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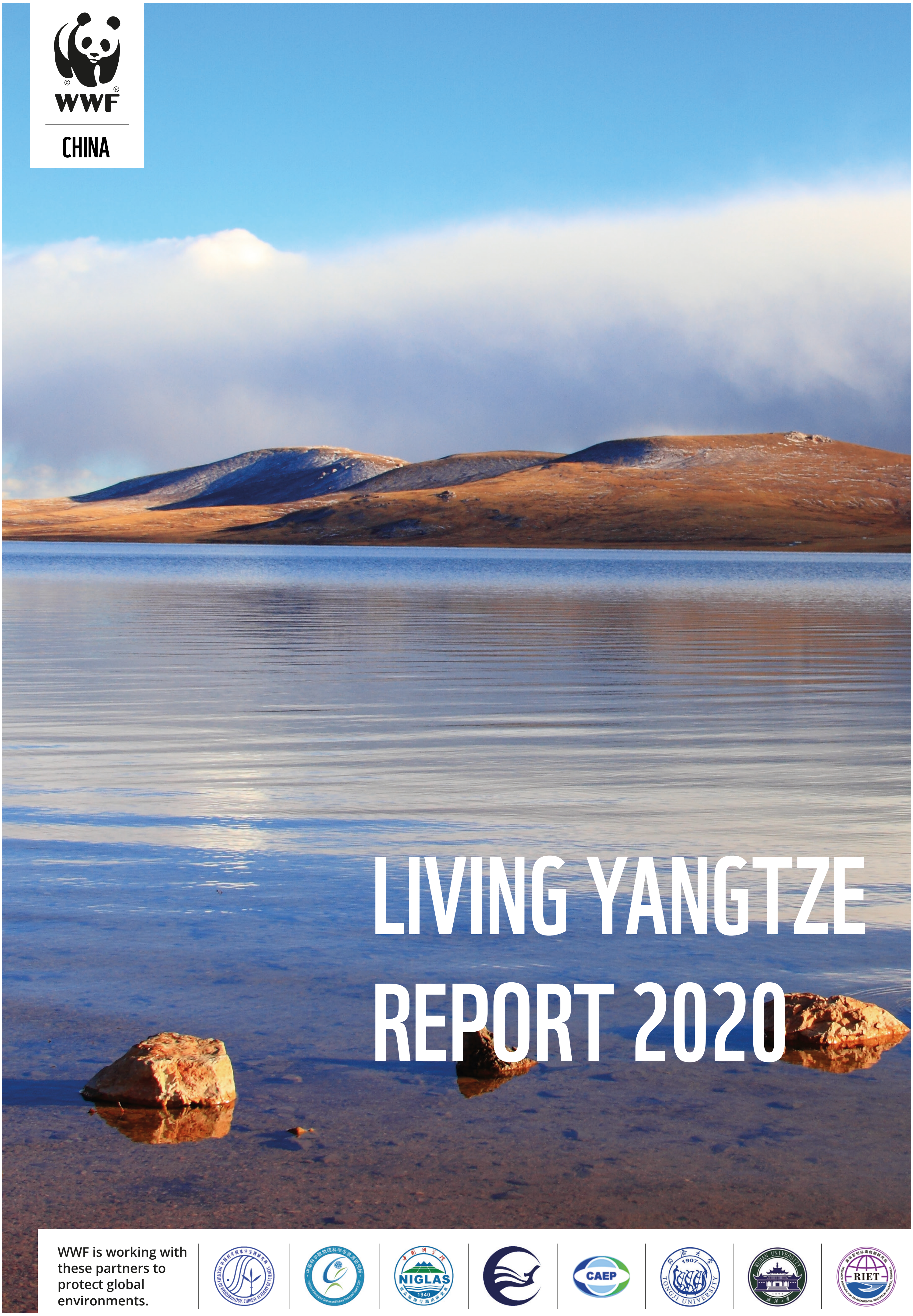

LIVING YANGTZE REPORT 2020

WWF is working with these partners to protect global environments.

Starting from 1998, the World Wild Fund for Nature (WWF) has regularly released the *Living Planet Report* to track the status of global biodiversity.

Over this same period, WWF has dedicated itself to protecting the Yangtze River freshwater ecosystems through conducting research and implementing evidence-based conservation programs. WWF works to conserve wetlands, protect flagship species and habitats, promote environmental flows, support the green transformation of industry and communities, and enhance the value of ecosystem services in the Yangtze River basin.

Based on 20 years of experience working in the Yangtze basin, WWF developed the conceptual framework of the "Living Yangtze Index" and launched the *Living Yangtze Report* project in 2018. The report aspires to track the health of freshwater ecosystems in the Yangtze River basin and contribute to an "all-out effort to protect the Yangtze River".

2021 is considered a critical year for biodiversity. The international community is reviewing the progress that has been made in global sustainable development and biodiversity protection, and prepares for post-2020 global biodiversity framework. As such, this work is very timely and, in collaboration with the organizations listed below, WWF is proud to release the first *Living* Yangtze *Report*.

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Cover image：Nianji Lake in the source area of Yangtze River ©WWF Baoyu Wei

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Ulan Moron©Huiguang Yang

CONTENTS

FORWARD

Restoring the health of Yangtze River for the benefit of people and nature

The world's freshwater ecosystems are in crisis. WWF's Living Planet Report 2020 found that freshwater species populations have collapsed by 84 per cent on average since 1970, highlighting the damage we have done to our rivers, lakes and wetlands – ecosystems that are crucial to the ecological balance of the planet, and provide vital services to our society and economy.

A healthy Yangtze River basin is central to China's future. It provides water, food and livelihoods for hundreds of millions of people and sustains much of the Chinese economy. It is also home to incredible biodiversity from giant pandas and snow leopards to over 400 species of fish and the world's only freshwater porpoise. But today, the Yangtze is under immense pressure and its health is failing fast. Preserving biodiversity in the Yangtze, restoring ecosystems to a healthy state, and achieving proper management and sustainable use of resources will be vital to the economic and social development of China.

This new Living Yangtze Report provides an authoritative analysis of the current challenges in the basin, including climate change, alterations to its flow, land-use change and river-bank development, pollution, overfishing and invasive species. These pressures threaten the river's wealth of ecosystem services from water supplies to freshwater fisheries that feed millions, and mitigation of extreme floods and droughts.

At the heart of the report is the Yangtze Living Index, which concludes that the overall health of the Yangtze River basin is declining with its status deteriorating as the river flows from source to sea.

The index is a cutting-edge scientific tool that supports effective management of the river basin by providing a comprehensive set of data to track progress in biodiversity conservation, ecosystem restoration and the sustainability of the river's priceless natural resources.

As the first complete basin-level index in the world, the Living Yangtze Index is also an innovation that will hopefully be replicated across the world. We will not be able to reverse the loss of freshwater ecosystems and the decline in freshwater biodiversity until we better understand the status of the world's major river basins.

Thanks to the Living Yangtze Report, we now have a much more accurate picture of the health of Asia's longest river and how best to improve it for the benefit of the millions of people and the rich biodiversity it supports. I am confident that this report will contribute significantly to the effectiveness of efforts by the government, communities, companies and conservationists like WWF to restore the Yangtze to health – and help drive sustainable development in China.

Marco Lambertini
Director General
World Wide Fund for Nature (WWF) International

FORWARD

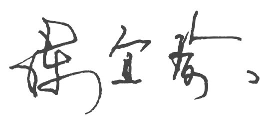
The Yangtze River is often referred to as "the Cradle of Chinese Civilization" – which signals both its role as the lifeline of the nation's sustainable socio-economic development, as well as its prominent role in safeguarding the nation's ecological security. In January 2016, President Xi Jinping presided over a symposium in Chongqing to promote the development of the Yangtze River Economic Belt, and stressed that, "We must proceed from the long-term interests of the Chinese nation to put restoring the ecological environment of the Yangtze River in a dominant position, making an all-out effort to protect it, and forbidding large-scale development of the river". At a similar symposium held in Wuhan in April 2018, Xi Jinping once again reinforced the need for an effective system of environmental protection by calling for a holistic approach in the conservation and restoration of the Yangtze River ecosystem.

The restoration of the Yangtze ecosystem should be carried out with a systematic and holistic perspective — that is, to regard and protect mountains, rivers, forests, farmlands, lakes and grasslands as a whole, rather than as separate sections. Bearing this in mind, we should use evidence-based approaches to trace and analyze the health of the Yangtze ecosystem, identify the weak links and challenges, and comprehensively address the drivers and impacts of degradation to restore the river.

The Living Yangtze Report 2020, initiated and developed by WWF together with a team of multi-disciplinary scientists, is an essential tool for evaluating the health of the Yangtze River . I personally commend this Report, not only because it embodies the close collaboration and great contributions of experts from many different fields involved in the research and conservation of the Yangtze River, but also because the Report is science-based and explores deep questions in simple terms, so that it the country's mother river can be better understood by relevant government bodies and across all sectors of the society.

As far as I know, WWF has published the Living Planet Report every two years. By tracking the health of our planet and the impact of human activity, the Living Planet Report has played a unique role in raising public awareness of the health of the Earth, inspiring tangible action from large businesses around the world, as well as building global consensus on combating the decline of biodiversity.

This Living Yangtze Report, which was inspired by the Living Planet Report, is the first time WWF has taken the river basin as the core research subject. Three years ago, when the Living Yangtze Report was still in the pipeline, I was visited and consulted by WWF about the feasibility of this research. At that time, I encouraged them to do it, as I knew that despite the challenges that this project posed, it was one worthy of trying. Today, I am glad to welcome the official release of this Report. Presently, China is at the critical moment of seeking the right solutions to the problems faced by the Yangtze River by "stepping up conservation of the Yangtze River and stopping its over development". The Living Yangtze Report, I believe, will be a valuable resource for the public to better understand the grave threats facing the Yangtze River, and a guiding reference for the related departments, river basin authorities and local governments to make scientific strategies, in a bid to maintain a living Yangtze River now and forever.



Yiyu Chen
Academician
Chinese Academy of Sciences

Source of Yangtze©Zhongwu Wang

THE YANGTZE RIVER— OUR MOTHER RIVER

▼ The diversity in climatic, geographical and geomorphological conditions and complex river-lake relations makes the Yangtze River basin one of the most biologically diverse ecoregions in the world.

▼ The Yangtze River Economic Belt (YREB), linked by the Yangtze River Golden Waterway, is of great strategic significance to China's economic and social development.

▼ The report aims to provide a systematic and objective diagnostic of the health of Yangtze River in order to support the ecological and environmental conservation of the river basin, promote the green development of the YREB, stimulate and promote active participation of multi-stakeholders in the basin.

1.1 A UNIQUE AND DIVERSE ECOSYSTEM

The Yangtze River is a globally unique and complex ecosystem.

The Yangtze River emerges in the Tanggula Mountains of the Qinghai-Tibet Plateau. Its main river flows from west to east over roughly 6,300 km, through eleven provinces (autonomous regions and municipalities directly under the central government). They are Qinghai, Tibet, Yunnan, Sichuan, Chongqing, Hubei, Hunan, Jiangxi, Anhui, Jiangsu and Shanghai. Its tributaries stretch to another eight provinces (and autonomous regions) namely Gansu, Shaanxi, Henan, Guizhou, Guangxi, Guangdong, Fujian and Zhejiang. The 1.8 million km2 area of the Yangtze River basin accounts for approximately one fifth of China's land area and is home to 459 million people, approximately one third of China's total population.

With a terrain that is high altitude in the northwest and low in the southeast, the Yangtze River basin spans China's three-step topography from west to east. Largely located in the East Asia monsoon region, the basin has a visible monsoon climate. Its vast territory and complicated landforms endow the basin with a variety of regional climatic characteristics. The abundant precipitation in the basin is higher in the region's south and the middle and lower reaches than the region's north and upper reaches, showing a decreasing trend as you move from southeast to northwest. The Yangtze River is well-drained and has over 7,000 tributaries. 437 of these tributaries cover drainage areas of more than 1,000km2 each. The basin includes numerous lakes, mainly distributed in the middle and lower reaches. Of these lakes, Poyang, Dongting, Taihu and Chaohu make up four of China's five largest freshwater lakes[1]. The Yangtze basin can be divided into twelve water resource zones at level 2 (WRZ-L2): the upper Jinsha River basin (upstream of Shigu station), the middle and lower Jinsha River basin (from Shigu station to Yibin station), the Minjiang/Tuojiang River basins, the Jialing River basin, the Wujiang River basin, the upper Yangtze mainstem section from Yibin station to Yichang station, the Dongting Lake basin, the Hanjiang River basin, the Poyang Lake basin, the middle Yangtze mainstem section from Yichang station to Hukou station, the lower Yangtze mainstem section downstream of Hukou station, and the Taihu Lake basin.

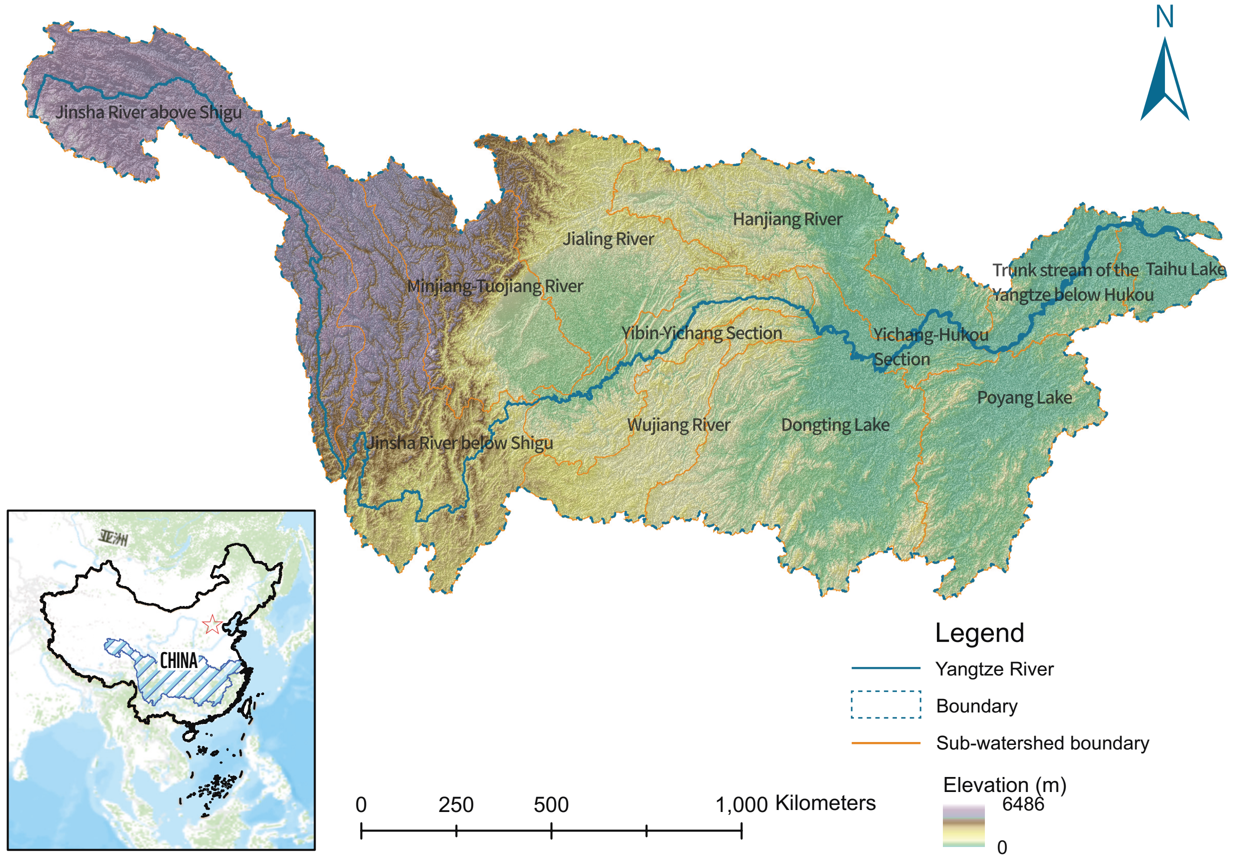


Fig.1-1 Sketch of the Yangtze River basin and its location

The Yangtze River basin is one of the world's most biologically diverse ecoregions due to its climatic, geographical and geomorphological diversity and complexity of river-lake relations. Flagship species, such as Giant panda (*Ailuropoda melanoleuca*), Chinese sturgeon (*Acipenser sinensis*), Yangtze river dolphin (*Lipotes vexillifer*), and Yangtze finless porpoise (*Neophocaena asiaeorientalis*), have lived in the region since before the dawn of human civilization.

Fish diversity is an important ecological feature of the Yangtze River basin, which is best illustrated by honorifics such as "the cradle of China's freshwater fishery", and "a treasure trove of fish genes". 416 different species of fish live in the Yangtze River basin, including 362 pure freshwater fish species. In addition,178 fish species, accounting for 42.8% of total species are endemic, 97 of which live in the upper reaches[2]. The richness of fish diversity contributes to the abundance of fishery resources in the basin. The Yangtze River once annually yielded as many as 10 billion crablets, 200 million eel and 30 billion of "the four major Chinese carp", that is to say black carp (*Mylopharyngodon piceus*), grass carp (*Ctenopharyngodon idellus*), silver carp (*Hypophthalmichthys molitrix*) and bighead carp (*Aristichthys nobilis*).

416
Fish species

362
Freshwater fish species

178
Yangtze endemic fish species

97
Upper Yangtze endemic fish species

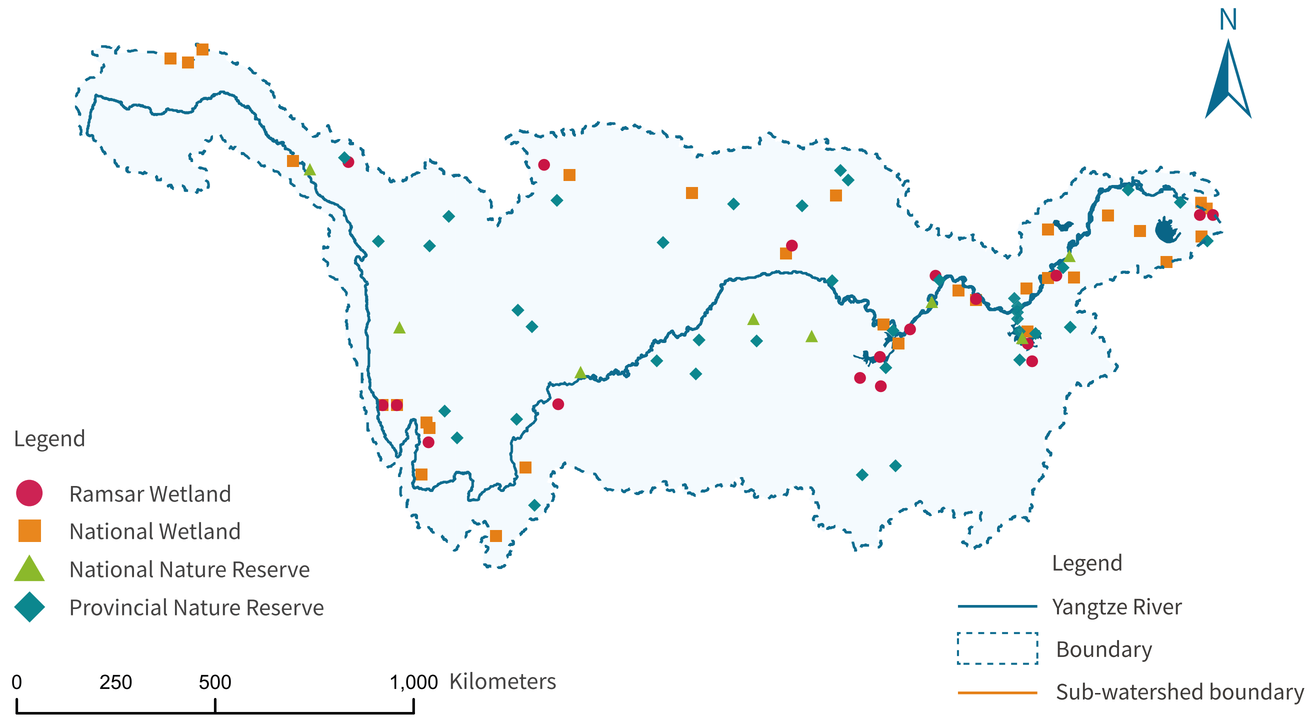


Fig.1-2 Distribution of nature reserves in the Yangtze River basin

The combination of the basin's unique geographical location, abundant natural resources as well as its long history and culture accentuate the importance of the conservation of ecosystems and biodiversity in the Yangtze River basin, domestically as well as internationally. Reflecting the importance of the Yangtze, WWF has designated the basin as one of the 35 priority ecoregions for biodiversity conservation in the world[3].

1.2 A DRIVE FOR HIGH-QUALITY DEVELOPMENT

Protecting the Yangtze River ecosystem is of vital strategic significance to ecological security. However, over exploitation of the basin resources is putting the health of the ecological system under immense pressure.

The Yangtze River basin is a vast reservoir of resources including water, hydropower, soil, navigation channels, minerals, forests, grasslands and biodiversity. Water resources total 995.8 billion m^3, accounting for 35 per cent of the country's total. The 459 million inhabitants of the basin and another nearly 100 million people in China (through the South-to-North Water Diversion Project) are supplied with drinking water from the Yangtze River, making it the most important water source in China.

The Yangtze River, known as the "Golden Waterway", is also a key shipping artery connecting the eastern, central and western parts of China. Urban economic hubs such as the Yangtze River Delta Urban Agglomerations, the Middle Yangtze Urban Agglomerations, the Chengdu-Chongqing Urban Agglomeration, Central Yunnan and Central Guizhou, are of strategic importance to China's economic and social development[4] and depend directly or indirectly on the Yangtze River.

Despite recognition of the value of the Yangtze, over the past 40-plus years of China's rapid economic development, the Yangtze River basin has developed increasingly challenging problems related to overexploitation of natural resources, and ecological and environmental deterioration.

Along the Yangtze River cities and farmland create a great deal of wastewater and sewage that is often disposed of without being treated to the relevant standards, while inappropriate development of land, rivers, lakes and waterfronts, construction of reservoirs, and overfishing, have made the Yangtze River one of the world's most ecologically deteriorated rivers[1,5]. Global climate change is also posing a new challenge to biodiversity conservation in the Yangtze River basin, with glaciers melting and an increase in extreme weather and hydrological events.

Tianezhou Oxbow Nature Reserve©Jianchun Song

"The Yangtze River is sick, and it's seriously sick."

The health of the Yangtze River is failing fast, two fish species are already extinct, two are extinct in the wild (meaning that there might be species bred in captivity), while 61 of its freshwater fish species are threatened: five are critically endangered, 36 are endangered and 20 are vulnerable to extinction[2]. The construction of dams and creation of reservoirs in the basin have dramatically damaged the natural population of the four major Chinese carp and seen the abundance of fish larvae shrink year on year[6,7,8]. Factors such as disconnecting lakes from the Yangtze, water pollution and overfishing have cut the number of fish species in lakes by 30-50 per cent[9,10,11].

Pollution is also a significant challenge with 43 per cent, 37 per cent and 43 per cent of the national total of wastewater, Chemical Oxygen Demand (COD) and the total ammonia nitrogen being discharged in the Yangtze River Economic Belt[12]. COD and ammonia nitrogen discharge per unit area are 1.5 to 2 times the national average. Heavy and chemical industries densely settle along the Yangtze River and 30 per cent of environmentally risky enterprises are found under 5 km from drinking water sources. Nearly half of the country's key areas for the prevention and control of heavy metal pollution are located within the Yangtze River Economic Belt[13].

From 2000 to 2017, the Yangtze River basin witnessed a 195.2 per cent increase in urban areas, a 2.3 per cent decrease in farm land and a 0.43 per cent increase in forested areas. Urbanization is the primary driver for changes in the ecosystem patterns in the basin and is responsible for 48.0 per cent of these ecosystem changes[14].

