Bulletin of Chinese Academy of Sciences

Volume 35 | Issue 8 Article 1

August 2020

Foundation and Strategy of Well-Coordinated Environmental Conservation and Avoiding Excessive Development in the Yangtze River Economic Belt

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Abstract

The Yangtze River Economic Belt is a major regional development strategy of China, to form the backbone axis of the national "one body and two wings" development and opening-up pattern. This paper systematically analyzed ecological background and status of the Yangtze River Economic Belt, such as ecosystem service value of Yangtze River, ecological location, ecological types, ecological geographic pattern, natural conditions and natural ecological disasters. Then the major ecological and environmental issues were summarized, including serious water and air pollution, dramatic degradation of main tributaries of the Yangtze River and lakes, the increasing cumulative ecological and environmental impacts of major projects, and the unharmonious relationship between rivers and lakes. Finally, four protection strategies were proposed to ensure successful implementation of the well-coordinated environmental conservation and avoiding excessive development in the Yangtze River Economic Belt, including: implementing water quality goals management by stressing water eco-environmental protection of the Yangtze River with the top priority; forming a land and space development pattern dominated by intensive, concentrated spatial development and natural and open ecological space; continuing to implement the green ecological protection project of the Yangtze River Economic Belt; and breaking the division of departments and localities, and implementing comprehensive watershed management.

Keywords

Yangtze River Economic Belt; ecological status; environmental issues; protection strategy

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Citation: YANG Guishan, XU Xibao. Foundation and Strategy of Well-Coordinated Environmental Conservation and Avoiding Excessive Development in the Yangtze River Economic Belt [J]. Bulletin of Chinese Academy of Sciences, 2020 (8): 940–950.

Foundation and Strategy of Well-Coordinated Environmental Conservation and Avoiding Excessive Development in the Yangtze River Economic Belt

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Abstract: The Yangtze River Economic Belt is a major regional development strategy of China to form the backbone axis of the national "one body and two wings" development and opening-up pattern. This paper systematically analyzed ecological status and status of the Yangtze River Economic Belt, such as ecosystem service value, ecological location, ecological types, ecological geographic pattern, natural conditions and ecological disasters of the Yangtze River. Then the major ecological and environmental issues were summarized, including serious water and air pollution, dramatic degradation of main tributaries of the Yangtze River and lakes, the increasing cumulative impacts of major projects on ecology and environment, and the unharmonious relationship between rivers and lakes. Finally, four protection strategies were proposed to ensure the well-coordinated environmental conservation and avoid excessive development in the Yangtze River Economic Belt, including implementing water quality goals management by stressing water eco-environmental protection with the top priority; forming a land and space development pattern dominated by intensive, concentrated spatial development and natural and open ecological space; continuing to implement the green ecological protection project of the Yangtze River Economic Belt; integrating departments and localities to realize comprehensive watershed management.
DOI: 10.16418/j.issn.1000-3045. 20200511002-en

Keywords: Yangtze River Economic Belt; ecological status; environmental issues; protection strategy

The Yangtze River is the first longest river in China and the third longest river in the world. It is the national strategic water source in China and the golden waterway with the highest cargo volume among the inland rivers in the world. The Yangtze River plays an irreplaceable role in China's ecology and water security. Relying on this golden waterway, the construction of the Yangtze River Economic Belt is a major regional development strategy to form the backbone axis of the national "one body and two wings" development and opening-up pattern of China in the new era. In January 2016, General Secretary Xi Jinping emphasized at the Symposium on Promoting the Development of the Yangtze River Economic Belt held in Chongqing that "The Yangtze River, with the unique ecosystem, is an ecological treasure in China. Putting the ecological restoration of the Yangtze River in an overwhelming position to ensure the well-coordinated environmental conservation and avoid excessive development is a goal for now and a long time to come." This is the keynote of ecological priority and green development of the Yangtze River Economic Belt.

Despite the prominent ecological status and promising developmental potential, the Yangtze River Economic Belt is faced with grim ecological situation due to the long-term intensive development and the lack of scientific management for space development. The water problems of the Yangtze River are becoming increasingly serious. Since the main drinking water sources along the trunk are staggered with dangerous goods wharves and sewage outlets, the pollution zone along the shore is expanding and the water environment grade is decreasing. As a result, the species and number of aquatic organisms are decreasing and a variety of rare species become endangered. Moreover, the ecological degradation and frequent geological disasters in the upper reaches, the shrinkage of lakes and wetlands and the unharmonious relationship between rivers and lakes in the middle reaches, and the aggravation of water pollution and lake eutrophication in the lower reaches seriously threaten the position of the Yangtze River as a national strategic water source and an important ecological support zone. Well-coordinated environmental conservation and avoiding excessive development has become the foundation to maintain regional ecological security and improve the ecological civilization construction in the Yangtze River Economic Belt.

In this study, we examined the ecological status and summarized the major ecological and environmental issues in the development of the Yangtze River Economic Belt based on the data of Changjiang & Southwest Rivers Water Resources Bulletin, Ecological and Environmental Monitoring

Received: 2020-7-23
Supported by: Strategic Priority Research Program of Chinese Academy of Sciences (XDA23020000)

Bulletin of the Three Gorges Project (1997–2016), China Statistical Yearbooks, Weekly Monitoring Report of Water Quality in State-controlled Sections of China National Environmental Monitoring Centre (2006–2018), National Urban Air Quality Daily Report (2015–2019), remote sensing at different time phases, and long-term research projects. Furthermore, we proposed the overall strategy of well-coordinated environmental conservation and avoiding excessive development for reference to relevant research and policy makers.

