stage of soaring development.

### **1. Doing a good job of the macroscopic investigation and regional scheming work**

The importance and functions of the middle route of the water diversion program and its four accessory projects in the regional socio-economic development have a far more involvement than the role jointly played by several engineering projects of water conservancy. With joint efforts of the national authorities and local governments, the studies on the macroscopic development for the region will speed up the tempo and process in the regional coordination along the Hanjiang River mainstream where the regional development will be based on its abundant water resources. By paying more attention to the exploitation of the water potentials instead of its threats in the region, and by building up a well-concerted and sound industrial structure and economic order to couple the social development with the

regional setting composed of population, natural endowment and the environmental upgrade, it is expected the middle and lower reaches of the Hanjiang River would be growing into a paragon for sustainable development in the province and the whole country.

### **2. Enhancing a unified system of river management**

To address the problem of departmentalism, a protective mechanism should be formulated and perfected for the sustainable development of the region, starting from such issues as the organizational guarantee, constructive management, enactment of policies and statutes. A leading group should be set up to regulate and coordinate the sustainable development in the region. In addition, relevant rules and regulations are to be formulated so that an agreeable legal setting is to be provided for rational exploitation of the water resources in the region.

### **3. Speeding up the development of demonstrative projects for the modernization of the region's waterworks**

The demonstrative projects for the region's waterworks modernization, which have been jointly mapped out by the Ministry of Water Conservancy and the Hubei Provincial Government, should be enlisted in the relevant national plans. Furthermore, they should be put in force as soon as possible by taking feasible organizational means and introducing new approaches such as the mod-

ernized concepts of water conservancy and harmony between man and nature. The principles derived from the trinity of rational exploitation, optimized deployment and effective protection must be upheld in their organic integration of the construction of waterworks with economic growth, cultural development, ecological protection and tourism. With the aid of various projects designed for coping with anti-flood safety, deployment of natural resources, eco-environment protection, comprehensive exploitation, Hanjiang digitalization and modernized management, it is expected to solve the following long-standing issues and knotty problems in this aspect: the inferior hydrological norms decreed in the anti-inundation campaign, the low level in the regional development and irrational deployment of the water resources, inadequate intensity in ecosystem protection, the worsening situation of the regional environment, outmoded means in the management of water resources and the public's poor legal awareness of water-related laws and statutes. In this way, the region's social development may be embarking on a new road featuring a harmony between water resources and man, safety in water supply and sound ecosystem, top-performance management and optimized protection of the environment.

### **4. Enhance the effects to protect the environment and control the pollution**

One of the guidelines set for us



to operate the national program of water diversion is to introduce a correct order in our working priorities. Specifically speaking, we have to put the adoption of water-saving measures ahead of the water transshipment; the access to the water-supplying system to be proceeded by the control of water pollution and environment protection is in our top consideration and only after its achievement can we consider the problems and issues about water consumption so that the hydrological setting in an area whose water resources are to be diverted would not be impaired. To achieve this, we must greatly enhance our effects to enact related laws and statutes in a bid to protect our environment and stabilize the financial input into the prevention and treatment of water pollution in the region. Related policies must be formulated as soon as possible in addressing the work on the environment and pollution as an ecological industry when we come to make the formulation and enforcement of related policies. Local governments at various levels have to strengthen their administration of the individual responsibility system and define the targets for sustainable development in a feasible and concrete way. The latter would be enlisted as a compulsory norm for regularly checking up an administrator's personal performance.

### 5. Strengthening the dynamic monitoring and multi-disciplinary research on the local eco-environment

A tri-layered system of

automatic, semi-automatic and artificial monitoring networks should be introduced to keep surveying the main cross-sections of reservoirs, lakes, rivers and the water quality at underground water-supplying wells in the region to make a real-time, dynamic and all-round supervision on the local hydrological environment and provide necessary data for the management, prediction and precautionary alarm of the region's water setting. By forming the supervising network across the region, its various eco-cultural factors such as water loss, soil erosion, bio-diversity, protection of cultural relics and ups and downs in the eco-environmental setting can be made clear at any moment. At the same time, the planned blueprint of water diversion from the Yangtze to Hanjiang has to run through the valley's northern part, Lake Changhu and other ecological zones and the water diversion project's effects on the local agriculture and ecology have to be scrutinized in a meticulous and comprehensive way. On the other hand, because the valley is one of main wetland resources across the country, we have to make efforts to restore its ecological functions by probing the changes brought in by the operation of the water diversion project. Also, the latter's performance leads to various degrees in the uplift and drop of the local water level, and this needs a long-time surveying exertion and related analysis. By taking necessary measures, it is expected the losses may be mitigated to their minimum.

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## NEUROSCIENCE

149 Glial Synapses Found Plastic

## IMMUNOLOGY

150 A Cytokine Preventing Auto-immune Hepatitis

## ASTRONOMY

150 China's Largest Radio Antenna System

## WILDLIFE CONSERVATION

151 Good News from Giant Panda: Population Size Might Be Bigger than Thought

## NEUROSCIENCE

152 Studies Gain Insight into Neuronal Polarity

## ENERGY CONVERSION

152 A Centimeter-sized Micro-energy System

## TRADITIONAL CHINESE MEDICINE

153 Celastrol's Anticancer Mechanism Revealed

## INT'L COOPERATION

154 A Kavli Institute for Theoretical Physics Established at CAS

154 CAS, MPG Set up New Partner Groups in Shanghai

## PHYSICS

155 Less-expensive & Environment-friendly Fuel Cells

## BIOPHYSICS

156 CAS Scientist Receives Trieste Science Prize

## GENETICS

157 A Young Gene Specific to Man Identified

## HUMAN EVOLUTION

158 Advances Achieved on Studies of East Asian mtDNA Phylogeny

## ORGANIZATION

158 CAS to Set up a New Institute for Coastal Research

## Focus

159 Cool Technologies for the "Sky Train"

162 Scientists Urge Protection of Tropical Forests in Asia

164 Scientists Warn of Possible Floods Caused by Melting Glaciers

## Science and Society

166 Ecological Effects of the South-to-North Water Diversion Project on the Hanjiang River

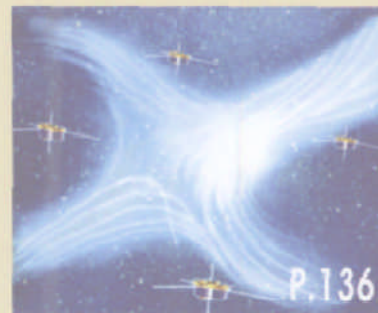
174 Energy Plant Research in China: Overview and Prospect

## Scientists

180 S&T Achievements of CAS Members Elected in 2005 (1)

## Academy and Its Affiliations

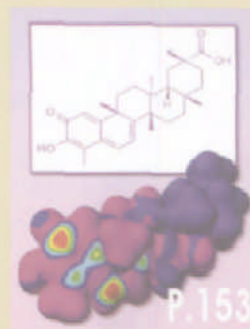
190 Newly Established Key Laboratories at CAS



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