China is facing a complex set of urgent issues in balancing the need to protect biodiversity, utilize natural resources in an efficient and rational manner, and safeguard the ecological security of the Yangtze River basin.

"Making all-out efforts to protect it, and forbidding large-scale development of the river".

In recognition of this, on January 5, 2016, at the symposium on promoting the development of the Yangtze River Economic Belt in Chongqing, Chinese President Xi Jinping stressed that "we must proceed from the long-term interests of the Chinese nation to put restoring the ecological environment of the Yangtze River at a dominant position, making all-out efforts to protect it, and forbidding large-scale development of the river".

In his speech on April 26, 2018 at the symposium on further promoting the development of the Yangtze River Economic Belt, Xi Jinping clarified the five relationships that should be accurately understood to promote the development of the Yangtze River Economic Belt. The first one of them is "to properly deal with the relationship between pressing ahead on the whole and making breakthroughs in key areas, so as to protect and restore the ecological environment of the Yangtze River in all aspects." He called again for putting restoration of the river's ecological environment high on the agenda in developing the Yangtze River economic belt. Such high-level support gives hope for reaching the goal of a healthy and productive Yangtze River basin, featuring more beautiful ecology, smoother transport, more coordinated economy, more integrated markets and more scientific mechanisms..

Restoring and protecting the biodiversity of the Yangtze River basin is a challenging long-term endeavor and one that will require further support.

1.3 EXPLORE THE "LIVING YANGTZE INDEX"

? How can we cure the "seriously sick" Yangtze?

Below is the prescription provided by Chinese President Xi Jinping:

——We should apply the holistic view of Traditional Chinese Medicine (TCM) in a scientific way, to trace the source of the sickness, diagnose the causes, identify the root causes, take objective measures and implement systematic treatment. The health of the Yangtze River must be assessed by conducting comprehensive ecological and environmental surveys to give us a full understanding of the hazards, as well as an assessment of the carrying capacity of resources and the environment.

——Based on the diagnosis, a systematic action plan for ecological and environmental restoration and protection should be developed "from the source", since mountains, rivers, forests, farmlands, lakes and grasslands are a community with a shared future. We will attempt to cure the sickness by tackling each problem in a holistic manner, dealing with the origins of the issues as well as with the symptoms.

——Tools include functional zoning to optimize, prioritize, restrict or prohibit development in different areas according to local conditions. We should plan ecological boundaries and establish reliable long-term monitoring and early warning mechanisms for the carrying capacity of resources and the environment. We should put effective comprehensive management measures into practice, so as to develop a living and nurturing river.

......

Over the past two decades, WWF has been committed to research and practice concerning the protection of freshwater ecosystems in the Yangtze River. The organization has completed a series of research projects and relevant events in collaboration with Chinese governments at all levels, as well as their partners. Key projects include the conservation of Ramsar Wetland sites, including Dongting Lake, Poyang Lake, Hong Lake, and Chongming Dongtan, the demonstration and promotion of stocking lakes with fry and crablets from the Yangtze River and reconnecting lakes to the Yangtze River, research and implementation of environmental flows in the Yangtze River, initiation of the Yangtze Wetland Network, scientific expeditions and protection actions related to the Yangtze finless porpoise, Wetland Ambassador Action, the Yangtze Forum, and the Taihu Forum.

In 2018, WWF and its strategic partners launched the *Living Yangtze Report* (hereinafter -the *Report*) project. The goal of the project is to provide a systematic and objective diagnostic report on the health of the Yangtze River, to guide solid decision-making on ecological and environmental protection enhancement policies in the Yangtze River basin and the implementation of green development of the Yangtze River Economic Belt, offer policy recommendations on protection and management of Yangtze River ecosystems, and motivate different stakeholders to actively participate in the protection of the Yangtze River.

The participating partners are Changjiang (Chinese spelling for Yangtze) River Scientific Research Institute (CRSRI), Chinese Academy of Environmental Planning (CAEP), Institute of Geographic Sciences and Natural Resources Research, Chinese Academy of Sciences (IGSNRR), Institute of Hydrobiology, Chinese Academy of Sciences (IHB), Key Laboratory of Yangtze River Water Environment, Ministry of Education (Tongji University) (KLYRWE), Nanjing Institute of Geography & Limnology, Chinese Academy of Sciences (NIGLAS), Research Institute for Environmental Innovation (Suzhou) Tsinghua (RIET), and School of Water Resources and Hydropower Engineering, Wuhan University (SWRHE).

Protection of Yangtze finless porpoise©Gui Li

Reconnect the rivers and lakes for a Living Yangtze©WWF Baoyu Wei

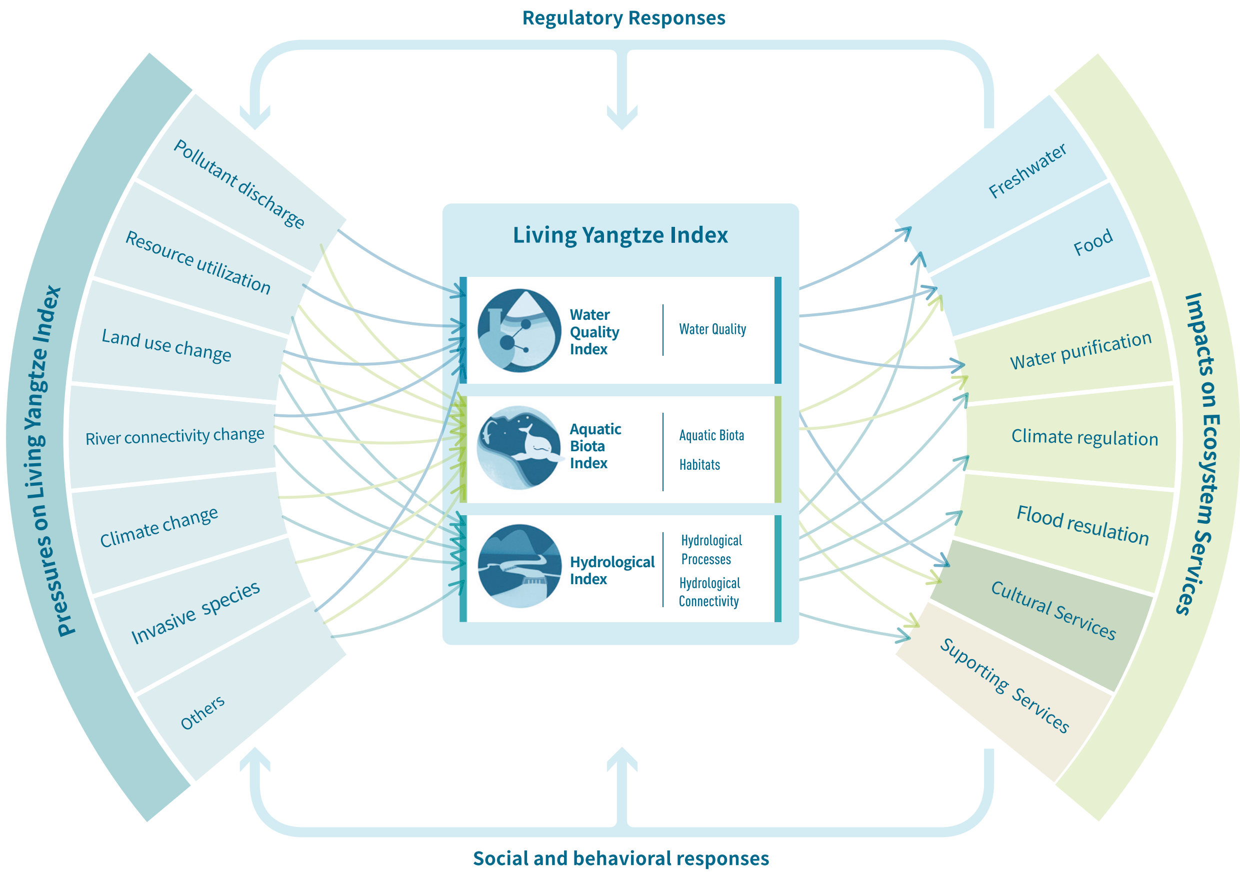


Fig.1-3 Conceptual framework of the ***Living Yangtze Report***

The Living Yangtze Index (LYI) is the core of the *Report*. The index primarily measures the health of the Yangtze River freshwater ecosystems. It addresses three aspects, namely aquatic biota (including aquatic biodiversity and habitats), water quality and hydrology (including hydrological processes and connectivity).

The *Report* measures and analyzes the main pressures on freshwater ecosystems in the Yangtze River. These include pollution, over-utilization of resources, impaired river/lake connectivity, reservoir regulations, changes in land use, waterfront exploitation, climate change and invasive species. The *Report* examines the relationships between these stresses on the freshwater ecosystems and the health of the Yangtze River, and proposes remedies to respond to pressures and challenges.

It should be noted that most of the data in the *Report* comes from journals, published papers and research results of the participating organizations. Considering data integrity and availability, the *Report* primarily uses data from 2014 to 2018 for status assessment. The assessment units are the Source of the Yangtze (upstream of Zhimenda station), the Upper Yangtze (the Jinsha River basin, the Minjiang/Tuojiang River basins, the Jialing River basin, the Wujiang River basin and the upper Yangtze mainstem section from Yibin station to Yichang station), the Middle Yangtze (the Hanjiang River basin and the middle Yangtze mainstem section from Yichang station to Hukou station, excluding the Dongting Lake and Poyang Lake basins), the Lower Yangtze (the lower Yangtze mainstem section downstream of Hukou station), the Dongting Lake basin, the Poyang Lake basin, the Chaohu Lake basin and the Taihu Lake basin. The assessment of aquatic biota index targets only the mainstem of the Yangtze River and the four lakes.

WWF believes that this report will help people form a new and more accurate understanding of the Yangtze River and provide a clear introduction to the essential components of the Living Yangtze Index.

The Living Yangtze Index reflects the health of the Yangtze River freshwater ecosystems

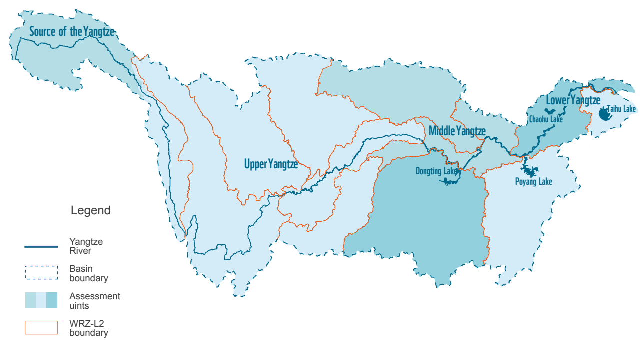
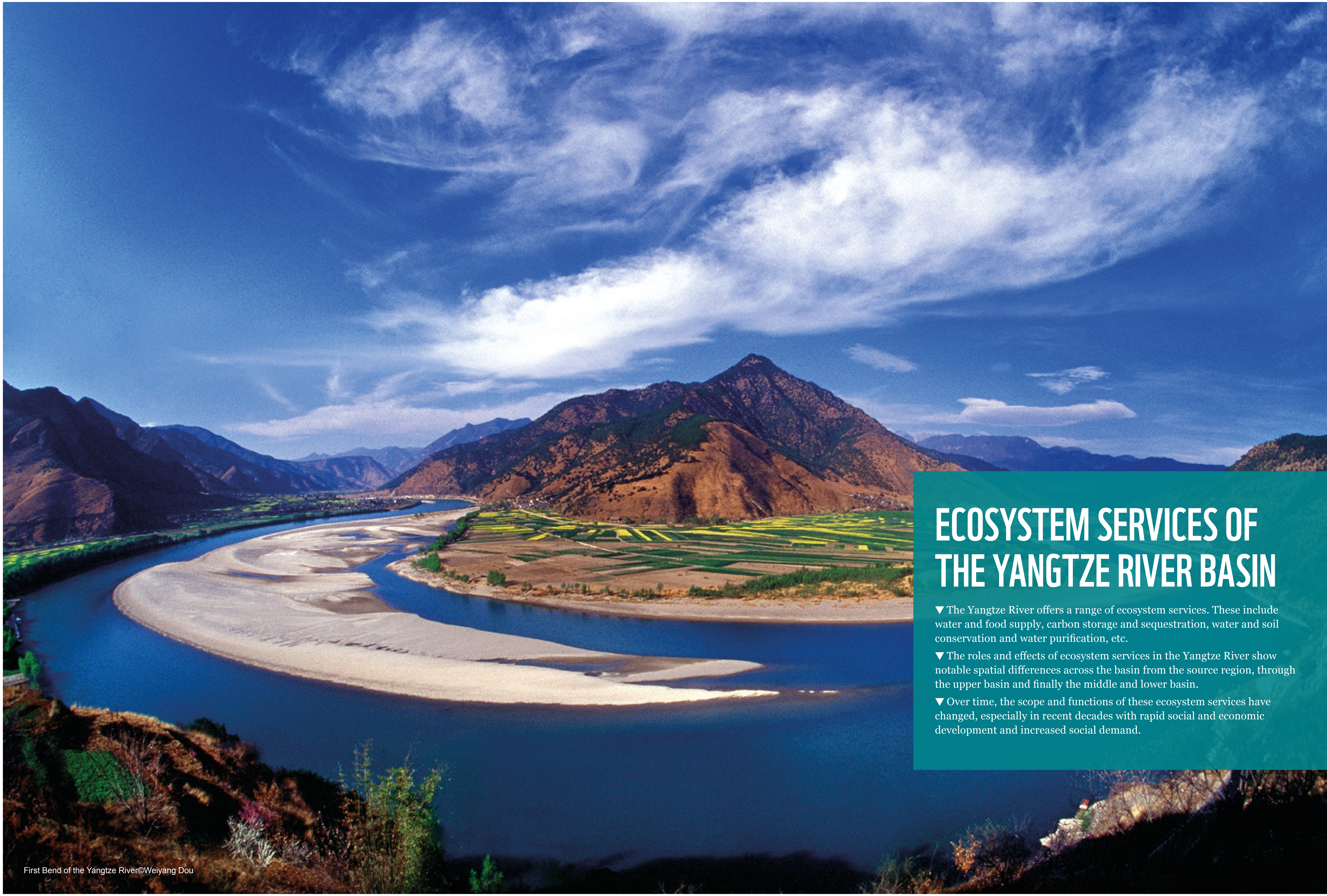


Fig.1-4 The Assessment Units of Living Yangtze Index



First Bend of the Yangtze River©Weiyang Dou

ECOSYSTEM SERVICES OF THE YANGTZE RIVER BASIN

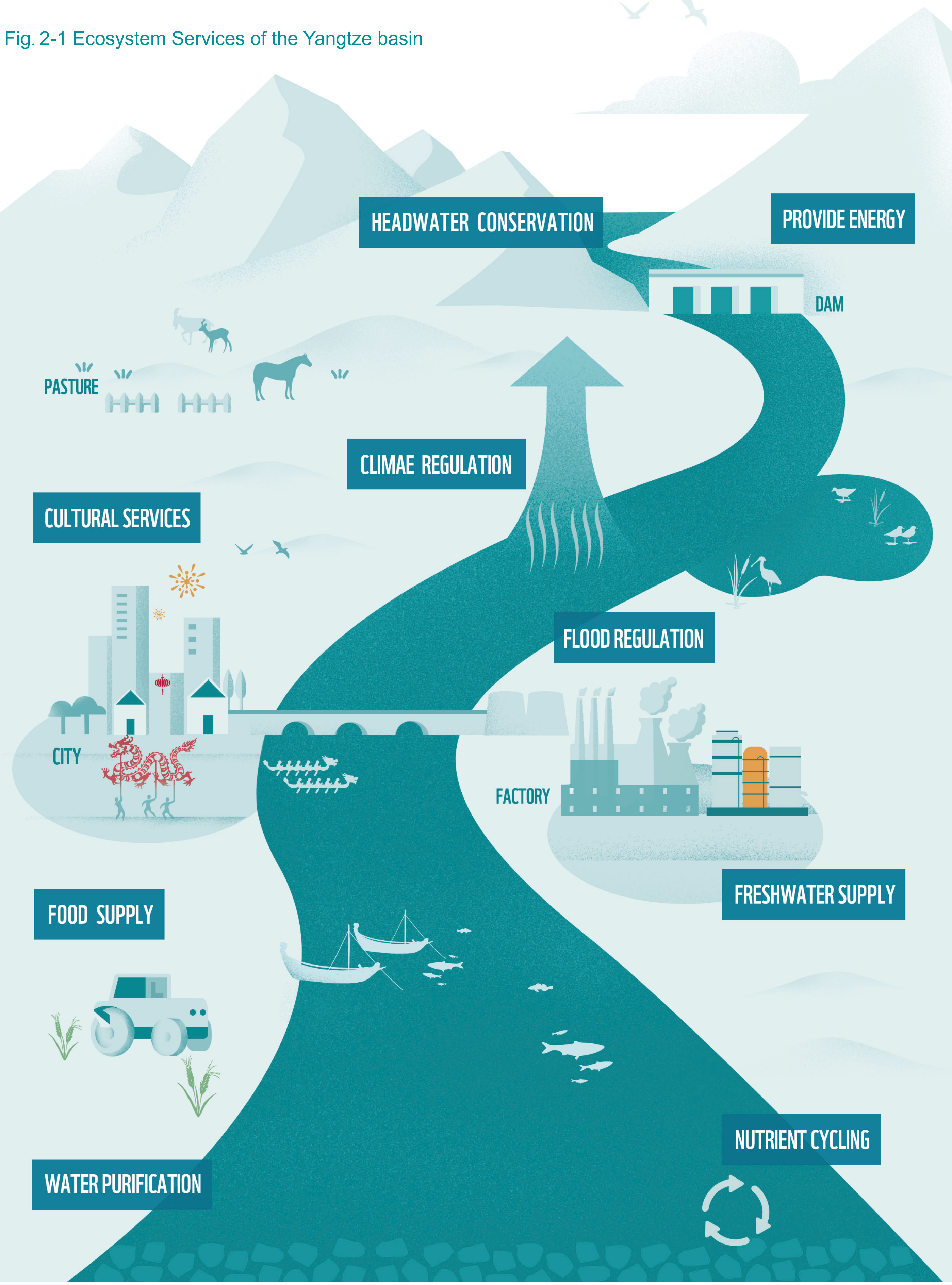
▼ The Yangtze River offers a range of ecosystem services. These include water and food supply, carbon storage and sequestration, water and soil conservation and water purification, etc.

▼ The roles and effects of ecosystem services in the Yangtze River show notable spatial differences across the basin from the source region, through the upper basin and finally the middle and lower basin.

▼ Over time, the scope and functions of these ecosystem services have changed, especially in recent decades with rapid social and economic development and increased social demand.

2.1 COMPOSITE ECOSYSTEM SERVICES

Fig. 2-1 Ecosystem Services of the Yangtze basin



The Yangtze River basin is home to 459 million people[15], roughly one third of China's total population. The Yangtze River Delta and the Middle and Lower Yangtze Plain are the most densely populated regions.

As China's "mother river", the Yangtze River region takes on the lion's share in propping up national economic and social development. In 2018, the GDP in the Yangtze River Economic Belt totaled RMB 40 trillion[15], approximately 40 per cent of the national GDP. Major contributors are the Taihu Lake basin (the Yangtze River Delta Metropolitan Area), the mainstem of the Yangtze below Hukou (the Lower Yangtze Plain), the Jianghan Plain (Wuhan Metropolis Circle), the Dongting Lake basin (Changsha-Zhuzhou-Xiangtan Urban Agglomeration), Minjiang/Tuojiang River basin, and Jialing River basin (Chengdu-Chongqing Twin-city Economic Circle) and the Poyang Lake basin.

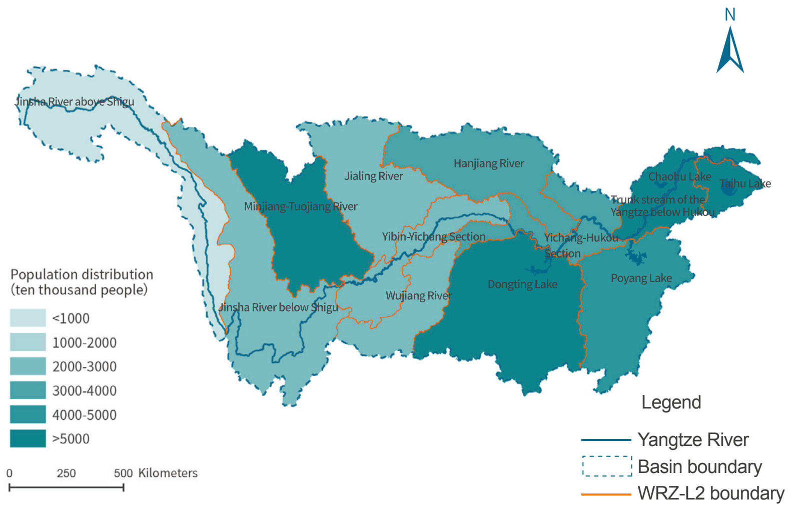


Fig. 2-2 Population distribution in different sub-basins of the Yangtze River basin

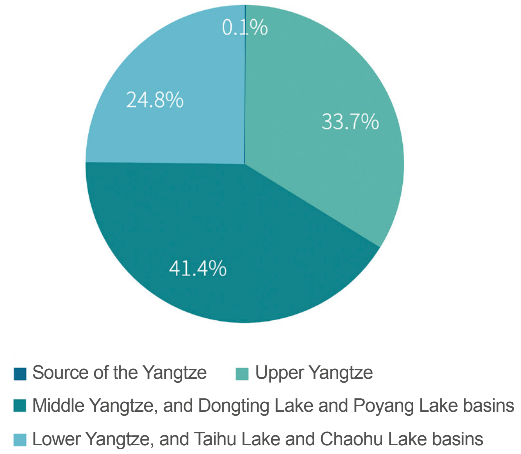


Fig. 2-3 Proportion of population in different regions of the Yangtze River basin

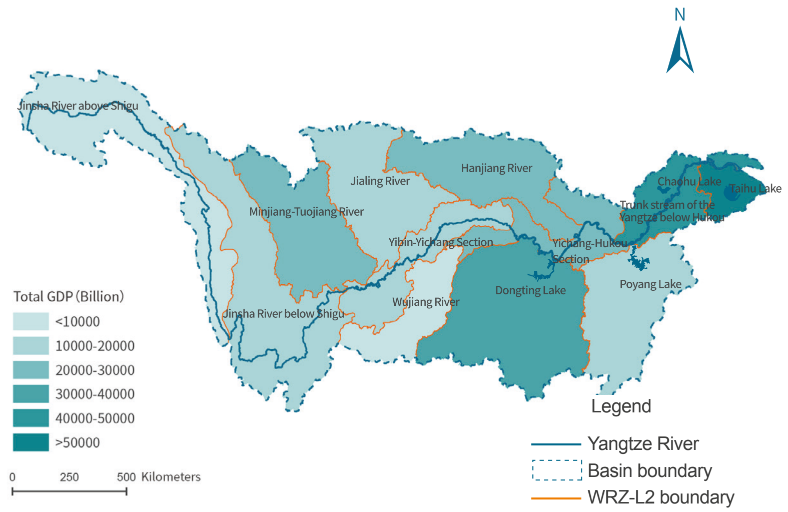


Fig. 2-4 Total GDP in different sub-basins of the Yangtze River basin

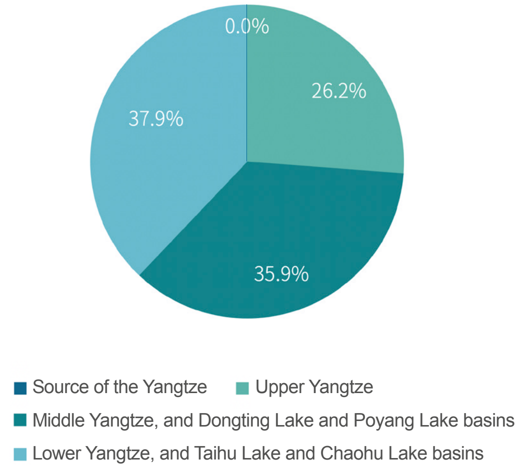
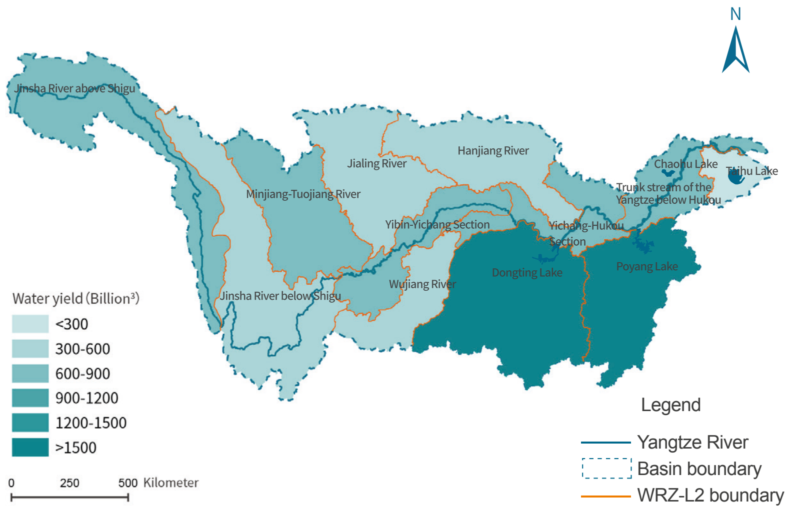


Fig. 2-5 Proportion of GDP in different regions of the Yangtze River basin

The Yangtze River basin is a huge ecosystem that provides multiple ecosystem services

As defined by the United Nations' *Millennium Ecosystem Assessment* (MEA), ecosystem services are the benefits people obtain from ecosystems. These include supply services (food and water supply for example), regulation services (such as flood regulation, headwater conservation, water purification, reduction of land degradation and diseases), support services (such as soil formation and nutrient cycling), and cultural services (recreation, spiritual and other non-material benefits). The colossal ecosystem of the Yangtze River basin provides a tremendous volume of ecosystem services that support China's economic and social development.