1 Ecological status of the Yangtze River Economic Belt and the ecological and environmental issues during development

1.1 The Yangtze River, with irreplaceable ecosystem service value, is a strategic water source for China

(1) The Yangtze River is an irreplaceable strategic water source and clean energy base of China. The mean annual runoff of the Yangtze River reaches 9.6×10^{11} m^3, which accounts for 36% of the total fresh water resources in China, meeting the water demand for production and living of about 42% of the population, 38% of grain production, and 44% of gross national product (GDP). Moreover, the interbasin water transfer projects such as the middle and east routes of the South-to-North Water Transfer Project from the Yangtze River alleviate the shortage of urban and rural water resources in North China. Therefore, the Yangtze River is crucial for water resources security in China. The theoretical hydropower potential and exploitable hydropower potential of the Yangtze River trunk and tributaries reach 3.05×10^8 kW and 2.81×10^8 kW, which respectively accounts for 40% and 53.4% of the total in China. In 2018, the hydroelectric power generation capacity of the Yangtze River was 7.93×10^{11} kWh, accounting for about 66.1% of the national total.

(2) As for the cargo volume, the Yangtze River tops the world's list of inland rivers. In 2019, the Yangtze River trunk ports completed cargo throughput of 3.03 billion tons and container throughput of 18.44 million standard containers, and there were 14 grand ports with the throughput above 100 million tons along the trunk. With the effective management of the main channel and the construction of deep-water channel in the Yangtze Estuary in recent years, the 12.5 m deep-water channel downstream of Nanjing has been connected and 50 000-ton seagoing vessel can reach Nanjing Port with full load.

(3) The fishery in the Yangtze River is irreplaceable. There are 378 species of fish in the Yangtze River system (including lakes), which account for about 33% of the total freshwater fish species in China. The Yangtze River system ranks the first in fish resources among all the rivers in China, including 147 endemic fish species (42% of the fish species in the Yangtze River). As an important production base of freshwater fish fry in China, the Yangtze River abounds in economic fishes such as four major Chinese carps (black carp, grass carp, silver carp, and bighead carp). Among the 35 major freshwater fish species for aquaculture in China, 26 species inhabit the Yangtze River, including many precious and high-value species such as *Siniperca chuatsi*, *Leiocassis longirostris*, *Silurus meridionalis*, *Myxocyprinus asiaticus*, *Pelteobagrus fulvidraco*, and *Spinibarbus sinensis*. Therefore, the Yangtze River is a primary center of freshwater fish germplasm resources in China.

1.2 The Yangtze River Economic Belt has important ecological location and is an important gene bank of natural species

(1) The Yangtze River Economic Belt is rich in natural species resources. The upper reaches possess almost all the terrestrial ecosystem types including forest, shrub, grassland, meadow, wetland, and alpine tundra, with high net primary productivity (NPP) and rich biodiversity. The ecosystem regulation and support services such as water source conservation, soil conservation, and biodiversity protection are far greater than supply services, while the ecosystem is relatively fragile. Therefore, the ecosystem in the upper reaches is highly original and has high value of centralized and continuous protection (Figure 1) [1]. The middle reaches are dominated by mountain forests, farmlands, rivers, lakes, and wetlands and thus have balanced regulation and support services with supply services. The lower reaches are mainly dominated by farmlands, rivers, lakes, and coastal wetlands.

(2) The advantaged location endows the Yangtze River Economic Belt superior conditions of light, heat, water, and soil. Therefore, this region harbors abundant fauna and flora and becomes an important gene bank of natural species, thereby having a great value of biodiversity protection. The Yangtze River harbors a total of 1 034 protected species, including 568 plant species, 142 mammal species, 168 avian species, 57 amphibian species, 85 reptile species, and 14 fish species. In addition, as an important habitat and refuge for many rare and endangered aquatic wildlife species in China, the Yangtze River has 14 species of aquatic wildlife in the Chinese first-class and second-class national protected animals lists, including *Acipenser sinensis*, *Psephurus gladius*, and *Acipenser dabryanus*. There are 6 088 plant species (1 428 genera, 208 families) in the Three Gorges reservoir, 7 037 plant species (1 476 genera, 202 families) in the middle reaches, and 4 259 plant species (1 180 genera, 174 families) in the lower reaches [2].

(3) According to the national ecological function zoning, the Yangtze River Economic Belt involves 25 important ecological function zones (47.1% of the total in China). Among them, eight zones are for water source conservation, including Qinba Mountain, Dabie Mountain, source area of Huaihe River, Nanling Mountain, source area of Dongjiang