The volume of water provided by the Yangtze River basin is high in the east but low in the west, with a perennial average water yield of about 966.2 billion m^3. In the basin, the Dongting Lake basin and the Poyang Lake basin are the two sub-basins with the highest water yield.



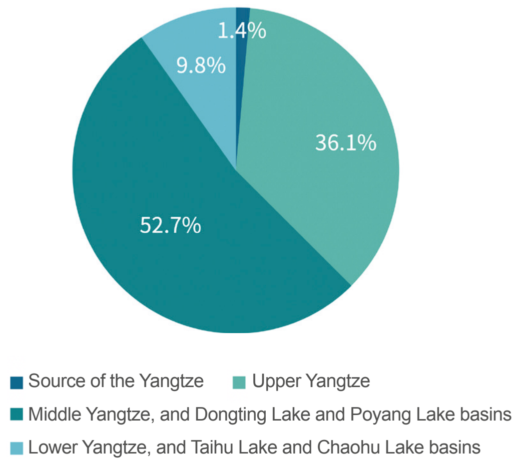


Fig. 2-6 Water Yield in different sub-basins of the Yangtze River basin

Fig. 2-7 Proportion of Water Yield in different regions of the Yangtze River basin

In 2018, the Yangtze River basin supplied 207.16 billion m3 of water, accounting for 34.4 per cent of the national total[16]. The Yangtze River not only supplies water for industrial and agricultural production and domestic use in general in the basin, but also supports water security in vast areas beyond the basin through water diversion projects like the South-to-North Water Diversion Project. In 2018, the Middle Route Phase I Project of the South-to-North Water Diversion alone diverted 7.67 billion m3 of water, effectively safeguarding the security of water supply in Northern China[17].

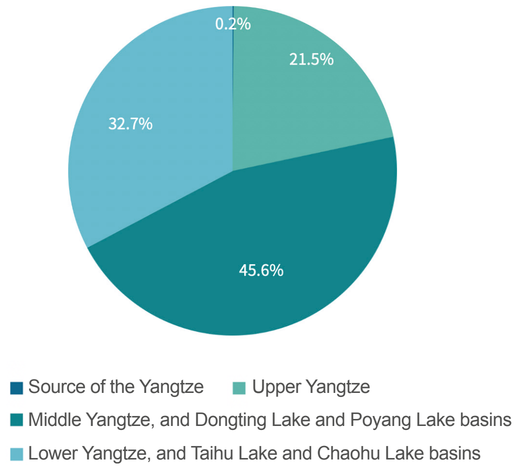


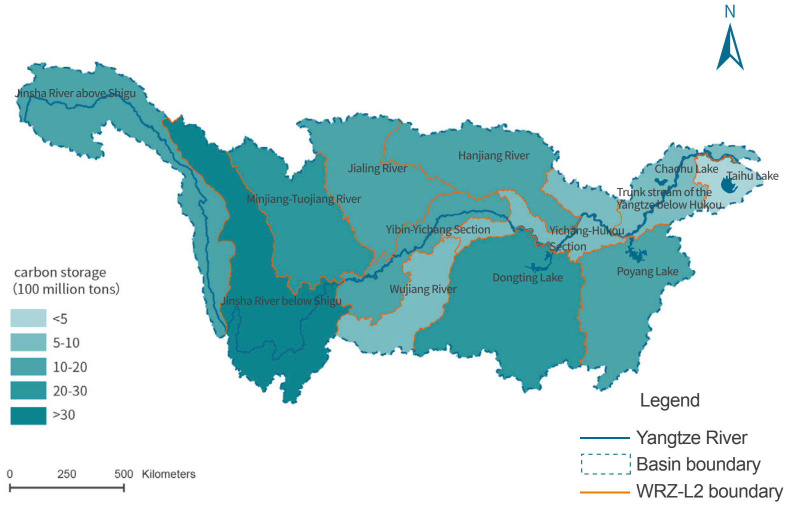
Fig. 2-8 Water Supply in different sub-basins of the Yangtze River basin

Fig. 2-9 Proportion of Water Supply in different regions of the Yangtze River basin

The *China Fishery Statistical Yearbook 2018* shows that the annual average fishing harvest in the middle Yangtze is about 590,000 tons. This represents the total harvest of fishery resources in the provinces situated in the middle reaches of the Yangtze River. This includes the Yangtze River itself as well as lakes and reservoirs[18].

The ecosystems such as forest and grasslands in the Yangtze River basin plays an important role to retain sediment. The InVEST* model simulation indicates that the annual average soil erosion in the basin is 1,386 tons per km^2 and roughly 2.53 billion tons a year. Soil erosion is caused by many factors and is linked with topographic features such as altitude, land use types as a result of human activities and slope gradient, where the erosion amount is often higher in areas with a greater slope gradient. For example, the total amount of soil erosion is 0.84 billion tons and 0.53 billion tons respectively in the upper Jinsha River, and the middle and lower Jinsha River, accounting for 33 per cent and 21 per cent of the total erosion in the Yangtze River basin. Meanwhile, nearly 400 million tons of soil are eroded in the Minjiang/Tuojiang River basins each year, accounting for 15.8 per cent of the total.

*InVEST (Integrated Valuation of Ecosystem Services and Trade-offs) model, is a model jointly developed by WWF, Stanford University and The Nature Conservancy (TNC) which models and visualizes the distribution and economic value of ecosystem services incorporating different land cover scenarios, aiming to provide a scientific basis for the evaluation of ecosystem services and balance human activities' benefits and impacts for decision makers.



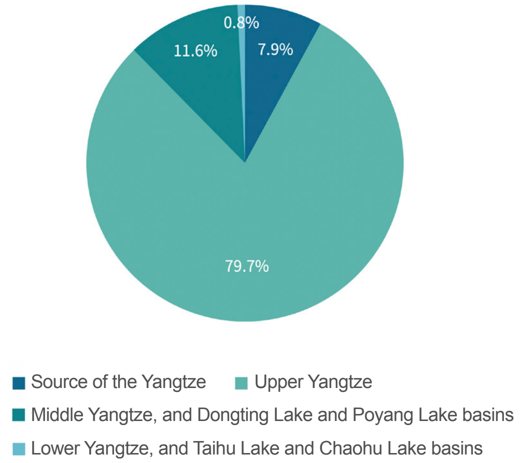
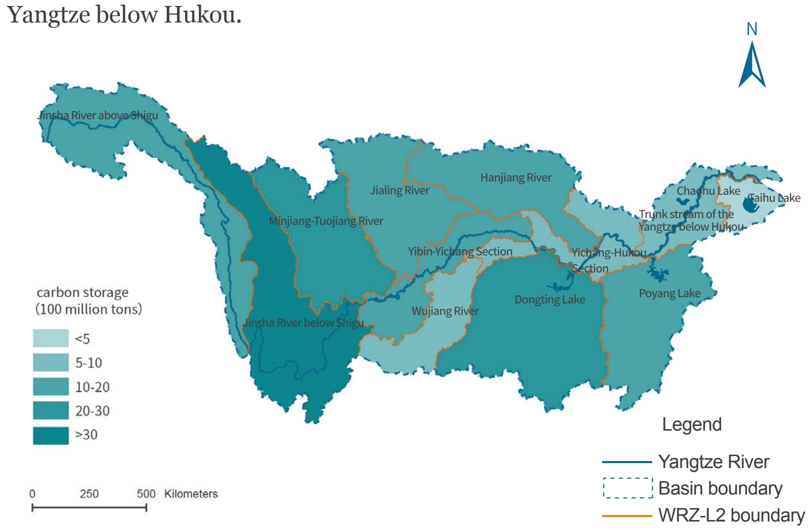


Fig. 2-10 Soil Erosion in different sub-basins of the Yangtze River basin

Fig. 2-11 Proportion of Soil Erosion in different regions of the Yangtze River basin

The Yangtze River plays a key role in storing and sequestering carbon, which has a direct impact on global climate change. According to the calculation of four common basic carbon stocks (aboveground carbon in vegetation, underground carbon, soil carbon and organic carbon in dead vegetation) ecosystems in the Yangtze River basin store approximately 19.36 billion tons of carbon. Of the sub-basins, the middle and lower Jinsha River basin has the largest carbon reserve. It is followed by the Dongting Lake basin, Minjiang/Tuojiang River basin and Jialing river basin. The carbon reserve is relatively low in the Taihu Lake basin and the mainstem of the Yangtze below Hukou.



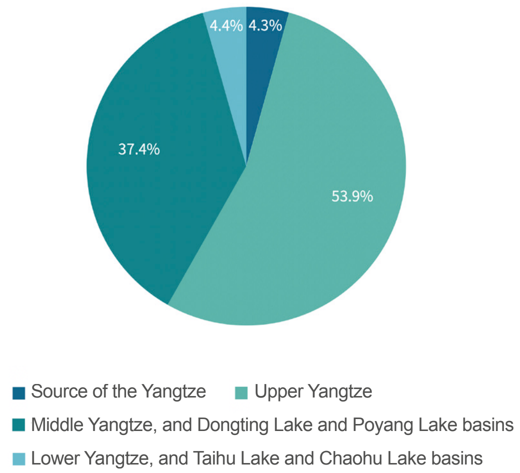


Fig. 2-12 Carbon storage in different sub-basins of the Yangtze River basin

Fig. 2-13 Proportion of carbon storage in different regions of the Yangtze River basin

The vegetation and soil of the Yangtze River basin are major contributors to removing nitrogen and phosphorus pollutants from runoff. The nutrient load of rivers is dependent on the total nutrient load in the basin and the removal capacity of vegetation and soil. The results of monitoring and computation indicate that there is an average delivery of 255,000 tons of nitrogen and 15,000 tons of phosphorus per year. This is after 180,000 tons of nonpoint source nitrogen and 55,000 tons of nonpoint source phosphorus pollution are retained and filtered by ecosystems. The highest levels of nutrient retention occur in the Dongting Lake basin, the lowest in the Taihu Lake basin.

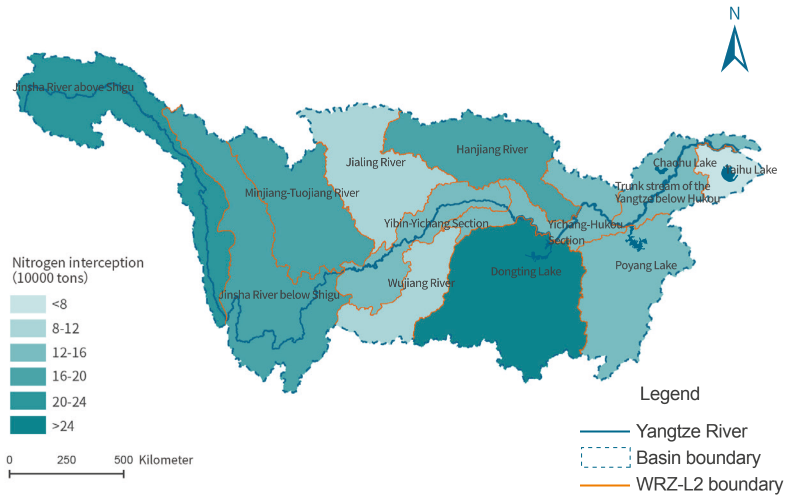


Fig. 2-14 Nitrogen interception in different sub-basins of the Yangtze River basin

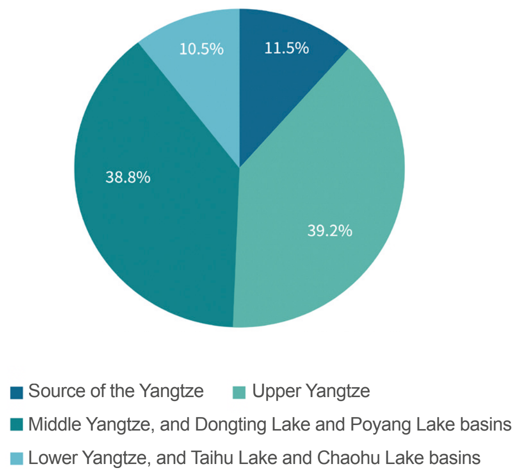


Fig. 2-15 Proportion of nitrogen interception in different regions of the Yangtze River basin

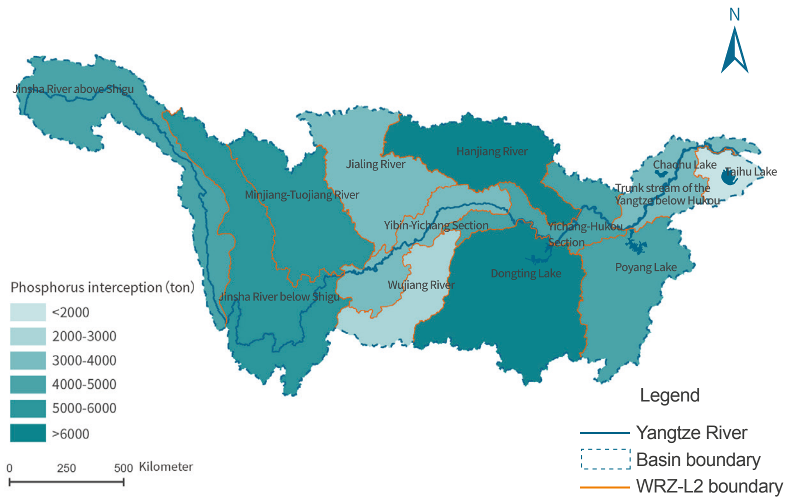


Fig. 2-16 Phosphorus interception in different sub-basins of the Yangtze River basin

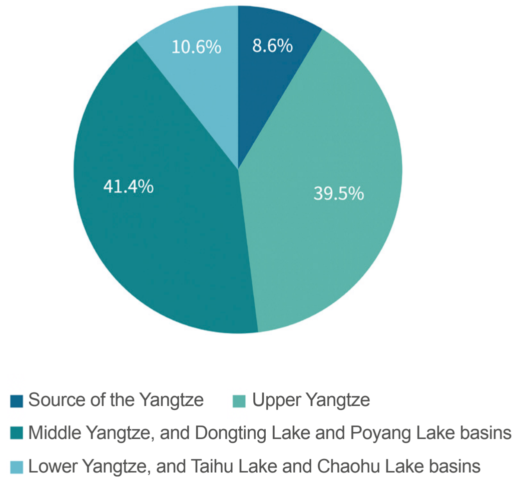


Fig. 2-17 Proportion of phosphorus interception in different regions of the Yangtze River basin

The *Report* assesses the mean Normalized Difference Vegetation Index (NDVI), a remote sensing indicator that reflects the vegetative cover on land. It is an important parameter that follows vegetation growth and nutrition, which is widely applied to the monitoring of vegetation growth status and coverage as well as the Habitat Quality Index (HQI). The mean NDVI of the Yangtze River basin is 0.76. A large part of the mountainous areas in the upper reaches are dry and hot valleys or alpine meadows with low vegetation coverage. In the Taihu Lake basin, built-up land occupies a large proportion resulting in a smaller area covered by green vegetation. The Hanjiang river basin, the Jialing river basin, the Dongting Lake basin and the Poyang Lake basin all feature high vegetation coverage rates and the vegetation is generally in good condition.

A better habitat usually shows higher biodiversity, with habitat deterioration implying a decrease in biodiversity. Habitat quality and its rate of degradation can be estimated by analyzing the impacts of human activities on land use or land cover patches in the river basin. The mean terrestrial habitat quality index in the Yangtze River basin is 0.814. Comparing 2000 and 2017, the habitat degradation rate in the upper and middle Yangtze is generally below 2 per cent, comparatively low in the west and high in the east. The habitat degradation rate averages 4 per cent in the Taihu Lake basin and 2.6 per cent in the mainstem of the Yangtze River below Hukou. The mean HQI is highest in the middle and lower Jinsha River, which is 0.876. All of these results are closely related to land use in the areas that have been studied.

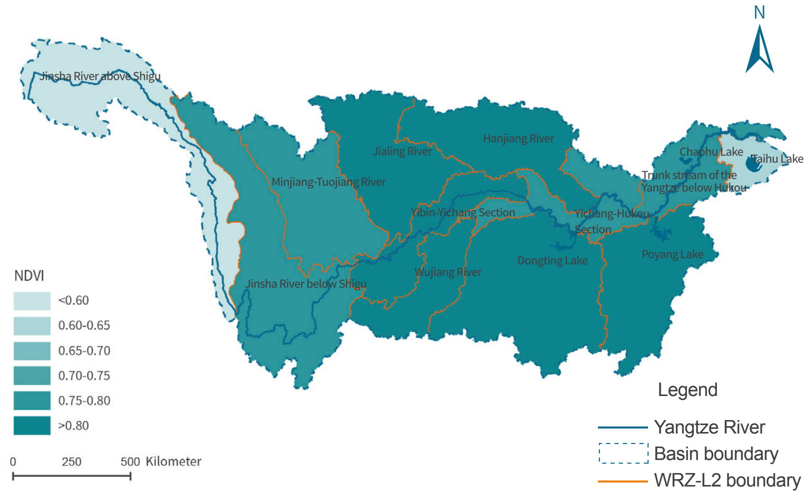


Fig. 2-18 Habitat quality index in different sub-basins of the Yangtze River basin

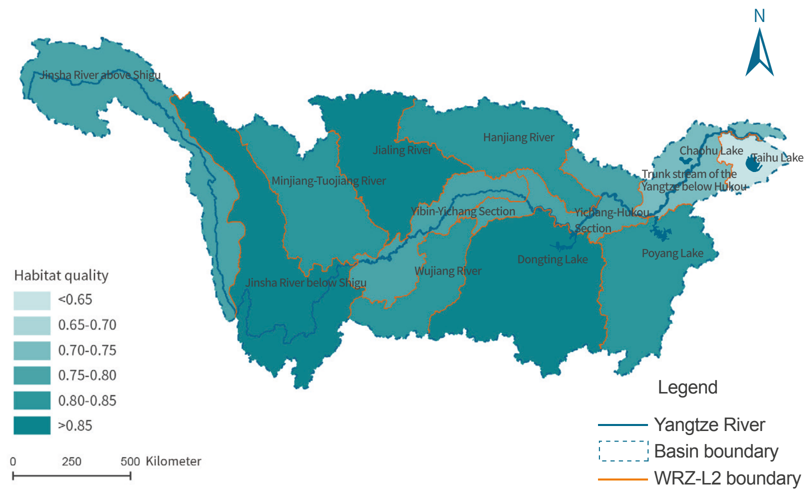


Fig. 2-19 Habitat degradation rate in different sub-basins of the Yangtze River basin

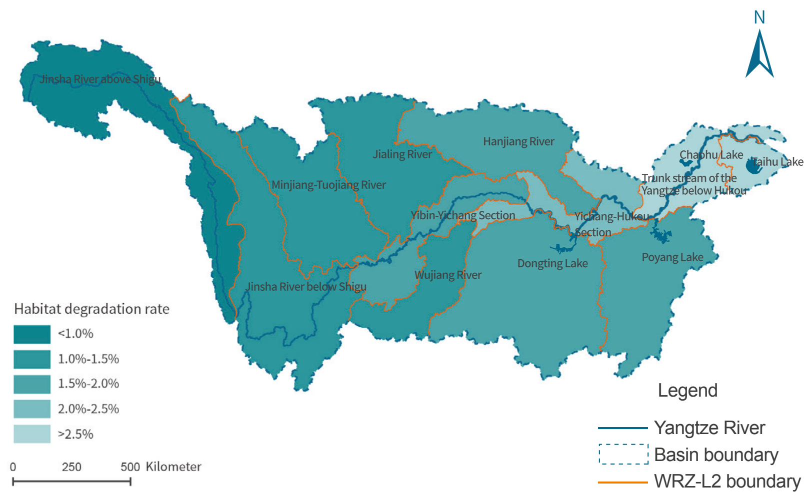


Fig. 2-20 Habitat degradation rate in different sub-basins of the Yangtze River basin

2.2 CHANGE OF ECOSYSTEM SERVICES OVER TIME

The provisioning services in the Yangtze River basin fluctuate over time. Biodiversity- and habitat-related supply and support services are under great pressure because of the huge demand created by rapid economic and social development. The degradation of natural fishery resources in the Yangtze River freshwater systems is particularly severe.

Healthy natural ecosystems are the foundation of the basin's rapid economic and social development. The only path to achieve high-quality economic and social development in the basin is by finding a better balance between maintaining healthy natural ecosystems and fulfilling resource demands created by economic and social development.

The *Report* assesses the change in some key types of ecosystem services in the Yangtze River basin over the past two decades by making a comparison to the baseline of 1995. The data fully expresses the contributions the basin has made to China's economic and social development and the cost it has paid over this period.

Fisherman's home at Jiangjiazui, west of Dongting Lake©Huaikuan Zhou

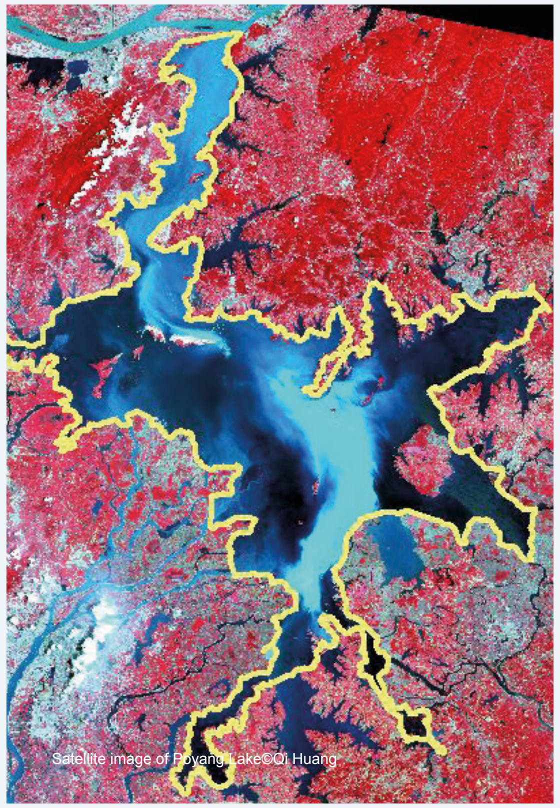
Ecosystem services of Poyang Lake

Poyang Lake is the largest freshwater lake in China, with a surface area of approximately 3,850 km^2. The lake receives inflow from five river systems including the Gan, Fu, Xin, Rao and Xiu rivers, and drains into the Yangtze River via the Hukou outlet. The annual runoff of Poyang Lake is about 150 billion m3, which makes up 15 percent of Yangtze River's freshwater resources.

Poyang Lake has a seasonal flood-drought cycle that sees significant changes to water levels between seasons and determines the lake-river exchange abilities. The natural rhythms and ecosystem functions of Poyang Lake have continued uninterrupted for thousands of years and Poyang Lake plays a critical role in flood regulation and storage. For example, on 11 July 2020, Poyang Lake reduced the flow to the Yangtze River from five river systems' inflow of 40,700m3/s to Hukou's outflow of 2000m3/s. The policy of returning reclaimed farmland into wetland and water area has also revitalized Poyang Lake and enabled 2 billion m3 of floodwater to be stored while lowering the water level by 25-30cm. Thus, Poyang Lake effectively supported flood control efforts and helped key dikes and dams to protect towns and tens of thousands of hectares of fertile land. However, challenges remain as shown by the floods of July 2020. Prolonged extremely heavy rainfall and upstream inflows led to a series of devastating floods across the Yangtze River mainstem, Dongting and Poyang Lakes and the Hanjiang river basin. The resulting water level rise in Poyang lake reached a historic high of 22.53m at Xingzi Station on 12 July 2020, surpassing the previous record in 1998. The floods also damaged a number of dikes and dams causing national concern about Poyang Lake.

In addition to flood controls, Poyang Lake is also internationally recognized for its biodiversity. During the dry seasons of autumn and winter, the water level of Poyang Lake recedes by about 10m, while large marshes appear all over the lake area providing a welcoming habitat for birds. Surveys show millions of migratory birds rest and forage here every year, including more than 95 percent of the world's white cranes.

Birds at Poyang Lake©WWF Baoyu Wei



Satellite image of Poyang Lake©Qi Huang

A stable supply of freshwater resources: the water yield is decreasing upstream and increasing downstream. To fulfill the demand of social and economic development, water supply provided by the basin has increased by 13.4 per cent compared to 1997. In addition, the Yangtze River has also increased water supply to areas outside the basin through a large number of water diversion projects.

Water yield +0.43%
Water supply +13.4%

Protection of the soil on which we live: the total amount of soil erosion in the basin has seen little change. Increases in soil erosion have mainly occurred in the middle and lower reaches.

+0.56%

Carbon sequestration contributing to climate change mitigation: carbon stock has increased by varying degrees in the upper stretches. It has decreased in the middle and lower stretches, except for the Hanjiang river basin.

+0.08%

Generally improved vegetation index: vegetation coverage and quality in the basin have notably improved. The vegetation index has increased by different levels, with the exception of the Taihu Lake basin.

+12.44%

-0.45%

Generally improved vegetation index: vegetation coverage and quality in the basin have notably improved. The vegetation index has increased by different levels, with the exception of the Taihu Lake basin.

-50.82%

Rapidly declining fishery resources: over the past twenty years, the harvest of natural fish resources in the Yangtze River has fallen by 50.82 per cent, especially in the trunk of the Yangtze River, where the decrease is 63.51 per cent. Figures for the decline in the Poyang Lake and the Dongting Lake fishing resources are 50.46 per cent and 46.70 per cent respectively.

Phosphorous output +2.42%
Phosphorous retention -0.8%

Inadequate nutrient retention capacity and increased pollution delivery: the output of nitrogen and phosphorous in the Yangtze River basin has risen, while the total nutrient retention has slightly dropped. Increased output comes mainly from the Dongting Lake and Poyang Lake basins. The Taihu Lake basin has seen the greatest decline in nitrogen and phosphorous retention capacity.

Fig. 2-21 Changes of some ecosystem services of the Yangtze River basin from 1995 to 2017

Natural capital and river basin management——Example: Liuyang River basin

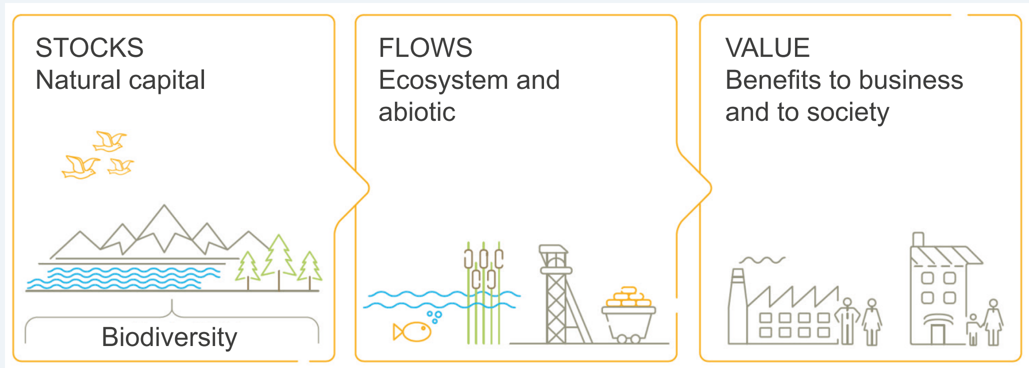
Natural capital can be defined as the stock of renewable and non-renewable resources such as plants, animals, air, water, soils, minerals that combine to yield a flow of services and/or benefits to people. Natural capital assessment and management are important tools to help planners prioritize and optimize the goals, targets and regulations of natural resource management and river basin protection.

In 2016, WWF, in cooperation with the Institute of Geographic Sciences and Natural Resources Research of the Chinese Academy of Sciences, completed China's first river basin-based natural resource assessment report titled "Natural Capital Assessment of the Liuyang River Basin". This report provides the necessary scientific and technical information for decision makers and stakeholders to understand, responsibly utilize and protect the natural capital in the river basin.

The assessment included a spatial analysis of the types of natural resources and value of natural capital in the Liuyang River basin, including water supply, soil conservation, and carbon sequestration as well as how these were changing over time (2000 to 2015). The results showed that forest coverage is 2818 km2, which is the largest ecosystem in the Liuyang River basin, accounting for 66 per cent of the whole basin area and providing important ecological functions such as headwater conservation, and soil and water conservation. The annual water supply of Liuyang River basin is significant at 2.49 billion m3.

Within the overall Liuyang basin, the source and riparian areas of Daxi River and Xiaoxi River and Dawei Mountain are the most important areas for water resources supply, with an annual water conservation amount of 1.37 billion m3. Without these soil and water conservation ecosystems, the annual erosion in the Liuyang River basin would be 30 million tons, the actual annual soil erosion is only about 1.3 million tons due to the healthy ecosystems in the river basin and the soil and water conservation functions they provide. From this we can calculate the total annual soil conservation provided by the Liuyang River basin ecosystem is 28.72 million tons, which is a great example of ecosystem function.

Natural capital assessments can reveal the status of natural capital and the effectiveness of protection measures, but an internationally agreed methodology of natural capital accounting is still lacking, especially for ecosystem services and adjustments. The good news is that China has been incorporating natural capital into decision-making through a number of processes including developing natural resource balance sheets and conducting evaluations of ecological product value. However, there is still a long way to go to apply these evaluation results to the effective and practical integrated management of the river basins.



Picture 2-22 Natural capital stocks, flows and value


Mudflat at the Yangtze estuary©Bin Zhang

LIVING YANGTZE INDEX (LYI)

▼ The LYI measures three dimensions: hydrology, water quality, and aquatic biota, which together provide a comprehensive picture of the health of the mainstem of the Yangtze and the four lakes in the Yangtze River basin.

▼ The Yangtze mainstem and the four lakes emerged with different evaluation results. The overall Living Yangtze Index of the mainstem Yangtze was evaluated as B-, with the source region as A, the upper and lower reaches as B-, and the middle reach as C. Both the Dongting Lake and Poyang Lake were evaluated as C, while the Taihu Lake and Chaohu Lake were evaluated as D and D-, which means improvements are needed.

3.1 WHAT IS THE LIVING YANGTZE INDEX?

Everything is borne of water. Human settlements follow water. Freshwater ecosystems account for just 4 per cent of the various natural ecosystems in the total Yangtze River basin area yet[16], they are important sources of food, home to significant biodiversity in the basin, key contributors in climate and flood regulation, and symbolic of the culture and emotions of the Chinese people.

Not only are the Yangtze River freshwater ecosystems the lifeblood of the Yangtze River basin, they are also a bellwether for the health of other natural ecosystems in the basin as the health of these freshwater ecosystems directly affects the various services the basin provides. Human activities in the basin have both a direct and indirect effect on the health of these freshwater ecosystems. Understanding the health status of the Yangtze River freshwater ecosystems is of critical importance.

The LYI is a set of quantitative information measuring the health of the Yangtze. The key factors determining the health of a freshwater ecosystem include water quality, water quantity, connectivity among water systems, aquatic biota, and the condition of the habitats[19,20].

The LYI therefore uses these three dimensions; hydrology, water quality, and aquatic biota (living organisms) to assess the overall health status of the Yangtze freshwater ecosystems. The indicators selected meet the principles of being representative, indicative, concise, and measurable over time.

Hydrological regimes (variations in the state and characteristics of a water body such as quantity and dynamics of water flow and connectivity) are important features of freshwater ecosystems and any shifts in these can affect water quality, habitat, and the life cycles of aquatic organisms[21]. Issues affecting hydrology include the amount of sediment (such as soil) transported by rivers and the changes in sediment, erosion and siltation (buildup of sediment). These changes not only affect the functioning of river systems, but also impact vital biogeochemical cycles, water quality, river-lake relationships, and the development of estuary deltas[22]. The hydrological index of the LYI shows the deviation of the current status of hydrological processes and connectivity from those that would be seen under natural river conditions.

Nutrients and organic materials (including pollutants) from terrestrial ecosystems are naturally released into aquatic ecosystems, affecting the trophic status (productivity of an ecosystem) which in turn directly impacts the water quality of aquatic ecosystems[21]. Therefore, to measure water quality, the LYI evaluates water quality through measuring the status of key pollution indicators that impact the trophic status and organic pollution.

Aquatic biota plays an important role in maintaining the structure and function of aquatic ecosystems, and also act as a health indicator for the ecosystem. As a result of their variable responses to environmental and habitat variations[23,24,25,26] an aquatic biota index was included in the LYI. In addition to measuring aquatic biota directly, the LYI also considered measuring habitat parameters as these are also closely linked with aquatic biota health and diversity. However, due to the very large spatial range of the Yangtze River basin there is only partial coverage of this indicator due to data limitations, the habitat data were therefore not included in calculation of the final LYI.

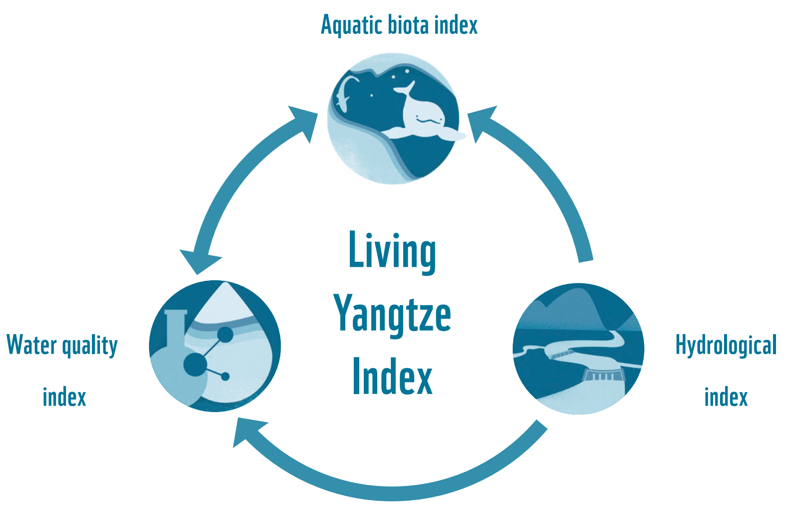


Fig. 3-1 Three dimensions of the Living Yangtze Index

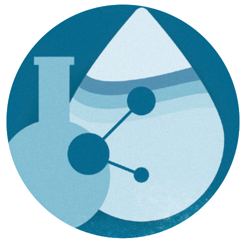
Fig. Three dimensions of Living Yangtze Index

The Hydrological Index

The assessment of the hydrological index in this report uses two categories of indicators: hydrological processes and connectivity.

To assess the Yangtze's hydrological processes, four indicators from the Indicators of Hydrologic Alteration (IHA) were selected[27,28]. - 1. "mean flow of flooding season", 2. "mean flow of drought season", 3. "number of high pulses each year" and 4. "duration of high pulses within each year". Of these indicators, the first two evaluate the overall hydrological process at the macro level and the latter two are related to habitat. To try and create a baseline against which to measure change, the LYI used measurements from before the 1980s to compare against multi-annual averages from 2014-2018.

The connectivity of the rivers in the longitudinal, lateral, and vertical dimensions[29] reveals the state of natural flow and underpins the transfer of the rivers' materials, energy, and information. The lateral connectivity of a river characterizes the flow between the main channel of the river and the floodplain or riparian zone[30], longitudinal connectivity refers to flow from upstream to downstream and between the mainstem and tributaries of the river, and vertical connectivity reflects the degree of connectivity between surface water and groundwater. Human activities, such as dam construction, affect the longitudinal continuity of the river as well as river hydrology and sediment transportation, resulting in changes to ecological processes. In the Yangtze River basin, where surface water resources are abundant, the connectivity between the surface and groundwater is smooth, thereby the vertical connectivity of rivers is good. There are two indicators used in this report to reflect connectivity: Degree of Fragmentation (DOF) and Degree of Regulation (DOR)[31].



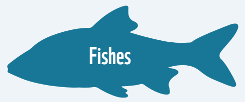
The Water Quality Index

Based on data from the water quality monitoring sections of the major water bodies of the Yangtze River basin, the Comprehensive Water Quality Index (CWQI) was calculated by using three major pollution indicators —— ammonia nitrogen, total phosphorus, and the permanganate index (which indicates the total load of organic and inorganic substances in water).[1] Together these provide a good representation of the levels of nutrients and organic pollutants in water bodies. The water quality index of LYI was calculated and evaluated based on the CWQI of each element in the river basin (mainstem, main tributaries, and lakes). The highest CWQI is present near the source of the mainstem (rated 1, most polluted rated 0). Using this as a reference the remaining sections of the river basin are analyzed and compared. The closer the water quality index is to 1, the better the water quality is and vice versa.

The Aquatic Biota Index

The aquatic biota assessment and indicators focus on the status of aquatic life and habitats. Indicators were chosen for their ability to accurately reflect ecosystem changes and the continuity and availability of data.

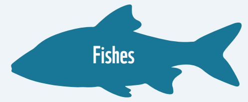
EVALUATION INDICATORS FOR THE MAINSTEM AQUATIC BIOTA[4,5,8,9,10,13]



Species richness (excluding exotic and invasive species), number of endemic species, status of endangered species, natural fishery resources, abundance of fish larvae (i.e., larvae of four major Chinese carps at Jianli cross section of the middle reach of the mainstem Yangtze River).

Population size

EVALUATION INDICATORS FOR THE AQUATIC BIOTA IN THE FOUR LAKES[32,33,34,35]



Species richness (excluding exotic and invasive species)

Population size

Species richness, diversity, dominant taxa (most prevalent species), taxa pollution tolerance

Species richness, diversity, structure of typical groups, dominance of a single group

Aquatic biota data were collected from field surveys, research reports, peer reviewed literature, and historical records and documents. Data covered the 1980s (to provide a baseline against which to measure change) and 2015-2018 (i.e., the current period), with unavailable data replaced by representative data from a similar period.

Habitat indicators are an important part of aquatic biota assessment and were originally planned to form a key focus of the LYI. Changes in the areas of sandbars and floodplains in the mainstem of the Yangtze River were assessed from remote sensing images. However, due to data availability, the results were obtained through cross comparison assessment on remote sensing images between specific time points (single year comparison), rather than mean value analysis on the images through consecutive years, which may impair the accuracy to an extent in the results, hence can be used for references only. For the four lakes, some indicators such as the conditions of the riparian zone (the area between land and a river or stream), proportion of vegetation coverage in relation to the total riparian zone area and the proportion of the riparian zone that has been covered by man-made impervious surfaces such as roads and buildings were also assessed. However, the lack of comprehensive quantitative habitat data led to a decision to exclude the habitat indicators from the aquatic biota index calculation shown above for this year although preliminary findings were qualitatively assessed and contributed to overall understanding.

Living Yangtze Index

Based on the indicators discussed above, the LYI was calculated by summing up individual section index values and accounting for corresponding watershed areas[36] for the hydrological and water quality indices, and corresponding river lengths[37] for the aquatic biota index. To produce the overall LYI for the mainstem river, the three types of indices were linear weighted.

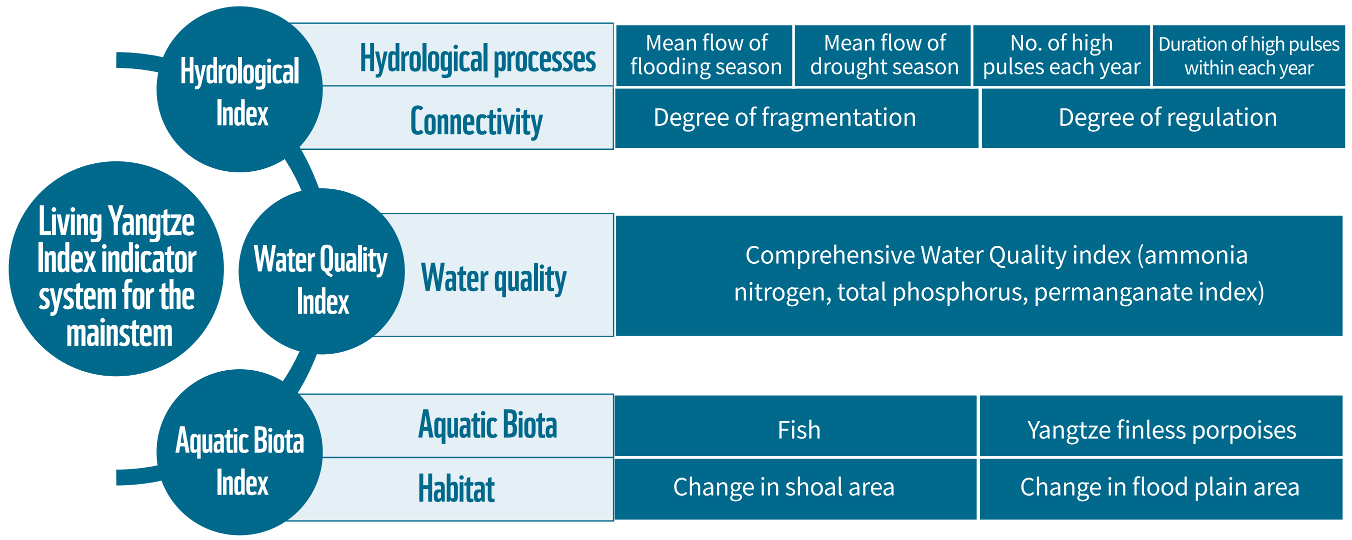


Fig. 3-3 Indicators used for calculating the mainstem LYI
(note: habitat is not included in the index calculation)

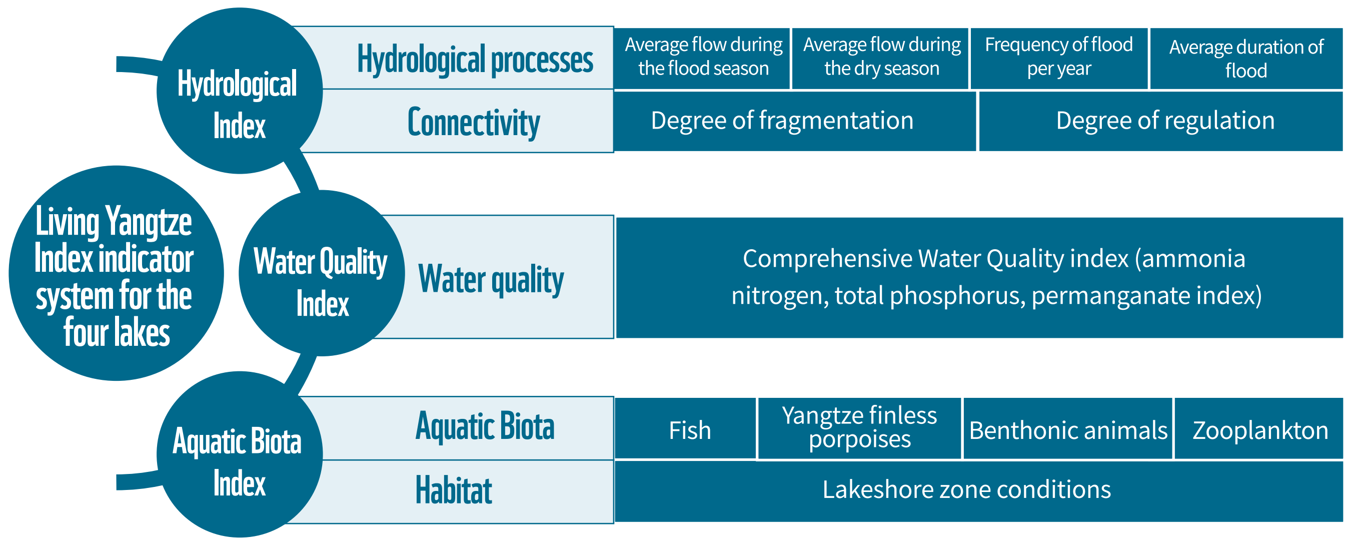


Fig. 3-3 Indicators used for calculating the LYI of four lakes
(note: 1. Habitat was not included in the index calculation.
2. Hydrological indicators of Taihu Lake and Chaohu Lake, which are disconnected from the Yangtze, were not assessed)

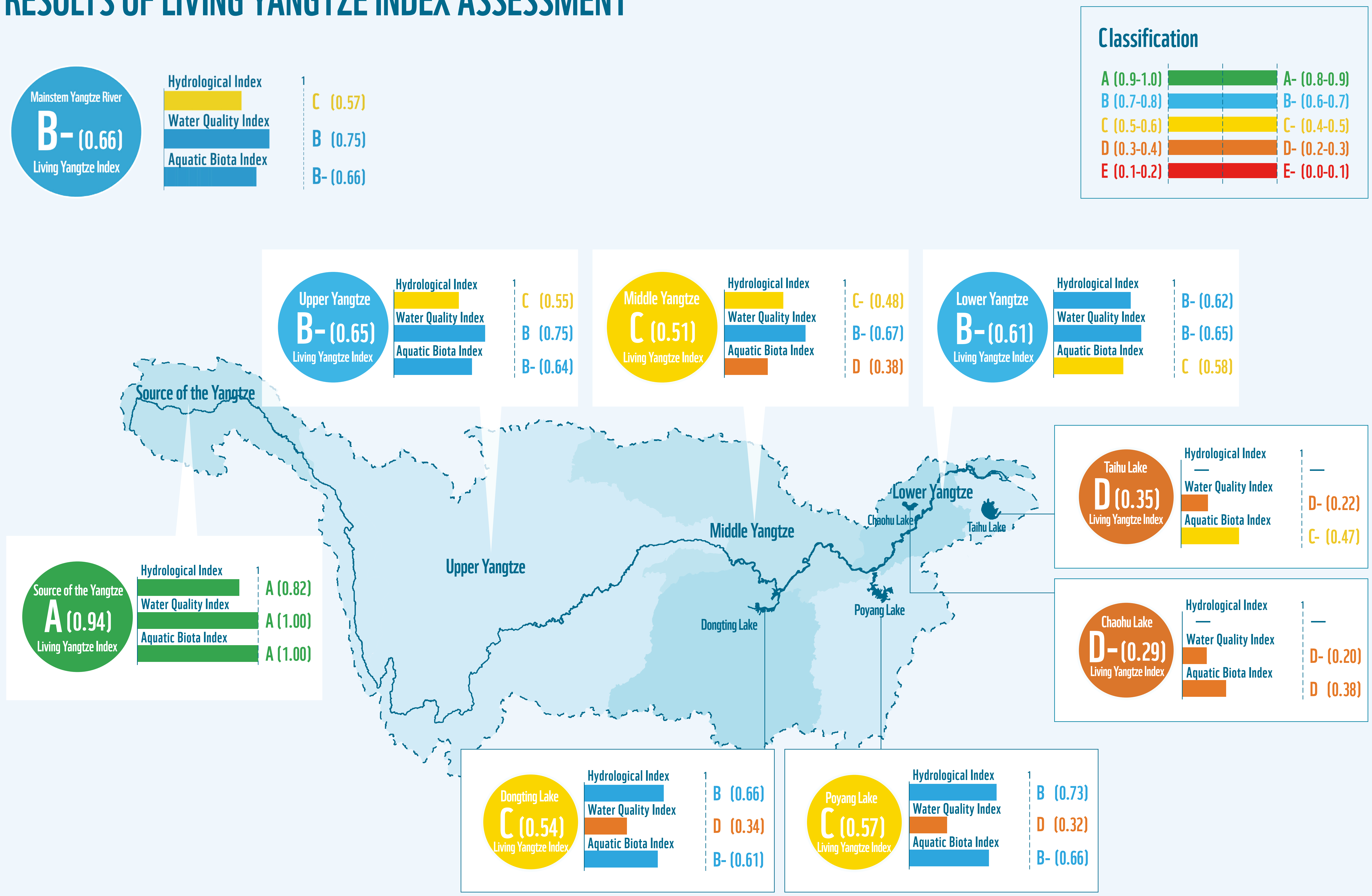
3.2 THE LYI OF THE MAINSTEM YANGTZE IS RATED AS B-

The comprehensive assessment of the LYI showed that the score of the overall LYI of the mainstem is 0.66 (1 is highest, 0 is lowest), which was classified as B-. The Source of the Yangtze was A (A being the highest), the mainstem of Upper and Lower Yangtze were B-, and the mainstem of Middle Yangtze was C. The evaluation grades of both Dongting Lake and Poyang Lake were C, while the Taihu Lake was D and Chaohu Lake was D- (E being the lowest).