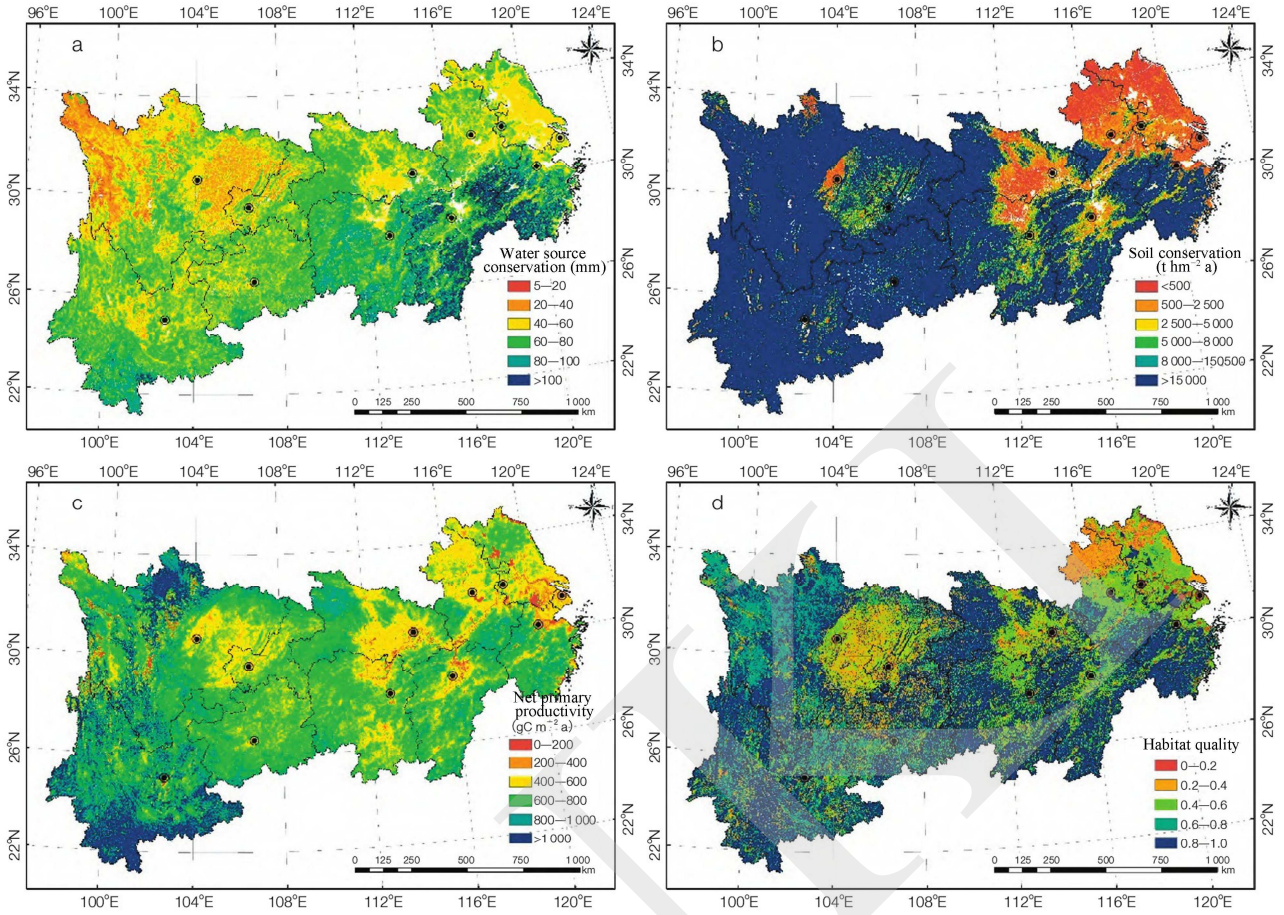

Figure 1 Spatial distribution of ecosystem services in the Yangtze River Economic Belt in 2015 [1]

(a) Water source conservation; (b) Soil conservation; (c) Net primary productivity; (d) Habitat quality.

River, Ruoergai County, Three Gorges Reservoir, and Danjiangkou Reservoir (Figure 2). There are 1 066 reserves, including 165 national reserves (90 forest reserves, 47 wild animal reserves, 14 inland water reserves, 12 wild plant reserves, 1 geological relic, and 1 archaeological relic). The total area of the reserves is 1.86×10^7 hm^2, accounting for about 9.1% of the total area of the Yangtze River Economic Belt.

1.3 The unique eco-geographical pattern leads to frequent ecological disasters in the Yangtze River Economic Belt

The complex and diverse geological and geomorphological environments and changeable climatic and hydrological conditions lead to frequent natural disasters (mainly floods and mountain disasters) in the Yangtze River Economic Belt. These natural disasters have become a major threat to the Yangtze River Economic Belt. The upper reaches, located at the junction of the first and second steps of China's terrain, features complex geological conditions, wide alpine and gorge region, and active neotectonic movement. Moreover, the earthquake, landslide, and debris flow disasters are frequent, widespread, and spacious and have abruptness, clustering, and disaster chain properties. Major geological and mountain disasters occur almost year after year here [2].

The flow direction of the Yangtze River coincides with the direction of rain belt. The rain belt stays for a long time and persistent rainstorms occur frequently. The drastic drop in terrain and rapid confluence in the upper reaches, together with the unsmooth flood storage and drainage in the middle and lower reaches lead to the encounter of rainstorm and flood. Besides, the numerous tributaries, blocks in the trunk of the middle reaches, and tidal backwater in the estuary result in the frequent catastrophic floods in the Yangtze River, especially in the middle and lower reaches. The flood disasters are characterized by high peak, large volume, and long duration.

1.4 The water and atmosphere pollution is serious in the Yangtze River Economic Belt

The Yangtze River Economic Belt has a long history of development, with dense population and developed economy. The rapid industrialization and urbanization have led to the massive discharge of environmental pollutants and obvious cumulative effect of environmental pollution. The environmental problems, represented by the decline of water and