	Aquatic Biota Index	Water Quality Index	Hydrological Index		Living Yangtze Index
	Biota	Water quality	Hydrological processes	Connectivity	
Source of the Yangtze	1	1	0.64	1	0.94
Upper Yangtze	0.64	0.75	0.51	0.59	0.65
Middle Yangtze	0.38	0.67	0.46	0.49	0.51
Lower Yangtze	0.58	0.65	0.61	0.63	0.61
Dongting Lake	0.61	0.34	0.58	0.73	0.54
Poyang Lake	0.66	0.32	0.69	0.74	0.57
Taihu Lake	0.47	0.22	-*	-*	0.35
Chaohu Lake	0.38	0.20	-*	-*	0.29

Table 3-5 Results of Living Yangtze Index assessment
(*Hydrological indicators of Taihu and Chaohu Lake were not assessed as they don't naturally connect to the Yangtze)

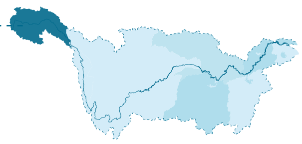
RESULTS OF LIVING YANGTZE INDEX ASSESSMENT



3.3 DIFFERENT INDEX RESULTS OF THE YANGTZE MAINSTEM, MAIN TRIBUTARIES AND KEY LAKES

The LYIs of the source areas, the upper reaches, the middle reaches, the lower reaches as well as the four lakes showed marked differences.

Source of the Yangtze: Living Yangtze Index Grade A

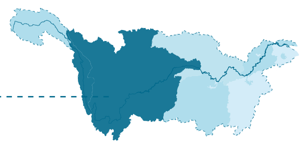


Based on the indicators assessed, the overall hydrological index was 0.82 (grade A), with the hydrological processes at 0.64, and the connectivity at 1.0.

The water quality index of the source area was graded as A. Between 2014 to 2018, the total phosphorus concentration, ammonia nitrogen and permanganate concentration were all able to reach or exceed standard Class II.

The mainstem aquatic biota index in the Source of the Yangtze was graded as A with every indicator reaching the highest level of quality.

Upper Yangtze: Living Yangtze Index Grade B-

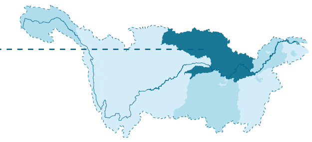


The hydrological index in the Upper Yangtze was 0.55 and the grade was C, among which the hydrological process score was 0.51, and the connectivity score was 0.59, this is significantly lower than the source area.

The water quality index in the mainstem of Upper Yangtze was graded as B-. Among the main tributaries in the Upper Yangtze, the water quality index value in the Chishui River is A, Wujiang River reached A-, Jialing River at B, while those of the Minjiang River and Tuojiang River were graded as C-. From 2014 to 2018, the concentration of total phosphorus, ammonia nitrogen, and the permanganate index in the mainstem of the Upper Yangtze reached the water quality standard of Class II. From 2014 to 2018, the Chishui River and Jialing River have maintained Class II water quality, while the water quality of the Minjiang River, Tuojiang River, and Wujiang River have all improved, with the main pollutant being phosphorus and its concentration in general showing a decreasing trend.

The evaluation result of the aquatic biota index in the mainstem of Upper Yangtze was graded as B-. Compared with the 1980s, the number of fish species in the mainstem of Upper Yangtze fell by 46 from a total of 161 (28.6 per cent decrease), the number of endemic species fell by 27 from a total of 96 (28.1per cent decrease), and 18 threatened species from a total of 35 disappeared (51.4 per cent decrease). During the dry season, the area of sandbars in the mainstem of Upper Yangtze shrank by 9 km^2 (14.7 per cent, from 62 to 53 km^2).

Middle Yangtze: Living Yangtze Index Grade C



The evaluation result of the hydrological index in the Middle Yangtze was 0.48 and the grade was C-, among which the hydrological processes score was 0.46, and the connectivity score was 0.49. Compared with other key tributaries of the whole Yangtze River basin, the indicators of the hydrological process and the connectivity of the Hanjiang River were relatively poor.

The water quality index in the Middle Yangtze was graded as B- overall with variations between sections. From 2014 to 2018, the mainstem total phosphorus concentration reached or exceeded Class III water quality standard, but without showing any clear annual trend whilst ammonia nitrogen and permanganate concentrations reached or exceeded Class II. The Qingjiang River, among all major tributaries of the Yangtze River, had the highest water quality index score with a grade of A. The overall grade of Hanjiang River was B-, with the water quality of the upper reach (upstream of the Danjiangkou Reservoir) being much better (Grade A) than that of the lower reach.

The evaluation result of the aquatic biota index in the Middle Yangtze was graded as D. Compared with the 1980s, the number of fish species in the mainstem of Middle Yangtze fell by 36 from a total of 97 (37.1 per cent decrease); the number of endemic species fell by 16 from a total of 38 (42.1 per cent decrease) 11 threatened species from a total of 16 disappeared (68.8 per cent decrease). The number of Yangtze finless porpoise has decreased from 902 to 193; the amount of natural fisheries has decreased from more than 400,000 tons in the 1950s to more than 200,000 t in the 1980s, and to 80,000 t at present (60 per cent decrease, from 1980s to present); the number of larvae fishes (i.e., the number of four major fish larvae passing the Jianli section of the middle reach of the Yangtze River) decreased from 6.7 billion to 900 million - a decrease of 5.8 billion. Indicators of greatest concern relate to declines in number of larvae, the number of the endemic species, the population of Yangtze finless porpoise, and the natural fisheries production.

It is worth noting that from 1966 to 2002, prior to the construction of the Three Gorges Dam, there was an overall balance between riverbed erosion and siltation in the middle reach of the Yangtze River. However, since 2003, the impact of the dam discharge has increased riverbed scouring[38]. Compared to 1987, the dry season of 2017 (December-January), sandbar area decreased by 22km^2 (6.5 per cent). During the wet season (July-August), the sandbar area decreased by 24km^2 (7.4 per cent), and the floodplain area increased by 29 km^2 (58.1 per cent).

Critical endangered Species – Chinese Sturgeon

Chinese sturgeon *(Acipenser sinensis)*

Chinese sturgeon(*Acipenser sinensis*)receives the highest level of legal protection in China (National Grade I Aquatic Wildlife Protected Animals) but is at significant risk of extinction. The International Union for Conservation of Nature (IUCN Red List) included it on the list of critically endangered species in 2010.

Chinese sturgeon are born in freshwater but live most of their lives in the sea, coming back to freshwater to spawn. During June and August of each year, the adults start their journey from the East China Sea to the Yangtze River estuary and then migrate upstream to the rivers. From October to November of the following year, they breed on the upstream spawning grounds and then return to the ocean after breeding, travelling a distance of over 5,000km. In May of the following year, the hatched Chinese sturgeon larvae arrive at the Yangtze River estuary to feed and grow in the tidal mudflats for three months in the northeast of Chongming Island before moving downriver to the East China Sea. Prior to the construction of Gezhouba hydropower project, there were over 10 spawning grounds spread across an 800 km river section at Yichang, which is located between the upstream Yangtze (Jinsha) River and the lower Yangtze River. However, the construction of the Gezhouba dam has drastically affected the spawning grounds and breeding population of Chinese sturgeon, with the breeding population below the Gezhouba dam falling from 1,495 in the 1980s to about 20 in 2017 (Figure S1).

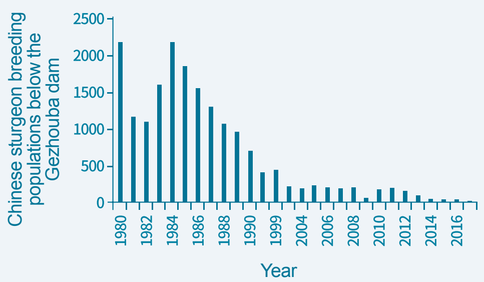


Fig. 3-3 Chinese sturgeon breeding populations below the Gezhouba dam (Chen et al., 2020)[48]

Functionally extinct or extinct Species

Baiji *(Lipotes vexillifer)*

Baiji (*Lipotes vexillifer*) is a member of the Cetacean family, and one of the National Grade I Aquatic Wildlife Protected Animals. It was listed by the IUCN Red List as critically endangered in 2018. There have been no confirmed sightings of Baiji since 2006 and it is suspected to be extinct.

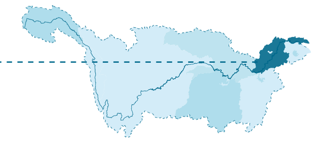
Chinese paddlefish *(Psephurus gladius)*

Chinese paddle fish (*Psephurus gladius*), commonly known as "elephant fish", swordfish and lyre fish, is believed to have had a small population in the Yangtze River for some time but accurate records are lacking. Prior to 1976, the annual catch of Chinese paddlefish in the Yangtze River was about 25,000 kg, since that time the population of this fish has decreased annually. The construction of the Gezhouba dam in 1981 particularly caused a dramatic drop in numbers downstream. In the 1980s, the annual average population count of the Chinese Paddlefish was only 15. After 1986, the number of young Chinese paddlefish rapidly fell in the middle and lower reaches of the Yangtze River from Yichang to the river mouth with the last sighting in 2003. The species was declared extinct on December 23, 2019.

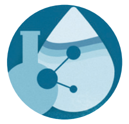
Reeves shad *(Tenualosa reevesii)*

Reeves shad (*Tenualosa reevesii*) was a well-known migratory fish in China and has high economic value although catches in the Yangtze River fluctuated greatly. Prior to 1962, the annual catch of *Macrura reevesi* in the Yangtze River was about 300-500 tons, with a peak of 1575 tons in 1974, which then plummeted to 136 tons in 1980, and dropped to less than 10 tons in 1987. This species has not been seen in the Yangtze River since the 1990s and can be assumed to be extinct.

Lower Yangtze: Living Yangtze Index Grade B-



The evaluation result of the hydrological index in the Lower Yangtze was 0.62 at B-, among which the hydrological processes score was 0.62, and the connectivity score was 0.63.



The water quality index was graded as B-. From 2014 to 2018, the total phosphorus concentration, ammonia nitrogen concentration, and permanganate index in the downstream mainstem met or exceeded Class II standard.

The evaluation result of the aquatic biota index was graded as C. In recent years, the number of fish species in the mainstem of the Lower Yangtze fell by 40 from a total of 112 (35.7 per cent decrease); the number of endemic species fell by 5 from a total of 30 (16.7 per cent decrease); the 1 threatened species disappeared from a total of 8 (12.5 per cent decrease). The Yangtze finless porpoise population decreased from 1,644 to 252 (84.7 per cent decrease), which was graded as E. The number of natural fisheries was graded as C.

As in the Middle Yangtze, the construction of the Three Gorges Dam has increased riverbed scouring[38]. Compared to 1987, during the dry season (December-February), the area of the sandbar on the lower reach of the Yangtze River increased by 93 km² (9.8 per cent). During the flood season (June-August), the area of the sandbar on the lower reach of the Yangtze River increased by 89 km² (9.8 per cent), and the floodplain area in the lower reach of the Yangtze River increased by 16km² (22.3 per cent).

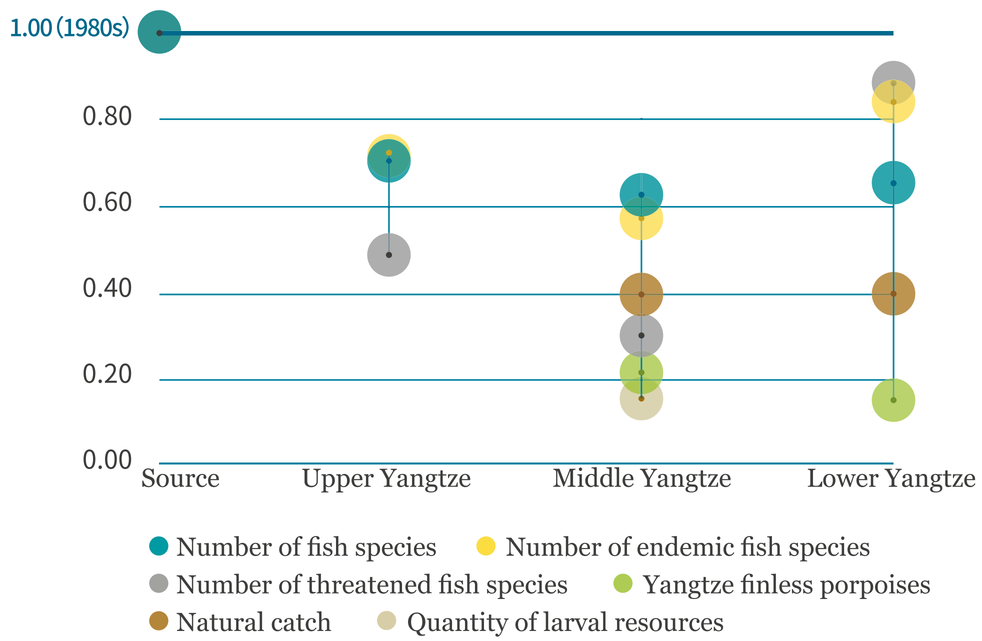
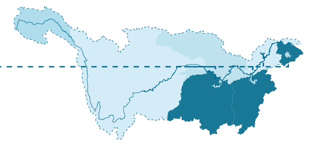


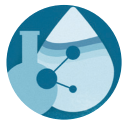
Fig.3-6 Aquatic biota assessment results of the mainstem Yangtze River

Four Lakes Living Yangtze Index Results



The Four lakes evaluated all received less satisfactory index results; the LYIs of both the Dongting Lake and Poyang Lake were C, and those of the Taihu Lake and Chaohu Lake were respectively D and D-.

The hydrological index values of the Dongting Lake and Poyang Lake were both graded as B. As the two lakes are hydrologically connected to the Yangtze River, the indicators of connectivity are mainly influenced by the connectivity of lake tributaries.



The water quality index values of the Dongting and Poyang were both graded as D, while Taihu Lake and Chaohu Lake were both D-. Among them, the score of the Chaohu Lake was the lowest, while that of the Dongting Lake was the highest. In 2018, the water quality of the four main lakes was generally from class IV to V, with the main pollutant being total phosphorus. Among them, the total phosphorus concentration of Chaohu Lake was at class V, while those of Poyang Lake, Dongting Lake and Taihu Lake were all at class IV.

The comprehensive evaluation of aquatic biota showed that the grades of Dongting Lake, Poyang Lake, Chaohu Lake and Taihu Lake were respectively B-, B- and C-, D.

Among them, the grades of phytoplankton in Dongting Lake and Poyang Lake were C and C-, and those of Taihu Lake and Chaohu Lake were D and D-; the grades of macroinvertebrates in both Dongting Lake and Poyang Lake were B-, while that of Taihu Lake was C, and that of Chaohu Lake was D; the grade of fish species number in Dongting Lake was B-, while those of the Poyang Lake and Taihu Lake were C, and Chaohu Lake was C-. The grade of the Yangtze finless porpoise population in Dongting Lake was C, and that of the Poyang Lake was A. In 2006, the number of Yangtze finless porpoise in Dongting Lake was 198±57 (calculated as 198) and about 400 in Poyang Lake; while in 2017, the number has decreased to 110 in Dongting Lake and increased to 457 in Poyang Lake[39,40].

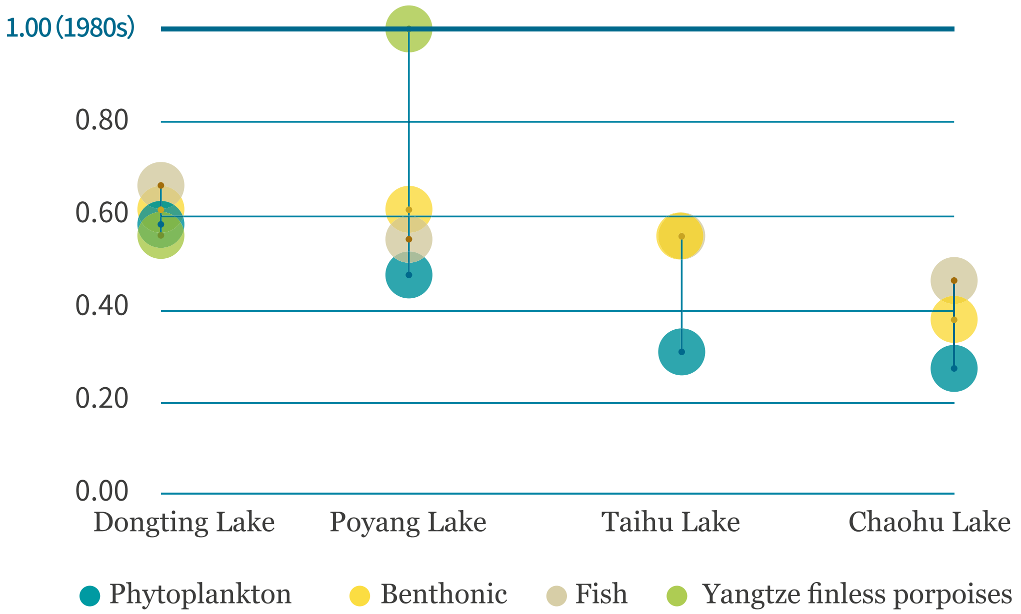


Fig.3-7 Aquatic biota assessment results for the four lakes in the Yangtze River basin

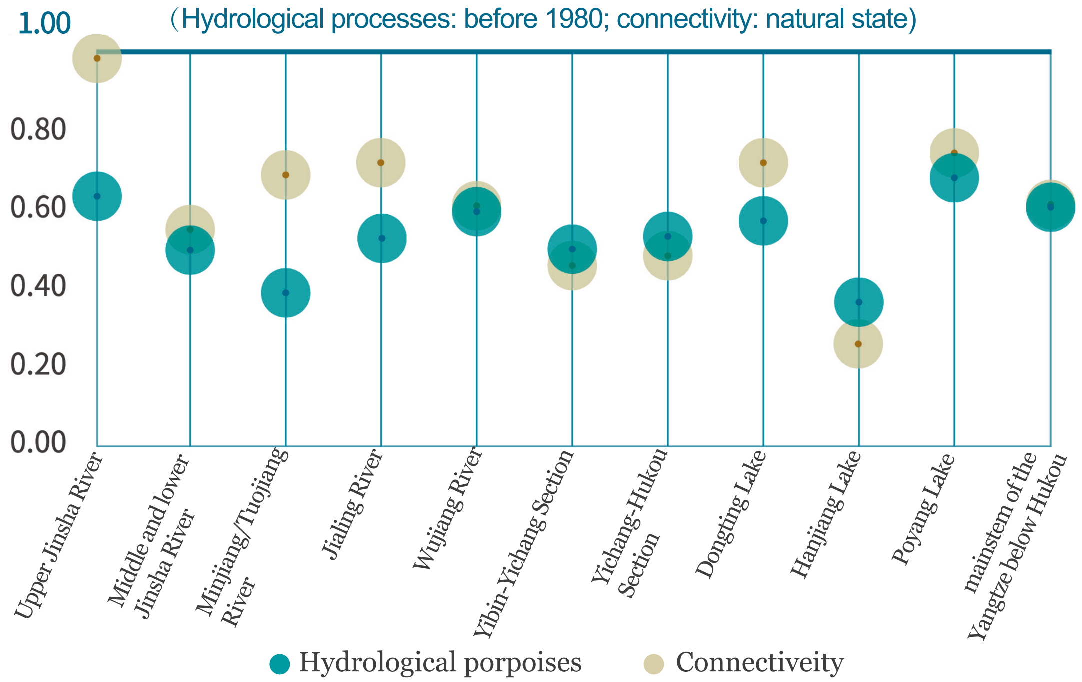


Fig.3-8 Hydrological index assessment results for the mainstem and tributaries of the Yangtze River, Dongting Lake and Poyang Lake

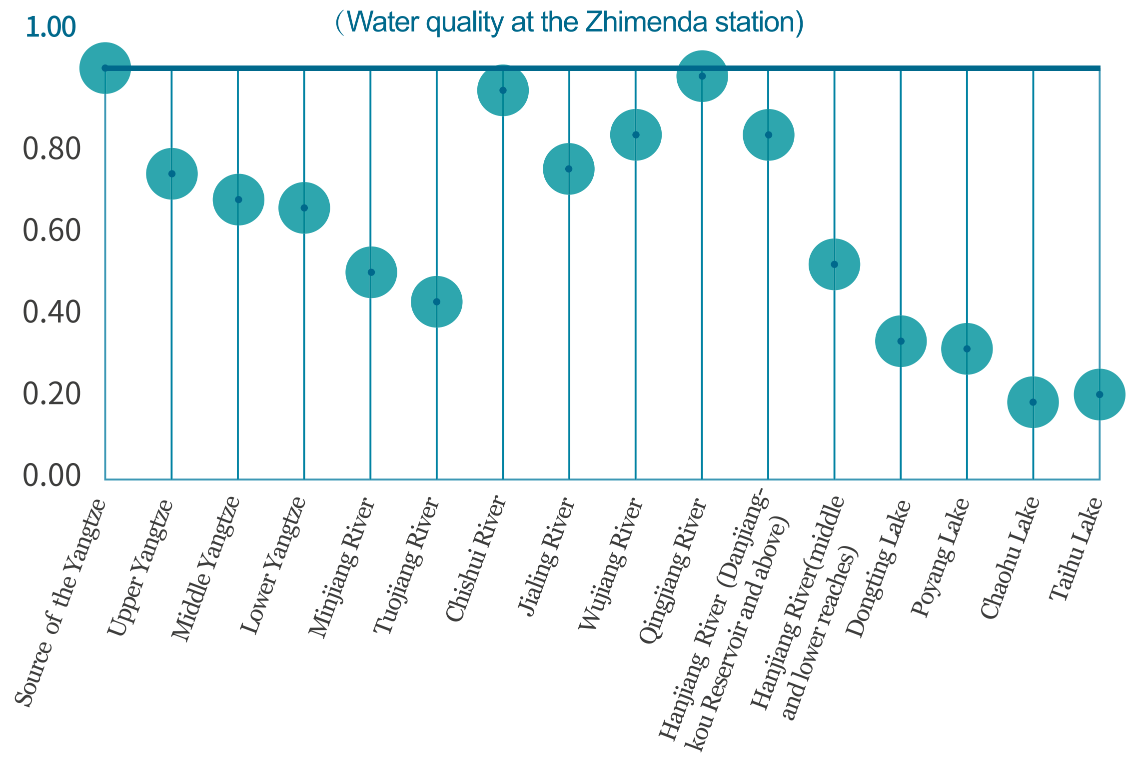


Fig.3-9 Water quality index assessment results for the mainstem and tributaries of the Yangtze River and the four lakes in the Yangtze River basin

Geladandong Snow Mountain©Jinde Zhao

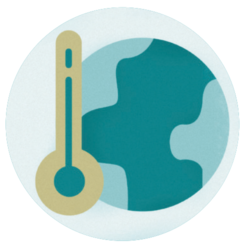
PRESSURES AND CHALLENGES OF THE LIVING YANGTZE INDEX

▼ The Living Yangtze Index is based on a comprehensive assessment of the hydrology, water quality and aquatic biota of the Yangtze. The health state of the Yangtze basin reflected by the Living Yangtze Index is subject to a variety of pressures.

4.1 MAIN THREATS TO THE YANGTZE RIVER

The results of this year's LYI reflect the changes in the freshwater ecosystems of the Yangtze River over the past 40 years. These ecosystems have provided tremendous benefits to China's rapid economic and social development in the past decades. However, the functions and health of these ecosystems have been overwhelmed by this development and are now at risk. The Yangtze ecosystems have been under complex pressures caused by various drivers, such as population growth, rapid industrial, agricultural and fishery development, urbanization, hydroelectricity development and navigation. New uncertainties and challenges are presented by global climatic change, adding to local problems and increasing the difficulty in finding a balance between high-quality development and conservation of the Yangtze River.

Identifying the root causes of the deterioration of the Yangtze River ecosystems is critical to designing an effective protection and restoration action plan. Based on the available data, the key threats to the Yangtze basin have been classified as climate change, hydrological change, land-use change and river-bank development, pollution, over-exploitation of resources and invasive species. The nature and impact of these challenges are discussed below.

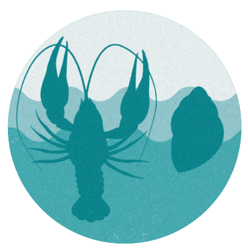


Climate Change

Changes in river (lake) connectivity and reservoir regulation

Land use change and shoreline development

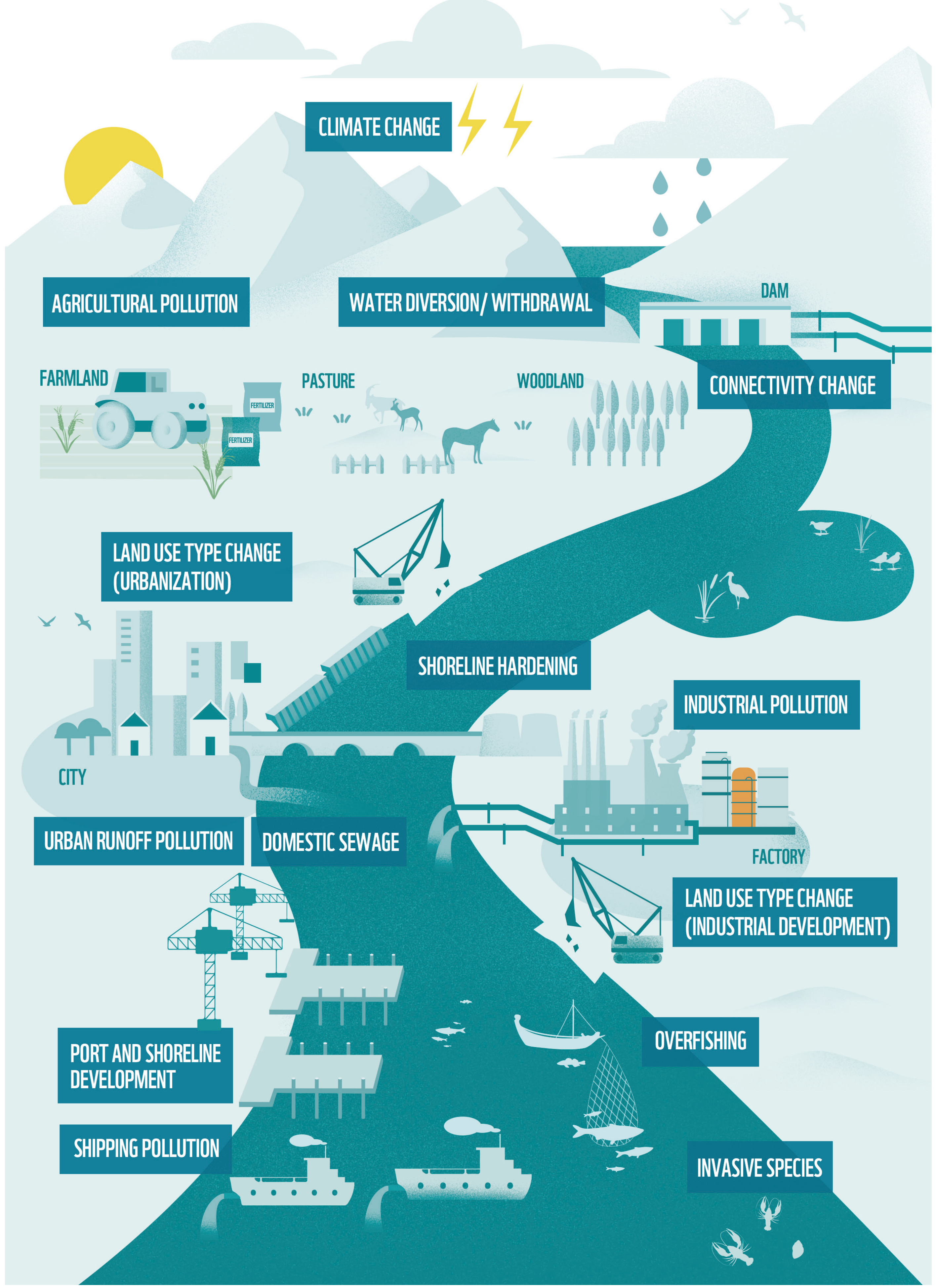
Pollution discharge



Invasive Species

Resource Over-utilization

Fig. 4-1 Pressures and Challenges of the Living Yangtze Index



Climate Change

Climate change includes both changes in the climatic system caused by natural variability and changes caused by human factors (emissions of greenhouse gases such as carbon dioxide). According to the fifth Assessment Report (AR5) of the Intergovernmental Panel on Climate Change (IPCC), the global average surface temperature has increased by 0.85°C[41] over the past 130 years (1880-2012). Climate Change will increase the frequency and intensity of extreme weather events such as drought, rainstorms and floods.

El Niño-Southern Oscillation events (ENSO) have significant effects on the climate in the Yangtze region[42,43]. ENSO is the strongest interannual signal of the coupled ocean-atmosphere system in the tropical Pacific Ocean[44], which usually manifests as a large-scale warming (El Nino) or cooling (La Niña) signal on the sea surface temperature in the tropical Pacific Ocean every 2-7 years[45]. These ENSO events have significant impacts on precipitation and temperature in the Yangtze River basin, with El Nino years associated with increased temperature and decreased precipitation, accompanied by increased probability of droughts. La Niña years are generally associated with increased rainfall and relatively higher incidence of floods[46]. The abrupt drought-to-waterlogging transition in the middle and lower reaches of the Yangtze River experienced in early summer in 2011 was likely related to the La Niña event which took place between July 2010 and April 2011 and unusually low temperature of the Indian Ocean[47,48].

In addition to ENSO, climate change is also projected to cause changes in habitat conditions including water temperature, flow velocity, and flow rate, and thus affect the growth, survival, and reproduction of aquatic organisms.

Changes in river (lake) connectivity and reservoir regulation

The changes of river (lake) connectivity and reservoir regulation not only affect the hydrological processes of the Yangtze River, but also affect the Yangtze River Delta and the health and stability of the ecosystems by changing the hydrological processes and the river's landform and morphology[49].

The changes to longitudinal, lateral, vertical, and temporal river connectivity have not only blocked the migratory passages of fish, but also led to drastic changes to fish habitats. For example, the construction of the Three Gorges Dam and the creation of the associated reservoir expanded the water surface of the river channel, submerging habitats and changing the water hydrology from a rapid flow to a static pool. Species dependent on flowing water (rheophilic fish) have been negatively affected whilst others preferring still water (limnophilic fish) are doing well. In addition, the storing of water in the reservoirs has greatly slowed the flow velocity of the water leading to build-up of nitrogen and phosphorus deposits and increasing the probability of algae bloom issues.

Land use change and shoreline development

There have been decades of significant changes to land use in the Yangtze basin. Large-scale land reclamation starting from the 1950s significantly reduced the areas of lake water surface and wetlands whilst huge demand for a steady supply of water to support ongoing economic and social development has also depleted lake areas. Policy changes since 1998 have reversed this trend, returning farmland to lakes and increasing the water surface area, but the recovered area is still insufficient and there is significant room for expansion. Another positive trend is in the forested area of the basin. After forest coverage in the Yangtze River basin reached a low point in the 1970s. Government-led afforestation efforts since the 1980s have successfully increased forest coverage, especially in the upper reaches.

Between 2000 to 2017, land covered by roads and buildings in the overall Yangtze River basin increased by 195.2 per cent. In the Upper Yangtze basin, coverage of urban land, forests and wetlands increased, while land under roads and buildings increased by 159.1 per cent. Farmland, glaciers/permanent snow areas and grassland decreased. In the Middle Yangtze basin, farmland, grassland, forest and water surface decreased by 1.3 per cent, 4.8 per cent, 0.3 per cent and 6.1 per cent respectively, while the urban land increased by 177.8 per cent. In the Lower Yangtze, urban land has grown significantly by 246.3 per cent, accompanied by significant decreases of farmland (6.6 per cent) and grassland (53.4 per cent).

Land use cover change impacts both the hydrological processes and water quality of the Yangtze River. Changes in land use have altered the hydrological processes, including infiltration, evapotranspiration and runoff, in turn this impacts the water resources, flood and drought conditions in the Yangtze River basin. The process of urbanization has turned many seepage surfaces into impermeable surfaces, resulting in reduced infiltration, increased surface runoff, and increased peak urban flood drainage. Urban runoff has also become one of the main sources of water pollution due to runoff flushing away gasoline, motor oil, heavy metals, garbage, fertilizers, pesticides and other pollutants on roads, parking lots, roofs and green spaces.

Urbanization and industrialization, as well as the development of ports and shorelines, has also reduced the living space of aquatic organisms in the Yangtze River basin by occupying and changing habitats. In 2017, industrial activities along the mainstem Yangtze River in the Yangtze River Economic Belt occupied 486.73 kilometers of shoreline, ports occupied 87 kilometers of the first and second-grade water source protection zones, and industrial activities occupied about 28 kilometers of first and second-grade water source protection zones[50].

	Woodland	Grassland	Construction land	Cultivated land	Water body	Unused land
2000	76.39	59.25	0.83	43.71	3.00	0.65
2017	76.06	59.09	2.45	42.69	2.88	0.66
Variation	−0.33	−0.16	1.62	−1.02	−0.12	0.01
Rate of change	−0.43%	−0.27%	195.18%	−2.33%	−4.00%	1.54%

Unit: km²

Fig. 4-2 Changes in the area of land use types in the Yangtze River Basin (2000-2017)

Pollution

Industrial and domestic water pollution from 459 million people is discharged into the Yangtze River freshwater ecosystems. The municipal wastewater discharge is directly related to the number of residents, the larger the number of residents, the more domestic sewage. Likewise, an increase in industrial production brings about an increase in the amount of industrial wastewater generated, which ultimately leads to an increase in industrial pollution discharges. Levels of pollution from agriculture are related to the overall productivity of agriculture, forestry, animal husbandry and fisheries as well as the volume of fertilizer being used. The increase in these activities and corresponding growth in fertilizer use have led to an increase in pollutants that enter the water body with rainfall runoff. The problem is compounded by urban expansion and reduction in green spaces, which change the underlying surface of the basin, resulting in the non-point pollutants (those which have a large number of small sources such as fertilizer on fields or oil from vehicles) being flushed by rainfall into the river directly along with the runoff rather than filtering into the soil. Non-point source pollution in urban areas is becoming a more prominent issue and is difficult to deal with. Another pollution challenge resulting from human activity stems from shipping, with ship exhaust emissions, accidents, sewage and garbage discharge, and stirred sludge all growing issues. In 2001, 5 052 tons of dangerous goods were transported in the Jiangsu section of the Yangtze River – a figure that had risen to 150 million tons by 2015. In this area alone there are 83 water intakes, accidents could easily have disastrous consequences if they cannot be dealt with rapidly.

Pollution not only leads to the deterioration of water quality, but also affects the habitats of aquatic organisms, which can further undermine the health of the ecosystem. Sufficient investment in environmental pollution control can effectively reduce pollution discharge into water systems. From 2008 to 2017, all provinces in the Yangtze River basin continued to increase their pollution control efforts, and the overall investment showed an upward trend, increasing from 106.3 billion yuan in 2008 to 228.6 billion yuan in 2017, an increase of 115 per cent. In 2017, the investment in pollution control in the Upper Yangtze reached 46 billion yuan, the Middle Yangtze reached 86.2 billion yuan and the Lower Yangtze reached 96.4 billion yuan.

Emerging pollutants in the Yangtze River

"Emerging pollutants" generally refer to substances that may need to be regulated based on their frequency of detection and evaluation of potential health risks. The relevant environmental management policies, regulations, or emission control standards, however, have yet to be developed. Such substances are not necessarily new chemicals but usually pollutants that have been existing in nature for a long time at low concentrations, with awareness of the hazards posed emerging only recently. Nowadays, a number of emerging pollutants such as microplastics, pharmaceuticals and personal care products (PPCPs), perfluorinated compounds (PFCs), polybrominated diphenyl ethers (PBDEs) and other trace organic pollutants are attracting increased attention from the public in response to research showing growing concentrations and harm.

Microplastics are small plastic fragments less than 5 mm in length. They are ubiquitously present in the environment and can enter the human food chain and human body. Researchers even found that microplastics were present in human stool samples. Microplastics pose a risk to both aquatic environments and human health. As China is the world's largest plastic producer and contributes the most to marine plastic debris, China can offer a significant contribution to efforts to solve microplastics pollution.

PPCPs mainly comprise a series of chemicals including antibiotics, anti-inflammatory drugs, analgesics, synthetic musk, hair dyes, sunscreen products and their metabolites. Their use in veterinary medicine, agricultural medicine, human medicine, and cosmetics is the main way they enter the environment. PPCPs accumulate in the environment constantly and can be considered as persistent pollutants.

PFCs are a type of persistent organic pollutants with PFOS and PFOA forming the largest body of PFC pollutants. They have been discovered globally in air, water, soil and even found in the blood, liver and kidneys of animals and humans. Some of these PFCs, such as PFOS and PFOA, are potential developmental toxicants and are suspected endocrine disruptors with effects on sex hormone levels.

PBDEs are a type of organic bromine compounds used as flame retardant additives, which are hydrophobic, persistent, bio accumulative and difficult to degrade. PBDEs have been used in a variety of products, such as building materials, plastics, appliances, televisions, computer circuit boards and chassis. Long-term exposure to low-concentration PBDEs can cause neurobehavioral defects and may cause cancer.

These emerging pollutants have been found in varying quantities in the Yangtze River, especially in sediments. Related environmental management policies, regulations and emission standards for many of them are yet to be developed, however those pollutants have the potential to cause harm to humans and/or ecological systems. They deserve immediate attention and awareness from related stakeholders.

Resource Over-utilization

The natural resources of the Yangtze that are heavily over-utilized include fish and water. Overfishing is a large reason behind the decline of fish resources in the Yangtze River. Two problems have emerged, one is the continuous increase in the number of fishermen in the Yangtze River from 354,000 in 1980 to 622,000 in 2017, another is the excessive use of small mesh size nets, as well as illegal and electric fishing. Not only are fish decreasing in number, but they are decreasing in size. The natural fish catch on the Yangtze mainstem fell from 430,000 tons in 1954 to 80,000 tons in 2011.

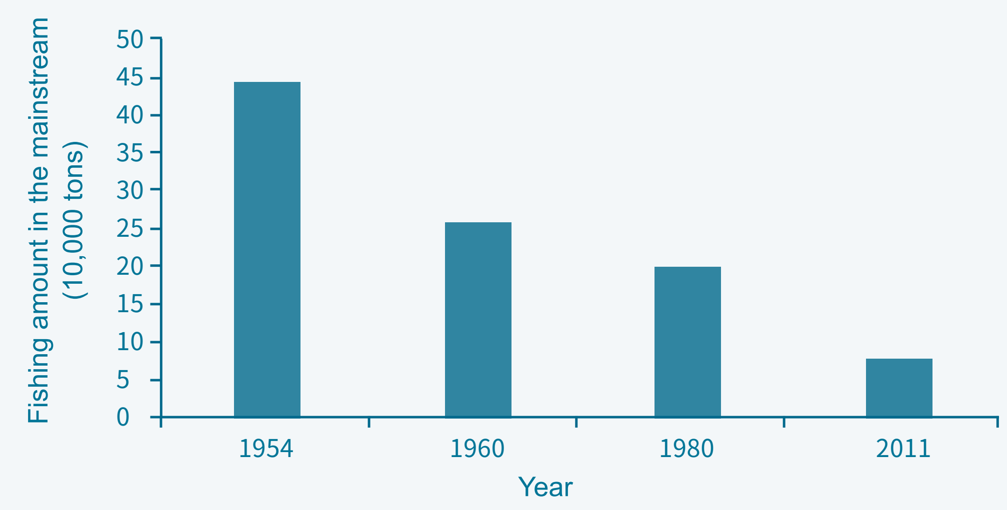
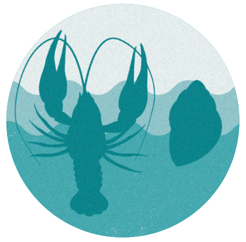


Fig. 4-3 Natural fish catch in the Yangtze mainstem[51]

The fish catch was positively correlated with the local population, the level of economic development and the demand for fish. According to the total amount of freshwater fish catch data in each region and province in China's Fishery Statistical Yearbook, the volume of fish caught is the largest in the downstream region, followed by the middle region. There were relatively low volumes of fish caught in the source region and upstream areas.

The water and natural resources of the Yangtze River underpin socioeconomic development and are of national strategic importance for the allocation of water resources in China. However, large-scale water withdrawal and diversion projects have effectively reduced water quantity and flow velocity of the rivers, undermining the environmental carrying capacity and self-purification capacity of the river system.



Invasive species

The spread of non-native species into habitats around the world has established itself as a serious global issue. The spread of exotic fish species has become increasingly serious with the process of global economic integration. Exotic fish species spread through the growth of aquaculture, ornamental fisheries, recreational fishing, fishing transportation, and religious release. The problems caused by invasive species relate to their direct and indirect impact on native species. Predation, inter-species competition, hybridization and disease transmission are all growing issues. There are currently 90 known exotic fish species in the Yangtze River basin, including *Gambusia affinis, Micropterus salmoides, Ictalurus punctatus,* and *Cirrhinus mrigala* .

Exotic species of aquatic plants are introduced for fodder, flowers, aquaculture fingerlings, water quality management and tidal land vegetation reconstruction. The expansion of invasive aquatic plants results in significant problems for ecosystems, agricultural production, transportation and human health. A total of 478 known invasive aquatic plants have spread to most of the river basins in China, including the Yellow River, the Yangtze River, the Pearl River, the Huaihe River and the Haihe River, accounting for about one third of China's total area[53]. A typical case is the exotic plant *Spartina Alterniflora* which had been spreading widely through the Yangtze and competed strongly with indigenous plants - *Phragmites australis* and *Scirpus mariqueter*[54]. In 2003, the Spartina alterniflora was widely distributed across almost all the Yangtze estuary beaches (except Chongming West and Hengsha Island) taking up 22.1 per cent of the total vegetation area. The Nanhui side beach had the largest affected area at 2,069 hectares, followed by Chongming East Beach and Jiuduansha Island[55]. Invasive species can be tackled, for example the "*Spartina alterniflora* ecological control and bird habitat optimization project in Shanghai Chongming Dongtan Bird National Nature Reserve" officially started work in 2013. After nearly 5 years of restoration and regeneration through water level adjustment and weeding, 1,691 hectares of *Spartina alterniflora* have been removed with a removal rate of up to 95 per cent, and the expansion of *Spartina alterniflora* in Chongming Dongtan was completely reversed[56].

Finally, the introduction of non-native invertebrates can also cause serious damage to local ecosystems. The most common invasive invertebrate species in the Yangtze basin is *Procambarus clarkii*[57], which has occupied many local habitats and competed with native species. *Pomacea canaliculata* has also gradually spread to most provinces in the Yangtze River basin in recent years[58].

The current status of research regarding invasive species in China is quite weak in comparison to international research. The few studies that exist mostly focus on the investigation and description of invasive species, or the study of their physiology and ecology rather than investigating their spread and means of both preventing the spread and mitigating impacts. China urgently needs to prevent and control invasive species before their large-scale expansion and adopt scientific approaches to investigate and solve the threat of invasive species.

Invasive species - Red swamp crayfish (*Procambarus clarkia*) and Channeled applesnail *(Pomacea canaliculate)*

Red swamp crayfish *(Procambarus clarkii)*, native to Southern United States and Northern Mexico, has been introduced to many areas around the world due to its high economic value. Red swamp crayfish is a highly adaptable, environmentally tolerant, and extremely fecund freshwater crayfish, and can inhabit a wide range of aquatic environments. Studies in the past 10 years showed that Red swamp crayfish have competed with, preyed on, and reduced populations and biodiversity of a wide variety of aquatic species, including aquatic plants, invertebrates, and amphibians, in their new habitats. As a result of commercial introductions to harvest as a food source, Red swamp crayfish will continue to spread.

Channeled applesnail *(Pomacea canaliculata)*, native to the Amazon basin of South America, was introduced to Guangdong, Guangxi, Jiangsu and other provinces of China around the 1980s, as a local food resource and as a fine gourmet item. In recent years, Channeled applesnail has spread from agricultural areas into wetlands and other natural freshwater systems in most of the provinces along the Yangtze River basin, leading to serious impacts on the aquatic systems, including flora, fauna and habitats, causing particular problems in the rice growing areas. Channeled applesnail acts as an intermediate host of the parasite *Angiostrongylus Cantonensis*, causing severe parasitic disease epidemics. It is also a crop pest and is considered the number one rice pest in China. In 2002, Channeled applesnail has been recorded as one of 16 alien pests in the country by the State Environmental Protection Administration of China. It is also the top 100 destructive invasive species in the world published by IUCN.