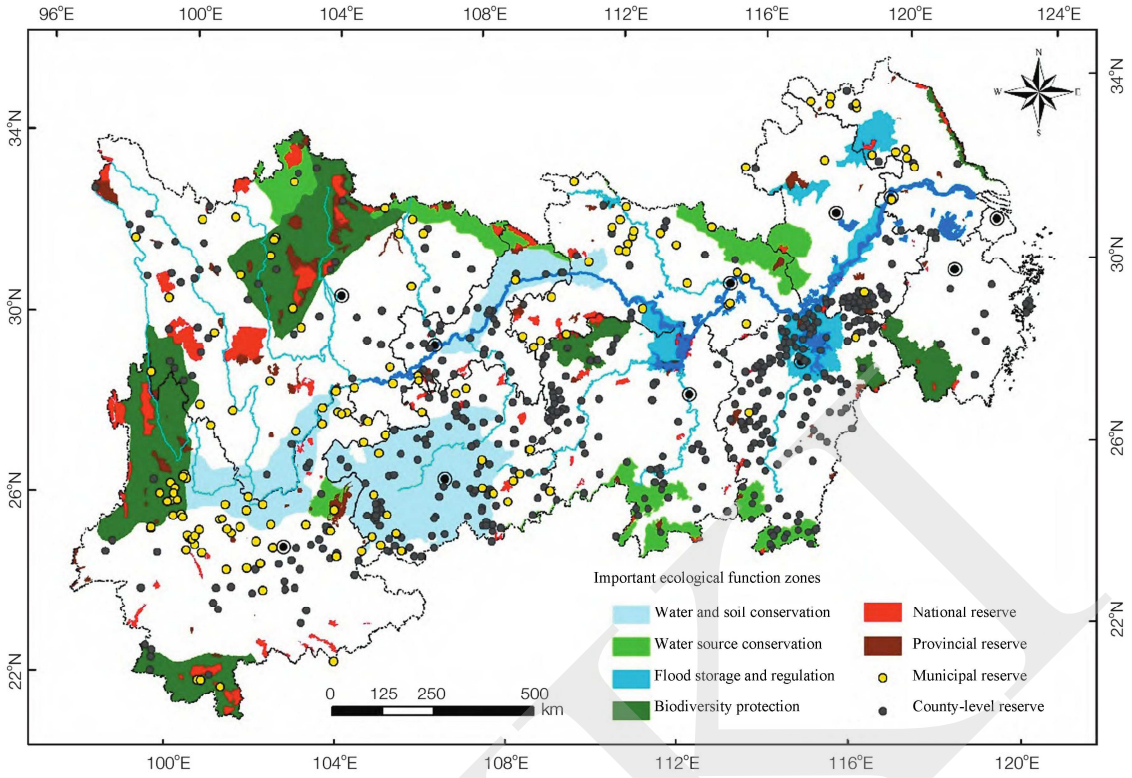

Figure 2 Spatial distribution of important ecological function zones and nature reserves in the Yangtze River Economic Belt [3,4]

atmosphere environmental quality, are severe. In 2018, 21.1% of 1 261 important water function zones failed to meet the standard [5]. From 2006 to 2018, the annual average values of pH in 9 sections, dissolved oxygen (DO) in 12 sections, permanganate index (COD_{Mn}) in 16 sections, and ammonia nitrogen in 6 sections of the 25 state-controlled sections in the trunk of the Yangtze River showed an upward trend. In 2018, the week proportion of water quality grade IV and below in 7 sections exceeded 30% (Figure 3).

(1) The overall water quality of lakes is poor. Among the 61 major lakes in the Yangtze River Basin in 2018, the area with the water quality grades I–III, IV–V, and V+ accounted for 11.1%, 86.0%, and 2.9%, respectively [5]. Except that West Lake had water quality grade III, Poyang Lake, Taihu Lake, Chaohu Lake, Dongting Lake, Dianchi Lake, Donghu Lake of Wuhan, and Xuanwu Lake had water quality grades IV–V+. Ninety-five (88%) of the 108 lakes with an area greater than 10 km^2 in the middle and lower reaches had the water quality beyond the eutrophication standard, of which 25 (23.1%) were hypereutrophic, while only 13 (12%) were mesotrophic and oligotrophic [6].

(2) The atmospheric environment is poor. The Yangtze River Delta and Chengdu Plain are among the regions with the most haze days in China. The number of haze days in most cities of the Yangtze River Delta, Chengdu City and the surrounding areas is more than 50, and that in some cities of Jiangsu and northern Zhejiang exceeds 100 [2]. The annual mean concentration of ozone (O_3) in 76.2% of 126 prefecture cities and the annual mean concentration of nitrogen dioxide (NO_2) in 29.4% of prefecture cities showed an upward trend. From 2015 to 2019, the proportion of fine particulate matter ($PM_{2.5}$) kept decreasing; the proportion of inhalable particulate matter (PM_{10}) was over 50%; the proportion of O_3 continued to rise (Figure 4). Volatile organic compounds (VOCs) and nitrogen oxides (NO_x) are high in the Yangtze River Delta, resulting in severe secondary pollution problems such as O_3.

(3) Structural and layout risks are serious and environmental emergencies are frequent. There are 62 industrial parks along the Yangtze River. Particularly, heavy chemical enterprises exhibit intensive distribution here. There are more than 250 dangerous chemicals for production and transportation, and 40% of papermaking, 43% of synthetic ammonia, 81% of ammonium phosphate, 72% of printed and dyed cloth, and 40% of caustic soda production capacity are concentrated in this area. As a result, environmental emergencies occur frequently, seriously threatening the water supply and ecological safety of the location and the downstream areas [7]. From 2008 to 2018, a total of 2 574 environmental emergencies occurred in the Yangtze River Economic Belt, accounting for 53.6% of the total in China. The environmental emergencies in Shanghai, Jiangsu, and Zhejiang accounted for more than 80% of the total in the belt (Figure 5). After 2013, the environmental emergencies in the belt showed a significant downward trend, while the high-density layout of heavy chemical enterprises still posed high cumulative and potential environmental risks.

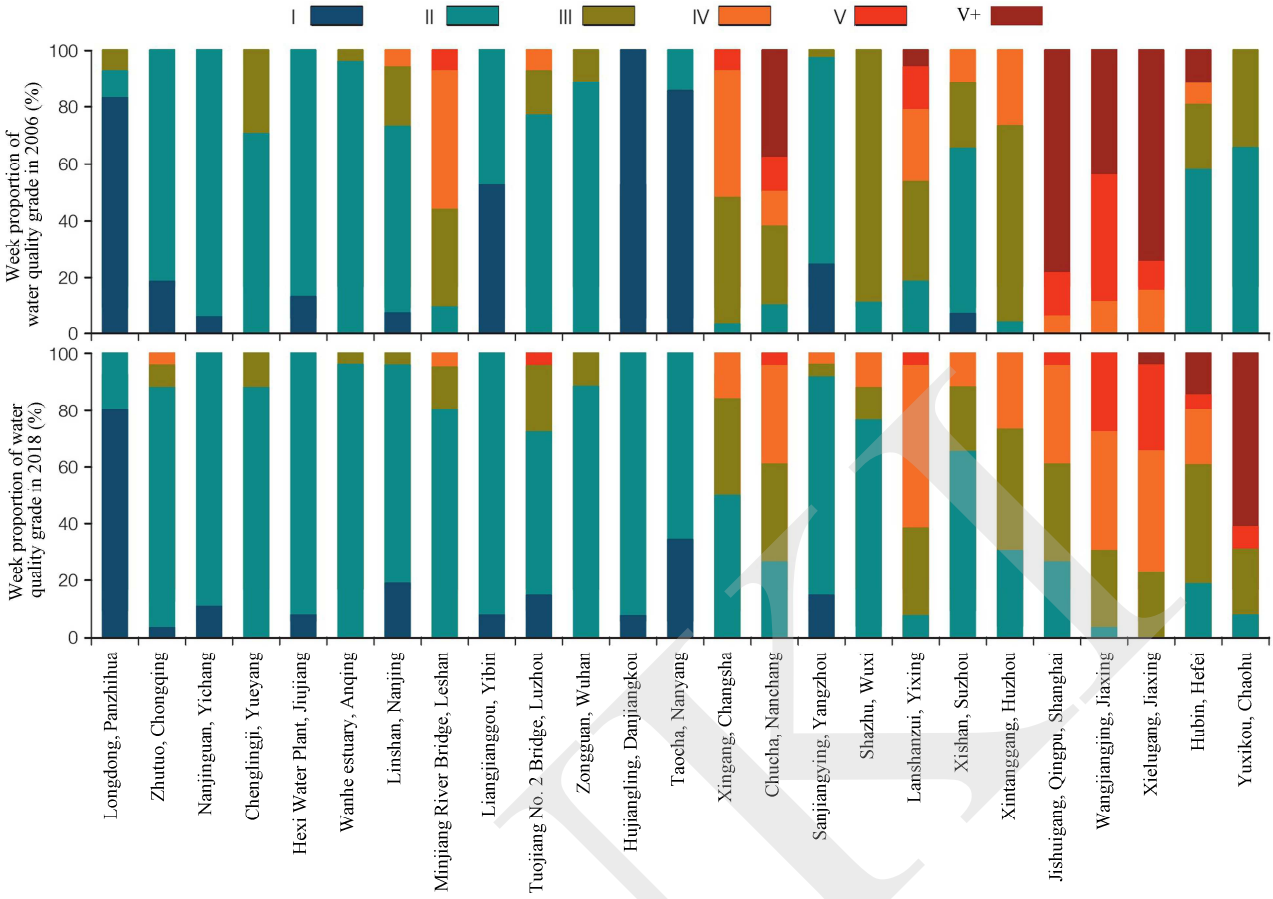

Figure 3 Week proportion of water quality grade in state-controlled section of Yangtze River Economic Belt in 2006 and 2018

Data source: Weekly Monitoring Report of Water Quality in State-controlled Sections of China National Environmental Monitoring Centre in 2006 and 2018.

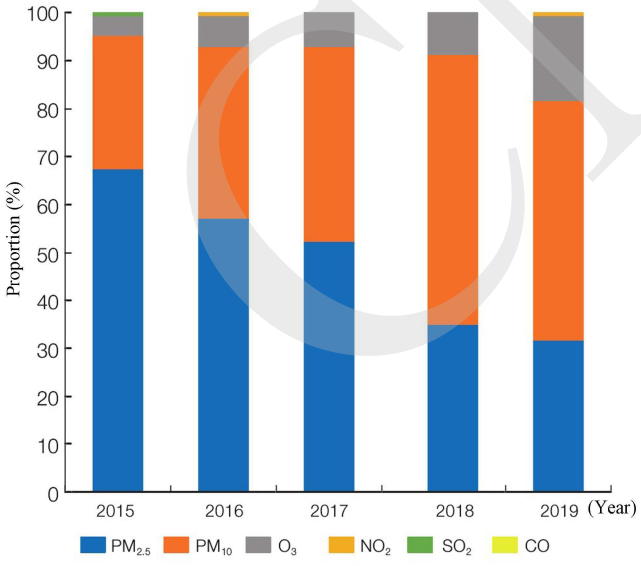

Figure 4 Proportions of major atmospheric pollutants in the Yangtze River Economic Belt from 2015 to 2019

Data source: National Urban Air Quality Daily Report (2015–2019) of the Ministry of Ecology and Environment of China.

1.5 Marked deterioration of water ecology in the Yangtze River and lakes

(1) The rapid degradation of aquatic organisms in the upper reaches of the Yangtze River. Especially, a series of cascade hydropower development has destroyed to varying degrees the spawning and breeding grounds and suitable habitats of rare and economic fish. From 2003 to 2010, after the Three Gorges Reservoir impounded, 23 species of endemic fish were found in the Three Gorges Reservoir area, which decreased by 51.1% than before; the dominance of endemic fish in the catches of the Three Gorges Reservoir area decreased by 35.3%–99.9%; the spawning amount of the four major Chinese carps significantly reduced, and the annual mean spawning amount of the four major Chinese carps in Jianli Section in the middle reaches was 228 million eggs, which was 90.0% lower than that before the impoundment in 1997–2002. Although the ecological rehabilitation implemented since 2011 has improved the status of four major Chinese carps, the spawning amount was only 23.9% of that in 1997–2002 (Figure 6) [8]. The annual mean natural fishery catches of the Yangtze River in 2003–2016 were 42.7% less than that in 1997–2002. The lake bioresources in Yunnan-Guizhou Plateau