4.2 SPATIAL VARIATIONS IN PRESSURE ON THE YANGTZE RIVER

The impacts of climate change, land use change, resource over-utilization, pollution discharges, changes in river connectivity and reservoir regulation on the Yangtze River have obvious temporal and spatial differences. The *Report* identifies the main pressures in Upper, Middle and Lower Yangtze but cannot provide an accurate quantitative reflection of the overall cumulative impact of these factors as the results are not fully comparable across the evaluated areas.

	Changes in river connectivity and reservoir dispatching	Changes in land use types	Resource utilization	Pollution discharge	Climate change
Upper Yangtze	Moderate	Moderate	Moderate	Moderate	Moderate
Middle Yangtze	High	Moderate	High	Moderate	Moderate
Lower Yangtze	Low	Low	High	High	Moderate
Dongting Lake (aquatic biota index only)	Moderate	Moderate	High	Moderate	Low
Poyang Lake (aquatic biota index only)	Moderate	Moderate	High	Moderate	Low
Taihu Lake (aquatic biota index only)	Low	Moderate	Moderate	High	Low
Chaohu Lake (aquatic biota index only)	Low	Moderate	Moderate	High	Low

Rating

High significance · Moderate significance · Low significance

Table 4-4 Analysis results of the significance of the pressures on the Living Yangtze Index in Upper, Middle and Lower Yangtze, and the four lakes

Note: due to the lack of research and comprehensive data regarding invasive species at this stage, the *Report* omits this pressure in this analysis.

Yangtze Source Region Pressures

The LYI for the Yangtze source region is assessed as very good or "A" grade overall with the hydrology, water quality and aquatic biota indices also rated as A. No significant local human activities were identified as creating pressure on the source region of Yangtze River, the most significant pressure faced by the source area comes from global climate change although results indicate that climate change doesn't exert a significant impact on the core indices of hydrological processes. This might be explained by the following mechanism. In the context of climate change, the Yangtze source region shows a warming trend, which on the one hand increases the snowmelt runoff and on the other hand increases actual evapotranspiration. For total runoff, the rising contribution of snowmelt runoff may be weakened or offset by the growth of actual evapotranspiration, resulting in a great uncertainty in the runoff response to climate change[59]. However, in the long-term glacial runoff will decrease as the glaciers shrink. The Yangtze source region has been becoming warmer since 1971, and the annual average temperature has increased by about 0.8°Cover the past 40 years, making it an abnormal warming plateau region[60]. Surveys have shown the Jianggudi Runan glacier in the source region is shrinking by an average of six meters per year. Model predictions showed that due to the influence of climate change, glaciers at the source region will shrink by an average of 6.9 per cent and 11.6 per cent by 2030 and 2050, respectively, compared with those in 1970[61]. Rising temperatures in the source region has resulted in the glacier retreat and permafrost degradation.

Studies show that climate change threatens about 50 per cent of the world's freshwater fish[62] although specific examples of extinction are difficult to pinpoint due to the complex inter-acting nature of the underlying causes of species decline. The exact effects of climate change on the life history and community structure of aquatic organisms in the Yangtze source region are also not fully understood. Research indicates alpine meadows, as one of the main terrestrial vegetation types in the source region, will face more serious ecological stress due to global climate change[63]. Meanwhile, understanding the response mechanism of the freshwater ecosystems in the source region under climate change is crucial for effective protection and management of aquatic biodiversity. A single management strategy may not be appropriate for multiple fish species due to their different adaptation capabilities.

Challenges posed by climate change

Global warming increases the moisture holding capacity of the atmosphere, changing the frequency and intensity of heavy precipitation and consequently extreme weather events, such as regional floods and droughts. Studying climate impacts on extreme precipitation in the Yangtze River basin is valuable for quantitative evaluation of flood/drought hazards and attribution analysis of critical hydrological indexes.

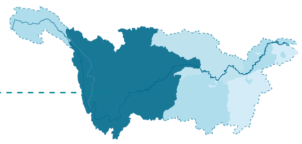
Over the past six decades, annual total wet-day (a wet day is defined as a day with daily precipitation amount no less than 1 mm) precipitation has been increasing significantly in Yangtze River's water resource catchments. Annual total wet-day precipitation and the maximum number of consecutive wet days are decreasing significantly in the upper reaches. In the middle reaches, annual contributions of very wet-day precipitation (R95ptot: total annual precipitation from days with daily precipitation amount larger than the 0.95^{th} percentile) are increasing significantly whilst the maximum number of consecutive wet days are decreasing significantly. By contrast, annual total wet-day precipitation, number of very heavy precipitation days (R20mm: annual count of days with daily precipitation amount larger than 20mm), annual maximum 5-day precipitation amount (Rx5day), and annual contributions of very wet-day precipitation (R95ptot) are all increasing in the lower reaches.

The El Niño - Southern Oscillation (ENSO) has a significant impact on the extreme precipitation events and floods from the mid-upper reaches to the source region of the Yangtze River basin. Specifically, La Niña-induced increased intensity and frequency of extreme precipitation events may create flood hazards from the mid-upper reaches to the source region of the Yangtze River basin. Global warming also impacts on the extreme precipitation indicators and floods in the mid-lower reaches of the Yangtze River basin. Specifically, increased annual total wet-day precipitation as well as enhanced intensity and frequency of extreme precipitation events due to global warming can create flood hazards in the mid-lower reaches of the Yangtze River basin.

An interactive combination of global warming, large-scale atmospheric circulation, and regional/local factors may cause a certain level of variation in the direction and magnitude of precipitation change, leading to a variety in changes of hydrological variables which are driven by precipitation in the Yangtze River basin. Global warming can also affect evapotranspiration and runoff in the basin via changing the near-surface temperature, which may add another layer of uncertainty to the changes in hydrological processes. Overall, the response of hydrological processes to climate change is complex and subject to more uncertainties than even that of precipitation.

Jianggendi Runan glacier©Shenglu Ma

Upper Yangtze Pressures



The results of the LYI for the Upper Yangtze indicate that although the aquatic organisms are doing relatively well, absolute loss regarding the numbers of species, endemic species and threatened species is significant and requires urgent attention. Fishery resources and fish diversity of the upper reaches are directly threatened by overfishing and illegal electric fishing. In response the government has instituted a ten-year fishing ban on the mainstem and major tributaries of the Yangtze River from January 1, 2021, which is expected to ease the resource utilization pressure.

The construction of multiple cascade hydropower projects in the Yangtze upper reaches and its tributaries (except the Chishui River) has exerted great pressure on the connectivity of the river, especially longitudinal connectivity. Among them, the longitudinal connectivity indices of the middle and lower Jinsha River, Minjiang River, Tuojiang River, Jialing River, Wujiang River and Yangtze mainstem from Yibin station to Yichang station are at a low level. Construction of multiple hydropower projects in the upper reaches has also affected fish through changes in river connectivity, blocking the passage of migratory fish, and changing fish habitats. Studies have shown that the development of upstream cascade hydropower stations may affect the important habitats of 46 endemic fish species and the population of 134 fish species, and block the migration passage of 35 species of migratory fish[64]. In addition, urbanization in the upper reaches is increasing rapidly, encroaching on shoreland and wetlands, affecting the survival of aquatic organisms.

Changes in land use types, river connectivity, reservoir regulation and climate change have all had significant but varied impacts on the hydrological processes in the upper reaches. For example, for the middle and lower Jinsha River basin, increased urbanization has increased surface runoff, shortening the time between rain and peak runoff as well as affecting average flood duration. For the Minjiang/Tuojiang River basin, global warming could reduce the annual number of floods and the La Niña (El Niño) events could increase (decrease) the average flow during flood season. Global warming is expected to decrease the annual number of floods and average flow during flood season in the Wujiang River. For the mainstem Yangtze from Yibin to Yichang, the La Niña event will increase its average flow during flood season, while the El Niño events will decrease the average flow.

The most significant pressure on the water quality in the upper reaches comes from non-point pollution from agriculture, forestry, animal husbandry and fishery. Nutrients such as nitrogen and phosphorus enter the water body along with rainfall runoff, and increase the water pollution. The increase in wastewater collection and treatment capacity helped to alleviate the pressure from point sources on water quality. The length of drainage pipes in the upper reaches of the Yangtze has increased from 21,691.65 km in 2008 to 55,450.21 km in 2017, an increase of 155.6 per cent.

Total phosphorus pollution control in Wujiang River

Wujiang River originates in Guizhou Province, flows through Youyang County and Pengshui County in the north of Guizhou and southeast of Chongqing, and enters the Yangtze River at the Fuling District of Chongqing City. The main body of the river is 1 037 km long with an overall basin area of 87,900 km^2.

The average total phosphorus concentration in Guizhou section of the Wujiang River was about 0.8 mg/L in 2011, two times the amount allowable under the lowest V Class level according to China's Environmental Quality Standards for Surface Water (GB3838-2002). This is mainly the result of high concentrations of phosphorus discharge from a specific spring, while the phosphorus pollution of the tributaries including WengAn, Yangshui and Xifeng rivers are mainly caused by phosphorus fertilizer and chemical industry.

In response to this issue, the Guizhou Provincial government established a number of projects to reduce and control phosphorus pollution in the Wujiang River. For example, Zhonghua Kailin Fertilizer Company has updated wastewater treatment assets, a new 2000m^3/h pump station was built to reuse the spring water, and the contamination issues of the polluted spring were thoroughly treated. At the same time, Guizhou government required phosphorous producers to undertake a number of programs to reduce pollution including upgrading wastewater treatment facilities, improving ore management and reducing waste and closing smaller phosphorous mines. All these efforts have paid off with the water quality of the Wujiang River improving significantly in recent years. In 2019, the water quality reached or exceeded III Class, and the total phosphorus concentration fell by over 90 per cent compared to 2011.

Significant stress factors on water quality

Pollution emissions: The most significant stress causing water quality deterioration is from agriculture, forestry and animal husbandry. These activities have caused more nitrogen and phosphorus to enter water bodies with rainwater runoff, and increased environmental stress.

Significant stress factors of hydrological processes

Climate change: The La Niña event will increase the occurrences of annual floods in the Jialing River, and the average flow of the Minjiang/Tuojiang River, Jialing River, and Yangtze mainstem from Yibin station to Yichang station during the flood season. Affected by global warming, the frequency of flooding in the Minjiang/Tuojiang

Reservoir dispatching: When the Jialing River and Wujiang River experience increasing floods during the flood season, the reservoir may store more water and adjust the flow due to the demand for flood retention.

Changes in land use types: In the middle and lower Jinsha River basin and the Jialing River Basin, increased urbanization has led to an increase in surface runoff components and shorter average flood duration.

Significant stress factors for aquatic biota

Resource utilization: Overfishing in the mainstem of the upper Yangtze River is also very serious. Due to the rich species of fishes and the high price of wild fishes, overfishing and illegal electric fishing directly threaten the upstream fishery resources and fish diversity.

Changes in river connectivity: The construction of numerous hydropower projects in the upper reaches of the Yangtze River has caused changes in river connectivity, which has blocked the migration channels of migratory fishes, and altered habitats.

Changes in land use types: Urbanization in the upper reaches of the Yangtze River is increasing rapidly, leading to urban encroachment on a large area of shoreland and wetlands, affecting survival of aquatic life.

Pollution emissions: Factories in the upper reaches of the Yangtze River illegally discharge a large amount of organic matter, as well as highly toxic mud phosphorus and yellow phosphorus-containing wastewater, which directly cause a large number of fish deaths.

Climate change: Climate warming caused by climate change in the upper reaches of the Yangtze River may exacerbate the negative impact of hydropower operations on cold-water fish spawning activities in the basin.

Fig. 4-5 Significant pressure factors of aquatic biota, hydrology and water quality indices in the Upper Yangtze (the significance declines from the left to right)

Middle Yangtze Pressures

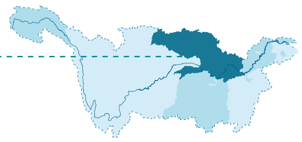
The primary problems faced by the Middle Yangtze include changes in river connectivity and resource utilization, additional pressures include pollution discharge, land development and climate change negatively affecting aquatic organisms, water quality and hydrology.

Resource over-utilization, particularly fishing, and changes in river connectivity have had the most significant impact on the aquatic organisms living in the middle reaches, while land development is also increasingly causing problems. Construction of upstream hydropower stations has not only changed river connectivity and blocked migration passages between the upper and the middle and lower reaches, but has also affected fish resources in the middle and lower reaches by changing water conditions (water temperature, transparency as well as hydrological and hydraulic conditions). The Middle Yangtze is the main spawning ground of the four major Chinese carp. With the construction of reservoirs such as the Three Gorges Reservoir, the natural population of these carp has decreased sharply. The same tendency is found in breeding quantities, spawning scales, and the supplementary groups9[9,10,65]. In addition, the land development resulting from rapid urbanization in the middle reaches has also squeezed the living space of aquatic organisms.

The pressures on water quality in the middle reaches mainly come from pollution discharge and total water consumption. In terms of total nitrogen output, due to the large area of arable and agricultural land, the total nitrogen output to the Dongting Lake basin (45,000 tons), Poyang Lake basin (33,000 tons) and Hanjiang River basin (25,000 tons) is relatively high, respectively accounting for 18 per cent, 13 per cent and 10 per cent of the total nitrogen output of the Yangtze River basin. However, based on the nitrogen output load per unit area, the mainstem basin below Hukou is the highest, followed by the Taihu basin and the mainstem basin from Yichang to Hukou. Increasing sewage treatment capacity can improve water quality and reduce water quality stresses from point sources. From 2008 to 2017, the total amount of sewage treatment in all sub-basins in the middle reaches showed an upward trend, especially in Dongting Lake basin, where the total amount of sewage treatment increased by over 140 per cent. There is an additional issue related to water resource over-extraction, water quality falls with increased withdrawals indicating that an increase in water consumption will negatively impact water quality. In 2017, the middle reaches accounted for about 45 per cent of the total water consumption in the Yangtze River basin, with Dongting Lake taking the largest share, at about 36.645 billion cubic meters.

Reservoir regulation, climate change and land use change have significant impacts on the hydrological processes in the mainstem of the Middle Yangtze. Global warming is correlated to the increase in average flow of Hankou station during the dry season. The La Niña event in ENSO shows a strong correlation with the increase in average flow during flood season at Hankou station and Yichang station. At the same time, there is a significant correlation between reservoir regulation and the number of high flow events each year as well as average flow during the flood season at Hankou station and Yichang station.

Climate change and urbanization are also significantly related to the hydrological processes of the Hanjiang River. Climate Change is correlated to the increase in the number of high pulses each year and mean duration of high pulses within each year, as well as the increase of mean flow in flood season and the decrease of mean flow in dry season in the Hanjiang River. The La Niña event in ENSO is correlated to the increase in the mean duration of high pulses within each year and mean flow during the flood season in the Hanjiang River. The increased level of urbanization will also lead to the increase of number of high pulses events each year and the mean flow during flood season.



Significant stress factors on water quality

Pollution emissions
Increased sewage treatment has reduced environmental pollution stress. For example, in the Dongting Lake Basin, the total sewage treatment volume has increased by 145 per cent.

Resource utilization
Increased water consumption stresses the environment. In 2017, the middle reaches of the Yangtze River Basin had the largest water consumption, accounting for about 45 per cent of the total water consumption in the Yangtze River Basin.

Significant stress factors on hydrological processes

Reservoir dispatching
The longer the average duration of high pulses in the Hanjiang River Basin, the more floods in the Yichang-Hukou section during the flood season, and the greater the mean flow, all of which may cause the reservoir to store more water and adjust the flow due to the demand for flood retention.

Climate change
Affected by climate change, the frequency and average duration of floods in the Hanjiang River Basin could increase, the average flow during the flood season could increase, and the average flow during the dry season could decrease. The La Niña event will increase the average flood duration of the Hanjiang River, and the average flow of the Hanjiang River and the Yichang-Hukou section during the flood season.

Changes in land use types
Increased urbanization in the Hanjiang River Basin has led to an increase in surface runoff components, flood frequency, and average flow during the flood season.

Stress factors on aquatic biota

Resource utilization
Overfishing has directly caused a sharp decline in the catch and diversity, and indirectly affected other aquatic organisms, such as the Yangtze finless porpoise, through by-catch and reducing available food resources.

Changes in river connectivity
The construction of hydropower stations in the middle reaches of the Yangtze River has blocked migration channels between upstream, midstream and downstream fishes, and also affected the fish resources in the middle and lower reaches by changing the hydrological conditions in the middle and lower reaches.

Changes in land use types
The land development stress brought about by rapid urbanization in the middle reaches of the Yangtze River has also squeezed the living space of aquatic organisms in the Yangtze River Basin.

Pollution emissions
The large amount of chemical fertilizers and pesticides applied by agriculture in the middle reaches of the Yangtze River has increased the pollutants in the water body and affected the growth and development of fish.

Climate change
The flood disasters triggered by climate change in the middle and lower reaches of the Yangtze River will affect the hydrological conditions and the living space of fishes in the middle and lower reaches of the Yangtze River, thereby affecting the structure of fish communities.

Fig. 4-6 Significant pressure factors of aquatic biota, hydrology and water quality indices in the Middle Yangtze (the significance declines from the left to right)

Implementation of E-flows from Three Gorges Dam

As typical species in the mid-lower reaches of the Yangtze River, four major Chinese carp (i.e. black carp, grass carp, silver carp, and variegated carp) have been significantly impacted by the Three Gorges Dam Project. An Environmental Impact Assessment of the Three Gorges Project found that the dam's impact on water flow and temperature negatively affected breeding patterns. Specifically, the spawning season has been delayed and the number of eggs produced has fallen alarmingly. According to monitoring stations on the Yangtze River the number of fish fell from 1.9 billion in 2002 prior to the construction of the Three Gorges Dam to 105 million in 2005, after the construction of the Dam. In 2005 for the first time zero fingerlings were caught at the Jianli Section[66].

In response, led by China's Yangtze River Flood Control and Drought Relief Headquarters, China Three Gorges Corporation have organized a number of experiments since 2011 to try and re-create suitable conditions for the spawning of the four Chinese carp. The experiments required a complex series of adjustments in multiple locations and reservoirs, but positive results were finally seen in 2017 with a record spawning number of the four major Chinese carps of 1.08 billion[67].

Spring at Three Gorges Dam©Ming Li

Study and action on plastic waste generation and management in the middle-lower Yangtze River area

Plastics pollution has become an emerging environmental issue in the world, attracting more attention among academic societies. The Yangtze River Economic Belt has a high population density and large economic volume. However, the systematic data was insufficient to support the assessment of its plastic pollution. In 2019, WWF supported the Eco-Environment Research Center of the Chinese Academy of Sciences to carry out the "Study and action on plastic waste generation and management in the middle-lower Yangtze River area" project. The middle-lower Yangtze River area was selected as the case study area, covering seven provinces or province-level municipalities. Generation and emission patterns of plastic waste in that area were analyzed by comprehensive data collection, including reviewing the annual statistic reports, industry reports, online and offline questionnaires, field investigations etc. The multi-source data on plastic use, as well as plastic waste recycling, treatment, disposal, and mismanagement (environmental leakage) were analyzed under the resolutions of prefecture-level cities and urban-rural gradient. Several generation and emission parameters of plastic domestic waste were determined, and the plastic waste management situation in terrestrial and river areas was analyzed. The results show that the plastic waste generation intensity in urban areas was higher than rural areas. Although the total amount of plastic waste produced in rural areas is far lower than that in cities and towns, the plastic waste leaking into natural environment in rural areas was higher.

When President Xi visited the Yangtze River, he encouraged people to continue properly protecting and restoring the Yangtze River as well as it ensuring good water quality. Since the strategy of Yangtze River protection was put forward, China has implemented several crucial actions against solid waste pollution in the Yangtze River basin. In 2018, the Ministry of Ecology and Environment and the National Development and Reform Commission issued the Action Plan for Protection and Eco-restoration of the Yangtze River, proposing that "by the end of 2020, all of the open dumps within the blue line of urban water body should be restored, and all towns along Yangtze River should establish municipal solid waste collection and treatment system". In order to implement the strategy of Yangtze River protection, the Ministry of Ecology and Environment has successively deployed the "Waste Removal Action" in 2018 and 2019. In 2019, WWF launched the global "Plastic Smart Cities" (PSC) initiative. By building a knowledge sharing platform with cities as the main body and sharing best practices, it enhances the plastic reduction potential of cities, supports circular economy, improves waste management, and facilitates the various stakeholders including governments, enterprises, the public, and research institutions to collaborate for solutions. In April 2020, Yangzhou City, located at the intersection of the Yangtze River and the Canal joined the PSC network. With the support of WWF, Yangzhou City is actively exploring plastic smart model in the surrounding areas of the city, which provides an important reference for the sustainable development of the Yangtze River Delta, and inspires cities with similar characteristics in China and abroad to tackle plastic pollution together.

Guazhou Sluice©WWF

Lower Yangtze Pressures

Resource over-utilization and pollution discharge are the primary pressures in the lower section of the Yangtze River. Climate change places moderate pressure on the health of the river, while the least significant factors are land development and changes in river connectivity.

Overfishing in the Lower Yangtze has multiple impacts, not only directly on fish resources. The Yangtze finless porpoise population has declined sharply due to overfishing, with deaths caused by accidental catch and shortage of food resources. Whilst accidental capture has been a long-term issue for Yangtze finless porpoise, additional pressures from food shortages that result from over-fishing have caused a sharp fall in numbers recently.

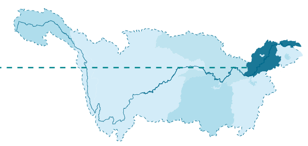
Land use change brought by urbanization in the Yangtze River Delta is also causing a loss of aquatic habitats and reduction in living space in the Lower Yangtze, whilst chemical industries discharging waste along the Yangtze River increase the risks of chemical contamination. Agricultural development has also increased nutrient input (nitrogen and phosphorus) in the neighbouring rivers and lakes, and pollutants such as particulates and pesticides threaten the natural habitats of the basin.

The impact of climate change on the mainstem of the Lower Yangtze is mainly reflected in changes to water flow events. An increase in mean flow during the dry season and the La Niña events lead to increase in average duration of high pulses and mean flow during flood season. Climate change is also expected to lead to runoff changes and sea level rise in the Yangtze River estuary area[68], both aggravating the frequency and intensity of flood and storm surges, affecting water quality in the water source protection area and causing coastal erosion and loss of tidal wetland habitats. The ecosystem and biodiversity at the river mouth could be impacted, and of particular concern are the impacts on the survival of Chinese sturgeon and birds in the eastern tidal area of Chongming.

Water infrastructure projects in the Lower Yangtze also divert and withdraw a large amount of water each year, exacerbating other pressures. Taking the water diversion project from Yangtze River to Taihu Lake as an example, the annual amount of water diverted from the Yangtze River is negatively correlated with the average flow of Datong Station during the dry season, indicating that the project has a significant impact on the water quantity in the basin below Hukou station during the dry season.

Artificial embankments and shorelines in the Lower Yangtze have a significant impact on lateral connectivity, reducing the levels of lateral connectivity in the Lower Yangtze to the lowest in the whole mainstem of the Yangtze River, exceeding only levels in the Hanjiang tributary.

With a high volume of water flow and decent hydrodynamic conditions, the lower reaches of the Yangtze River mainstem have relatively good self-purification capacity and environmental capacity. However, pollution stemming from a large population and intensive industry still put severe pressure on water quality in the Lower Yangtze. The Taihu Lake basin has the highest population density of 1,657 persons per square kilometer, followed by the mainstem basin below Hukou with a population density of 631 persons per square kilometer. The Yangtze River Delta and the middle and lower Yangtze Plain are the most populated areas in the basin. The higher the population density, the greater the amount of household sewage per unit area of land, and with the same degree of treatment, the greater the total amount of pollution discharged into the water bodies. The lower Yangtze basin also has the highest GDP per unit area, followed by the middle basin, while the source region and the upper basin have the lowest. Pollution levels are directly linked with intensity of industrial and economic activities. From 2008 to 2017, the GDP of the lower basin increased by roughly 145 per cent, while the total investment in environmental pollution control increased by only 16 per cent, a significant lag and an area where improvements are urgently recommended.