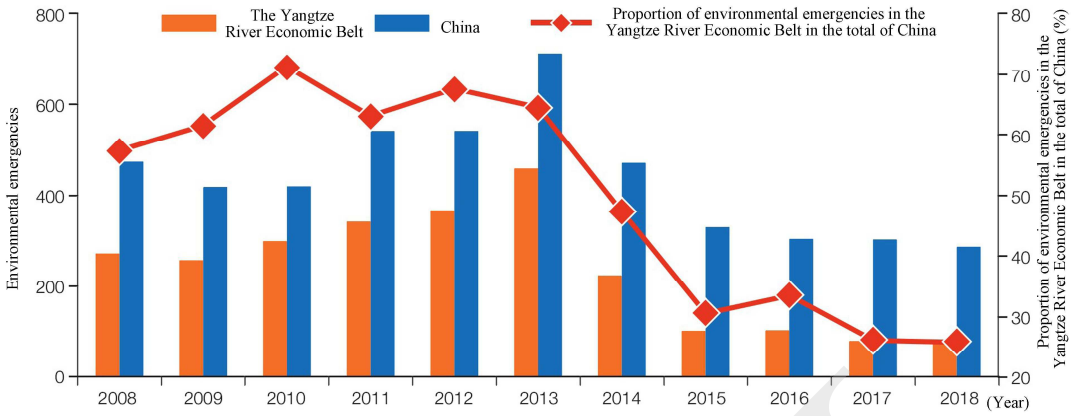

Figure 5 Environmental emergencies in the Yangtze River Economic Belt from 2008 to 2018

Data source: China Statistical Yearbooks 2008–2018.

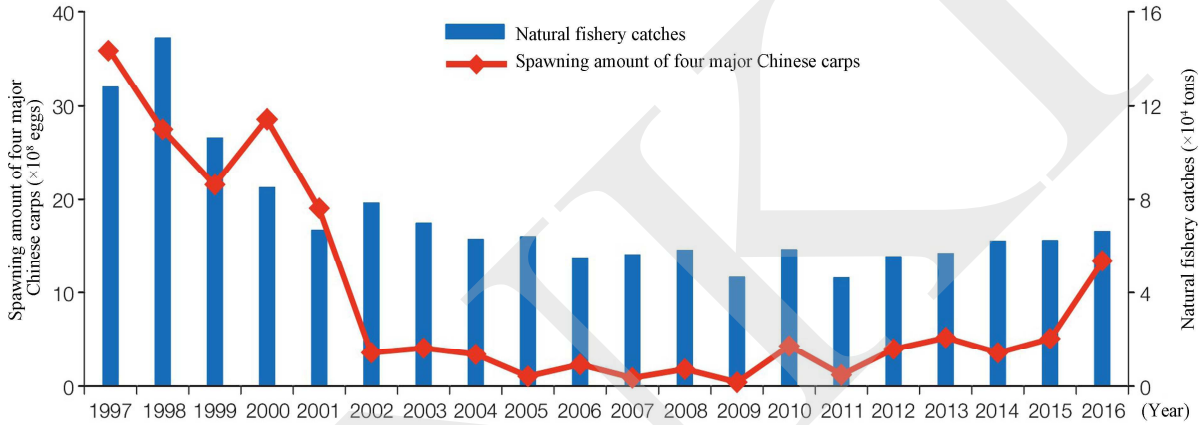

Figure 6 Natural fishery catches and spawning amount of four major Chinese carps in the Yangtze River from 1997 to 2016 [8]

Data source: Ecological and Environmental Monitoring Bulletin of the Three Gorges Project.

degenerated and the endemic species decreased rapidly; the fish fauna in Yunnan-Guizhou Plateau evolved toward the fish fauna in the middle and lower reaches of the Yangtze River, and the endemic species decreased remarkably.

(2) The obvious degradation of lake wetland ecology in the middle and lower reaches of the Yangtze River. In the middle reaches, the vegetation in the wetlands of Poyang Lake and Dongting Lake exhibited area expansion, downward migration, and obvious xeric characteristics, which led to significant changes in the habitats of migratory birds; the species and number of fish in rivers and lakes decreased sharply, and the migratory fish almost disappeared; the benthic molluscs such as snails and mussels decreased greatly, while the pollution-resistant Tubificidae and aquatic insect larvae increased; the populations and number of large cladoceran and copepods decreased, while the number of small rotifers and protozoa increased rapidly; the aquatic higher plants showed narrowed distribution, simple community structure, and disappearing of large emerged plants along the lake shore, and a large number of lakes changed from macrophytic lakes to algal lakes [9–11].

1.6 The cumulative impacts of major projects on ecology and environment, represented by unharmonious relationship between rivers and lakes, are increasing

(1) The construction of large reservoir groups changes the incoming water and sediment in the upper reaches of the Yangtze River, which affects the hydrology of rivers and lakes, wetland ecology, flood control and water supply. In recent decades, dam projects in the scope of the Yangtze River Economic Belt have experienced explosive growth, and only the Three Gorges in the upper reaches involved more than 20 large-scale water control projects. The construction of large reservoir groups has profoundly changed the incoming water and sediment in the upper reaches, causing increasingly obvious impacts on the hydrology and ecological environment of rivers and lakes in the middle and lower reaches. Since 2003, the inflow of the upper reaches has been low, and the annual runoff of Yichang Station in 2003–2014 was less than the mean of 1956–2014 in 80% of the years. The river channel below the dam in the middle reaches had low incoming water and sediment, and the annual

runoff of Hankou Station in the middle reaches was less than the mean in more than half of the years. The proportion of sediment coming from the upstream of Datong Station, the junction station between the middle and lower reaches, has dropped sharply from 86% (mean of 1956–2002) to 37% in 2003. On one hand, this led to long-distance and drastic scouring of the riverbed in the middle and lower reaches. The total scouring amount of the bankfull channel from Yichang to Hukou reached 1.06×10^9 m^3, 67% of which occurred from Yichang to Chenglingji. The degradation and bank collapse occurred from time to time, which seriously endangered the safety of the Yangtze River embankment. On the other hand, it led to the lowered water level of the trunk at the same flow and further weakened backwater effect of the Yangtze River on the Yangtze-connected lakes, which seriously influenced the water regulation and storage capacity of the lakes, the ecological balance of wetlands, and the flood control and water safety in the middle and lower reaches [9,10].

(2) The construction and reclamation of water conservancy projects cause unharmonious relationship between rivers and lakes. The Yangtze River Economic Belt is not only the most concentrated area of lakes (the number and area of lakes larger than 1 km^2 account for 25% of the national total) only second to the Qinghai-Tibet Plateau in China but also the area witnessing highly significant changes in the number and area of lakesover the past century [6]. Historically, most of these lakes are naturally connected with the Yangtze River or other rivers and play normal ecological service functions such as flood regulation and storage, water purification, freshwater supply, and biodiversity protection. With the active construction and reclamation of water conservancy projects since the 1950s, most of the lakes in this region have lost their natural hydraulic connection with rivers, and the relationship between rivers and lakes has gradually become unharmonious.

(3) River–lake isolation exacerbates lake shrinkage and biodiversity decline. The structure and function of many lake ecosystems are changed due to the abrupt change of hydrodynamic conditions, which blocks the connection between rivers and lakes, resulting in the disappearance of migratory aquatic animals from the original distribution lake area, as well as significantly reduced species and number of aquatic plants and lake fish. Moreover, the mass propagation of algae, especially cyanobacteria, and the decreasing species and miniaturization of benthic animals have become an important reason for frequent ecological disasters such as cyanobacterial bloom. For example, the outbreak of cyanobacterial blooms in Taihu Lake in 2007 caused a water supply crisis in Wuxi City. In addition, accelerated lake shrinkage and biodiversity decline are responsible for the rapid decreases in the number and area of lakes. Since the 1950s, the area of lakes from Yichang to Datong in the middle reaches has decreased by about 2/3 from 17 198 km^2 to about 6 600 km^2; the lakes (larger than 1 km^2) disappearing in the middle and lower reaches of the Yangtze River accounted for 44.4% of the total in China; the area of the five major freshwater lakes has significantly diminished, and the areas of Dongting Lake, Poyang Lake, and Taihu Lake decreased by 1 725 km^2, 2 267 km^2, and 172 km^2, respectively, which directly weakened lake storage and regulation capacity and further caused the situation of a normal flood resulting in a tremendous disaster [2,10].

(4) Major projects, together with climate changes, increase the complexity and uncertainty of ecological and environmental problems. Since the beginning of the 21st century, the hydrological situations of Dongting Lake and Poyang Lake, the existing Yangtze-connected lakes, have undergone drastic changes under the influence of multiple factors such as alternating dry-wet climate, water storage of water conservancy projects such as the Three Gorges in the upper reaches, and aggravation of human activities. The advance and prolongation of dry season, as well as frequent occurrence of ultra-low water level in dry season, have seriously affected industrial and agricultural production and domestic water of urban and rural residents in the lake area. Moreover, they lead to a series of ecological and environmental problems such as the ecological imbalance of lakes and wetlands and habitat degradation of migratory birds [9–11].

2 Overall protection strategy

The Yangtze River Economic Belt, in the superior location with well-developed transportation conditions, unique conditions of water, soil, gas, and natural resources, and a relatively complete industrial and urban system, is particularly suitable for comprehensive development. Well-coordinated environmental conservation and avoiding excessive development put environmental conservation with top priority and refuse to take the old route of extensive and disordered development at the expense of ecology and environment. The orderly, well-coordinated, and intensive development according to local conditions is the premise for ecological civilization construction with harmonious relationship between human beings and nature.

2.1 Implementing water quality goals management by stressing water eco-environmental protection with the top priority

(1) Strengthening the control on the development of industries and parks along the Yangtze River and implementing the source control of pollutants entering the river. The management of riverbank occupancy should be taken as the core to standardize orderly development. The land 0.5–1 km from the river and the bottomland off bank should be included in the scope of the riverbank. The riverbank occupancy should follow the principles of ecological priority, intensive development, and paid use, as well as licensing system. The layout of the industrial enterprises and the heavy chemical industrial

parks along the Yangtze River should be strictly managed. The enterprises with serious pollution outside the parks should be closed within a time limit. High-standard sewage treatment systems should be constructed to cover the development zones and industrial parks along the Yangtze River. The sewage outlets should be strictly managed to avoid direct discharge of dispersed industrial and domestic sewage. The water in the tributaries that fail to meet the grade V standards should be prohibited from entering the Yangtze River. In addition, it is necessary to implement regional environmental protection restrictions on the bank sections that fail to meet the basic requirements.

(2) Strengthening the target management of water quality in major tributaries of the Yangtze River and key lakes. Target management mode of environmental quality should be explored for realizing the transformation from the assessment of pollution reduction to that of environmental quality.

2.2 Forming a land and space development pattern dominated by intensive, concentrated spatial development and natural and open ecological space

(1) Enhancing the protection of ecosystem integrity and connectivity. Maintaining the ecosystem services in important ecological functional zones and controlling the development intensity of ecologically sensitive (fragile) areas should be taken as the focuses of protection. The identified ecological red lines (Figure 7) [12] should be optimized. The land–water ecological corridor with the Yangtze River as the main axis should be developed based on the effective management of the development scale and order of major hydropower projects, natural conservation, and river–lake connection.

(2) Strengthening ecological guidelines for land development and optimizing spatial layout. The ecological, living, and production space should be reasonably delineated based on the management of riverbank occupancy, and the environment access thresholds and negative list of development should be formulated. Strict ecological red line control and system of paying for environmental damage should be implemented. Intensive development of important urban agglomeration and development zones at or above the provincial level should be strengthened. Agricultural development space and green open space should be protected. A land and space development pattern dominated by intensive, concentrated spatial development and natural and open ecological space should be formed rapidly.

2.3 Continuously implementing ecological protection projects in the Yangtze River Economic Belt

(1) Water safety projects. The water source conservation should be ensured focusing on the protection of water sources and the upper reaches, the rational allocation of water in the middle reaches, and the protection of water environment in the lower reaches. The ecological red lines should be delimited for the protection of rivers and lakes to avoid the narrowing of rivers and lakes and the declined capacity of water regulation and storage. The projects of farmland for lakes and wetlands, strict prohibition on illegal occupation of bottomland of rivers and lakes, and limitation on the development

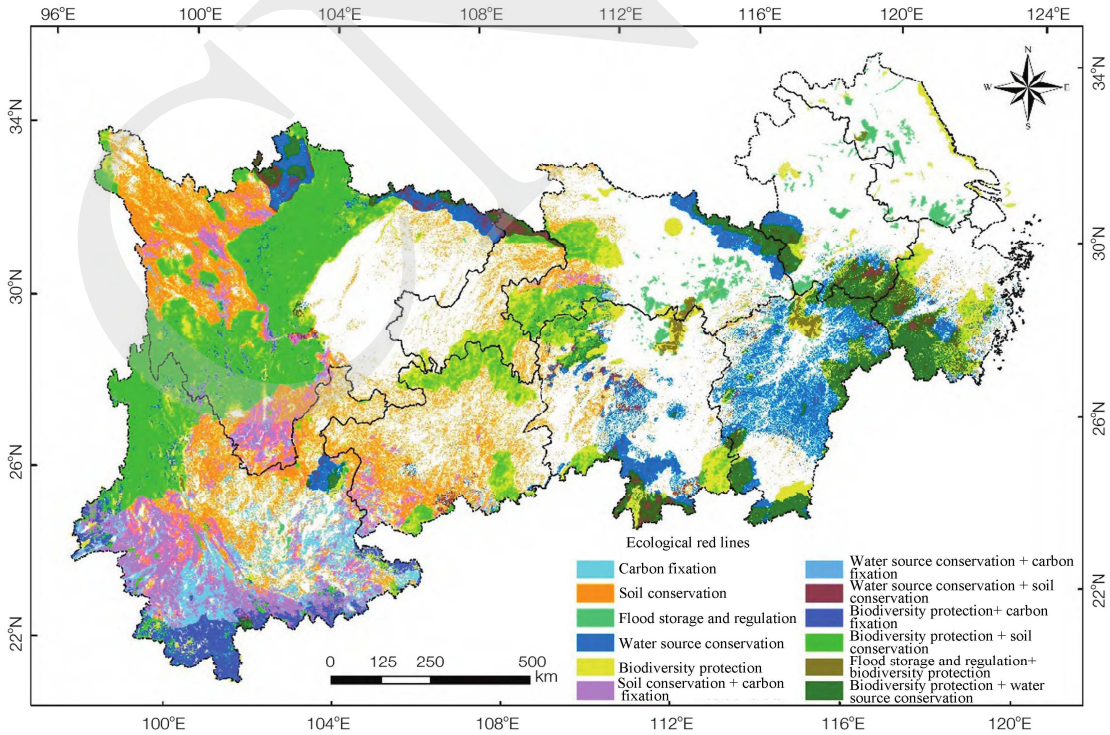

Figure 7 Ecological red lines in the Yangtze River Economic Belt [12]

intensity of flood storage areas should be implemented to restore and increase the capacity of water regulation and storage. Unified management and optimal regulation of reservoir groups, river–lake connection, projects of clean water flowing into river, and construction of minor watershed should be implemented to ensure regional water safety [2].

(2) Ecological conservation projects. The water ecological protection with focus on fish resources, strict control of the reclamation and development of wetlands, and ecological regulation of water conservancy projected conducive to fish protection should be guaranteed to protect the biodiversity and water ecosystem health of the Yangtze River.

(3) Major disaster prevention projects. The risk areas of mountain disasters such as earthquake, landslide, and debris flow in the upper reaches of the Yangtze River should be delimited for resettlement. The ecological projects such as farmland for forests and grasslands as well as afforestation of barren hills should be constructed to mitigate the harm of soil erosion. The embankment reinforcement, construction of flood storage and detention areas, and optimized dispatching of reservoir groups should be integrated to form a relatively complete comprehensive flood control system of the Yangtze River.

(4) Environmental and ecological risk prevention projects. A negative list should be established to form a strict system of classified supervision of environmental and ecological risk sources and real-time monitoring, warning, and disposal of risks. Environmental information should be shared for the regional joint prevention and control as well as emergency response. The sensitive river segments, layout of regional polluting enterprises, and transportation of dangerous chemicals should be strictly controlled.

2.4 Integrating departments and localities to realize comprehensive management

(1) Integrating departments and localities and establishing a cross-departments and cross-administrative region management agency of the Yangtze River Basin directly under the State Council. Drawing on the management experience of the Rhine River in Europe and the Tennessee River in the United States, comprehensive watershed management should be negotiated by interested parties. Efforts should be made to solve cross-regional and cross-department problems that cannot be solved within each administrative unit and department, to coordinate the comprehensive watershed planning and integrated management and control of spatial development, and to supervise the implementation of the Yangtze River Protection Law.

(2) Establishing and improving the systems of natural resource protection, paying for environmental damage and responsibility investigation, and ecological compensation in the whole Yangtze River Basin. In accordance with the general requirements of sticking to and perfecting the system of ecological civilization and promoting the harmonious coexistence of human and nature, the registration of property rights of natural resources assets, the paid use of natural resources (e.g., hydropower, mineral, and water), the total resource management, and the assessment of corresponding profit and loss in the Yangtze River Economic Belt should be established and improved. The phenomenon of enterprise earning money, government paying the bill, and the public suffering should be eliminated. The environmental damage compensation and compulsive restoration systems should be established to ascertain where the responsibility of environmental damage lies. The base values of key water volume and water quality indicators in the control section agreed by the state-controlled or interested administrative subjects should be taken as the reference to integrate the above systems. Based on the differences between the key indicators and the base values, the bidirectional compensation (paying) mechanism of compensation for increased indicator values and paying for decreased indicator values should be established.

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(Translated by SI GD)

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