Significant stress factors on water quality

Pollution emissions: The Yangtze River Delta and the Lower Yangtze are the most densely populated areas in the basin, with the highest GDP per unit area. Therefore, the stress of pollution emissions from life and production is also very high.

Significant stress factors on hydrological processes

Climate change: As a result of climate change, the average flow in the basin below Hukou could increase during the dry season. The La Niña event could cause an increase in the average duration of high pulses and the mean flow during the flood season in the basin below Hukou.

Resource utilization: A large number of water conservancy projects in the Yangtze River Delta involving a large amount of water diversion and extraction, have greater impact on the mainstem in dry years. Taking the "Water Diversion from Yangtze River to Taihu Lake" Project as an example, the larger the annual water diversion from the Yangtze River, the smaller the average flow rate during the dry season at Datong Station, indicating that the Project has a significant impact on the water volume in the basin below Hukou during the dry season.

Significant stress factors on aquatic biota

Resource utilization: Overfishing has directly caused a sharp decline in the catch and diversity, and indirectly affected other aquatic organisms, such as the Yangtze finless porpoise, through by-catch and reducing available food resources.

Changes in land use types: Urbanization in the Yangtze River Delta has caused the loss of the habitat and squeezed the living space of aquatic organisms in the lower Yangtze River.

Pollution emissions: Industrial waste and agricultural pollution from the dense chemical industry development along the Yangtze River have caused the discharge of nutrients, small sediments and pesticides, which seriously damaged the natural habitat of the basin.

Changes in river connectivity: Sluices and dams built in the lakes of the lower reaches of the Yangtze River will restrict or prevent the normal life cycle, growth and reproduction of aquatic migratory organisms.

Climate change: Floods triggered by climate change in the middle and lower reaches of the Yangtze River will affect the hydrological conditions and the living space of fishes in the middle and lower reaches of the Yangtze River, thereby affecting the structure of fish communities.

Fig. 4-7 Significant pressure factors of aquatic biota, hydrology and water quality indices in the Lower Yangtze (the significance declines from the left to right)

Four Lakes Pressures

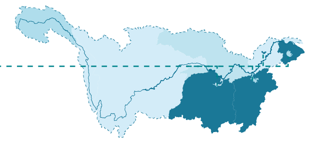
For the four lakes included in this research resource over-utilization is the most significant pressure for Dongting and Poyang Lake whilst pollution is the biggest issue facing Chaohu and Taihu Lakes

For Dongting and Poyang Lakes, over-use of fish stocks, excessive sand dredging, and land reclamation have all severely undermined the natural habitat and ecological cycles of the two lakes. In addition, climate change and reservoir regulation (including the reservoirs in Dongting Lake and Poyang Lake basins, the water level of the mainstem of the Yangtze River, and the regulation of the Three Gorges Reservoir) have impacted hydrological processes. Pollution and water resource over-utilization are also important factors influencing water quality in the two lake basins. Rapid socioeconomic growth in past decades caused a significant increase in demand for the water resources from the two lake basins and increased the pressure on water quality. In the meantime, with increased treatment of pollution, the total amount of pollutants entering the water bodies show an overall net reduction.

Pollution is the most significant problem in Chaohu Lake and Taihu Lake, followed by resource over- utilization and habitat degradation. This area has a large population, mass production and intense water pollution like the lower reaches of the Yangtze River, while there is more severe environmental stress due to the low self-purification capacity and water environmental capacity caused by insufficient hydrodynamic conditions.

In 2018, the water quality of more than half of the main tributaries of Taihu Lake fell below class III standard. The main pollutants exceeding the standard were 5-day biochemical oxygen demand (BOD_5), ammonia nitrogen, permanganate index, chemical oxygen demand (COD) and total phosphorus (TP)[69]. In 2018, the total phosphorus, total nitrogen and ammonia nitrogen concentrations of the three main tributaries in the west of Chaohu Lake (Nanfei River, Shiwuli River, Tangxi River and Paihe River) all showed a decreasing trend, but the total phosphorus concentration of Zhaohe River, Shuangqiao River and Zhegao River increased[70]. Pollution flowing from the tributaries into Taihu Lake and Chaohu Lake remains the main pressure factor.

Fishing volumes in Taihu Lake increased between 1996 and 2016, with an average annual growth of 2,551 tons[71]. However, Chaohu Lake fisheries peaked in the 1990s and had declined to 25,000 tons in 2015[72].



Controlling Cyanobacterial Blooms - Taihu Lake

Located in the lower basin of the Yangtze River, Taihu Lake is the third largest freshwater lake in China with a surface area of about 2,340 km^2. Crossing Jiangsu and Zhejiang Province, it has an annual average water storage of 4.75 billion m^3, an average water depth of about 2 m and basin area of nearly 37,000 km^2.

Since the 1970s, the ecosystems of Taihu Lake have come under increasing pressure from human activities such as urbanization and industrialization. In 2007 pollutants resulted in large cyanobacterial blooms forming, which threatened the water supply for Wuxi City, gaining public attention in China. Since the 1960s the water quality in Taihu Lake has consistently fallen by one grade every decade, dropping from the I-II Class in 1960s, to the II-III Class in early 1980s, and finally to below V Class in 2007 when the cyanobacterial bloom crisis occurred.

In June 2007, after Wuxi suffered a water crisis caused by cyanobacterial blooms in Taihu Lake, Jiangsu Province launched a new policy to prevent and mitigate future similar problems, which included industrial reform, sewage treatment, Yangtze-Taihu Lake water diversion, and wetland restoration. Innovative policies such as the river chief mechanism and compulsory pollution insurance were also introduced, achieving rapid results. Although the water quality of Lake Taihu steadily improved, it remained prone to developing blooms of dangerous algae with the attendant risks of water crisis. In April 2012, Jiangsu Province revised the protection policy and plan and upgraded the governance model for the basin. In partnership with WWF, Jiangsu Province has brought in multiple stakeholders to engage with basin governance and promoted full participation. Based on scientific ecological asset assessment and evaluation goals the new system builds in wider stakeholder participation and will promote regional economic development, environmental protection and social development. At the same time international best practice will be evaluated in river basin management mechanisms, and an international exchange platform will be developed with the goal of creating a model for international river basin ecological management.

Taihu Lake©Xiaodong Wang

Birds at Poyang Lake©WWFBaoyu Wei

RESEARCH TO FACILITATE A LIVING YANGTZE RIVER

▼ There are a number of crucial measures that should be implemented to improve the vitality of the Yangtze River. These include habitat conservation and restoration, the conservation of flagship species and biodiversity, the protection of water quality, the preservation of river (lake) connectivity, the scientific implementation of environmental flows and tackling climate change.

▼ Policy implementation should be targeted and modified based on the local conditions of the source region and the Upper, Middle and Lower Yangtze.

▼Everyone in this nation has a role to play in keeping the Yangtze River healthy – implementing policies, improving regulations, sharing data, strengthening scientific research, enhancing law enforcement, preventing risks and raising awareness.

According to estimates from the 2020 World Economic Forum (WEF), nearly 50 per cent of the highest probability and highest impact global risks are related to the loss of nature and climate change. These range from ecosystem collapse to extreme weather, water crises and anthropogenic environmental disasters. Biodiversity loss is also in the top 10 of global risks[73]. Less than 1 per cent of our planet's water is in freshwater ecosystems of rivers, lakes and inland wetlands, yet these systems support over 30 per cent of vertebrates and 10 per cent of all species globally[74]. This includes approximately 70 species of mammals that have adapted to freshwater, 5700 species of dragonflies and damselflies, over 250 turtle species[75], 17,800 fish species[76] and 1600 crab species[77]. There is also a high proportion of endemic species that live in freshwater ecosystems, and about half of the evaluated fish in the global freshwater ecoregions exists only in specific areas[78].

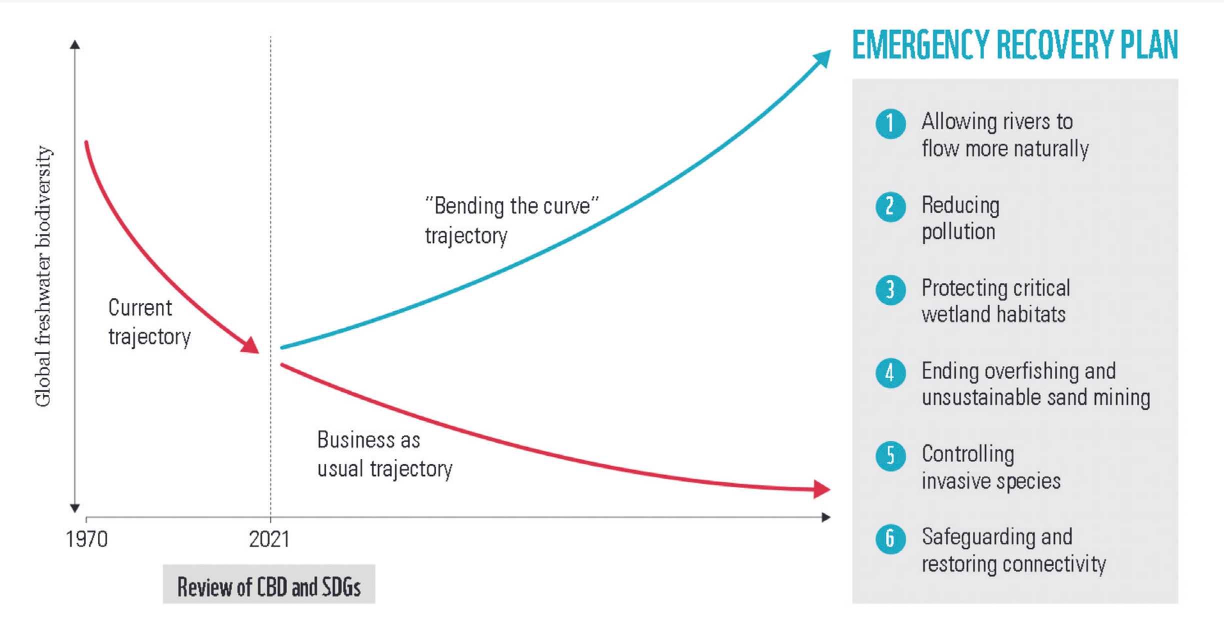
Freshwater ecosystems also provide humans with vital life-giving services including fresh water, food, and flood and drought control. However, since the 1970s 30 per cent of freshwater ecosystems have been lost. According to WWF's Living Planet Report 2020, freshwater species populations have fallen by 84 per cent on average over the same period[79]. Generally speaking, the loss of biodiversity in freshwater ecosystems is double or even triple that of forest and ocean ecosystems, although the species number per unit area of freshwater ecosystems is much higher[80].

Preserving biodiversity in the Yangtze River, restoring ecosystems to a healthy state and achieving proper management and sustainable use of resources are vital to the economic and social development of China. The LYI provides a critical tool to support effective management by providing a comprehensive set of data to help us track changes over time, gain a better understanding of the status of, and progress on, biodiversity conservation, ecosystem restoration and the sustainability of the resources of the Yangtze River. This will enable us to find the roots of the problems and the right solutions.

Bending the curve of global freshwater biodiversity loss: an emergency recovery plan

In 2019, an international group of freshwater ecosystem experts from the WWF freshwater team, academic institutions and other international organizations gathered to define priorities for bending the curve of freshwater biodiversity loss[81]. Borrowing from post-disaster recovery planning processes, they set out an ambitious but pragmatic Emergency Recovery Plan for freshwater biodiversity. The group used the Plan to generate thirteen specific recommendations for improving selected targets and indicators under the United Nations Convention on Biological Diversity (UNCBD) and Sustainable Development Goals (SDG).

The Plan is structured around six priorities for action: 1) accelerating implementation of environmental flows, 2) improving water quality, 3) protecting and restoring critical habitats, 4) managing exploitation of freshwater species and riverine aggregates, 5) preventing and controlling non-native species invasions, and 6) safeguarding and restoring river connectivity. Each priority action has already been implemented successfully in one or more situations across the globe, providing proof of concept and lessons that can inform scaling-up of actions.



5.1 IDENTIFYING KEY FACTORS THAT IMPROVE THE VITALITY OF THE YANGTZE RIVER

In recognition of the problems faced by the Yangtze basin the Chinese government has implemented a number of policies designed to help protect and restore the ecosystems in the basin.

To address issues from over-fishing and conserve the aquatic ecosystem, the Ministry of Agriculture and Rural Affairs issued a "List of Aquatic Life Reserves" where productive fishing was completely banned as of January 1st, 2020 (this includes 322 nature reserves and aquatic germplasm resource reserves in total). By January 1st, 2021, a complete ban on fishing will come into force covering the mainstem, the Minjiang River, the Tuojiang River, the Chishui River, the Jialing River, the Wu River, the Han River and the Dadu River. The ban also includes shallow lakes that are connected to the Yangtze, such as Poyang Lake and Dongting Lake.

In terms of the management of the aquatic environment, the Ministry of Ecology and Environment has developed a number of protection and action plans which identify and prioritize specific actions that should be taken to identify and mitigate problems (e.g., Protection Plan of the Ecological Environment of the Yangtze River Economic Belt, Action Plan for the Conservation and Restoration of the Yangtze River). The first one is improving inferior class V water in state-controlled sections, followed by examining and fixing sewage outlets into the rivers, the so-called "Green Shield" campaign, investigating and producing countermeasures for phosphorus ore, the phosphate chemical industry and the phosphogypsum stockpiles, addressing solid waste environmental violations, protection of drinking water sources, the elimination of heavily polluted bodies of water, and, lastly, the improvement of sewage treatment facilities in industrial parks.

To maintain a healthy flow of water, the national government has proposed a general guideline for the release of water from the reservoirs which prioritizes flood control over profits and water flow over electricity generation, emphasizing the need to safeguard ecological flow levels. To tackle problems caused by unauthorized hydropower stations the Ministry of Water Resources has provided guidance (Opinions on Carrying out the Cleanup and Rectification of Small-scall Hydropower Station in the Yangtze River Economic Belt) to help officials clean up and consolidate hydropower activities. In 2016, the General Office of the CPC Central Committee and the General Office of the State Council supported the nation-wide implementation of the "river chief system" (Opinions on Fully Promoting the River Chief System). This system is designed to strengthen the management and protection of rivers and lakes and help maintain a healthy status of these freshwater ecosystems. By June 2018, 31 provinces, including autonomous regions and cities, have adopted the river chief system.

However, despite these efforts, significant problems and vulnerabilities still exist with regards to the protection and restoration of the Yangtze River. These consist of high pollution loads, widespread ecological destruction, inadequate protection of key habitats, insufficient protection and regulation of water resources, the destruction of river connectivity and high environmental risks.

With the goal of enhancing the vitality of the Yangtze River, the Report provides guidance for priority action areas including identifying areas where more research is needed, policy or implementation are lacking, or awareness of the problem is the main issue. This analysis is based on existing policies regarding the protection of the Yangtze River, the evaluation results and the LYI pressure analysis (Table 5-1).

Key factor	Laws and regulations	Policy implementation	Awareness improvement	Research input	Data support	Social cooperation
Habitat conservation and restoration	★★★	★★★	★★	★★	★★	★★★
Flagship species and biodiversity conservation	★★★	★★	★★	★★★	★★	★★★
Water quality protection	★	★★★	★	★★	★★★	★★
River (lake) connectivity preservation and scientific implementation of environmental flows	★★	★★★	★★★	★★	★★★	★★★
Tackling climate change	★★	★★	★★★	★★★	★★	★★

★★★ URGENT ★★ AVERAGE ★ LOW

Table 5-1 Priority Action Areas

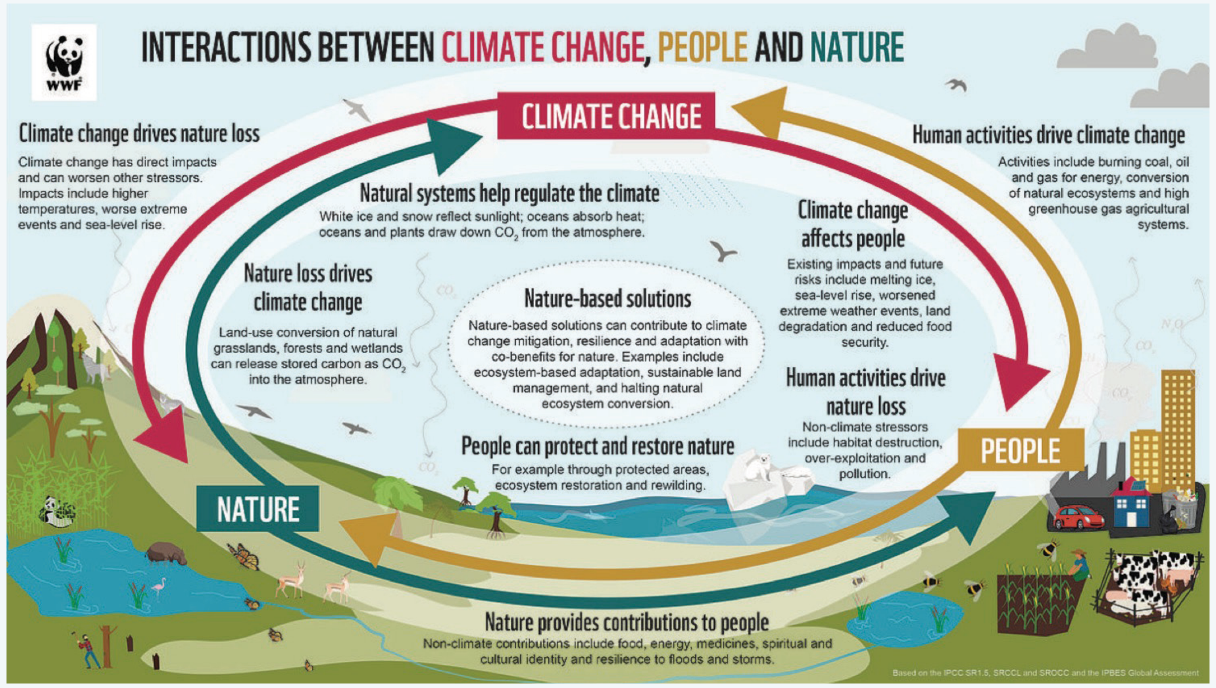
Nature-based solutions

Human society is facing a variety of challenges from biodiversity loss and climate change to food insecurity and disease, often occurring simultaneously. During the COVID-19 pandemic in 2020, China also dealt with severe flooding along the Yangtze River. From July 2020, several big floods occurred in the Yangtze River basin, creating catastrophic flooding hazards in the mid-lower reaches of Yangtze River mainstream, Dongting Lake and Poyang Lake. Flood control is becoming ever more complicated due to climate change, basin land development, occupation of natural lakes and wetlands, and narrowing of river and flood control channels.

While human beings are fighting against natural disasters, scientists continue to examine how to find a balance with nature. Nature-based Solutions (NbS), defined by the International Union for the Conservation of Nature (IUCN) as “actions to protect, sustainably manage, and restore natural or modified ecosystems, that address societal challenges effectively and adaptively, simultaneously providing human well-being and biodiversity benefits” are increasingly seen as providing a solution. The first global standard for NbS was confirmed on July 23, 2020.

NbS can be considered an umbrella concept covering a range of ecosystem-based approaches that address specific or multiple societal challenges, such as ecological restoration, ecosystem-based adaptation, and green infrastructure, while simultaneously providing human well-being and biodiversity benefits. For example, water interception and filtration provided by woodland and grassland ecosystems, flood control offered by floodplains and some types of wetlands, and storm surge protection provided by sea grass, mangroves and corals are all NbS to help society to cope with the challenges of natural disasters whilst providing economic benefits to communities.

The “World Water Development Report 2018: Nature-based Solutions for Water” points out that China’s Sponge Cities are a good example of NbS. The concept of a sponge city calls for the creation and use of natural drainage systems and low-impact facilities during urban development. For example, harvested rainwater can be treated and repurposed for irrigation and for home use, improving the natural water restoration of ecosystems, and also providing an important solution for urban waterlogging. For the Yangtze River basin, in particular, it can moderate the impacts of the underlying changes to runoff, and minimize the disruption to the hydrologic process of the Yangtze River basin during urbanization.



5.2 IMPLEMENTING TARGETED POLICIES IN DIFFERENT REGIONS

Source area and Upper Yangtze - Implementing pollution control, soil conservation and maintaining connectivity

The LYI rated the source region as A and the Upper Yangtze as B-. The source region is relatively undisturbed by human activity and without significant local pressure factors. Yet, the impact of climate change on its glaciers and ecosystem still needs to be highlighted and studied. In the upper reaches (Jinsha River and the Yangtze mainstem from Yibin station to Yichang station) negative impacts caused by human activities are mostly related to the hydrological processes, followed by water ecology. Soil erosion is the primary issue facing the tributaries of the upstream Yangtze River, the Minjiang River and the Tuojiang River.

The current status, level of threats and objectives of several key factors for the source region and the upper reaches of the Yangtze River are shown in Tables 5-2 and 5-3.

Key factor	Status quo	Level of threat	Objectives
Habitat conservation and restoration		Maintain the status quo	Low
Flagship species and biodiversity conservation		Maintain the status quo	Low
Water quality protection		Maintain the status quo	Low
River (lake) connectivity safeguarding and scientific implementation of environmental flows		Maintain the status quo	Low
Tackling climate change		Reduce GHG emissions and step up measures against water loss and soil erosion	High

High Medium Low

Table 5-2 Objectives of key factors in the source region of the Yangtze River
Note: The level of threat is graded as High, Medium and Low. The followings are equally graded.

Key factor	Status quo	Level of threat	Objectives
Habitat conservation and restoration		Step up measures against water loss and soil erosion, and continue to protect habitats	High
Flagship species and biodiversity conservation		Continue to intensify species conservation	Medium
Water quality protection		Reduce pollution discharge	High
River (lake) connectivity safeguarding and scientific implementation of environmental flows		Strengthen re-operation of cascade reservoirs to fulfill ecological requirements and better manage small hydropower stations on tributaries	High
Tackling climate change		Reduce GHG emissions	High

Table 5-3 Objectives of key factors in the Upper Yangtze

The *Report* suggests the source region should prioritize water resource conservation and tackling climate change, put more effort into water and soil conservation, mitigate soil erosion, enhance the protection of natural reserves, and continue to protect rare and endemic fish species.

Regarding the Upper Yangtze, the *Report* suggests a number of priority actions. Firstly, ensure that the hydrological rhythm and connectivity of the rivers is maintained or restored, and develop a comprehensive control and deployment plan for basin-wide water resources utilization projects. For instance, re-operate the reservoirs to ensure the flows fulfill ecological requirements, as well as strictly control and regulate the development of water resources utilization and hydropower projects. Secondly, enhance pollution control. This includes reducing the use of pesticides and fertilizers, developing standard large-scale fish farms, and increasing sewage treatment capacity and the sewage collection rate. Thirdly, strengthen water and soil erosion control and ecological restoration in the Yunnan-Guizhou-Sichuan karst areas, the upstream Yangtze River area, the Minjiang River and the Tuojiang River. This could include converting farmland to forests and grasslands, addressing desertification, improving the management of phosphorite mining, and regulating the construction of slag yards and tailings ponds.

Middle Yangtze – Restoring the freshwater ecosystem and protecting key species

In the Middle Yangtze, the aquatic biota suffers the greatest strain, followed by hydrological processes and water quality. The large number of reservoirs and water conservancy projects in the middle reaches have had a significant impact on the aquatic biota, water quality and hydrological processes. In the Dongting Lake and Poyang Lake, water quality experiences the highest pressure, followed by aquatic biota and hydrological processes.

Based on the evaluation results of the LYI for the Middle Yangtze, the current status, threat levels and objectives of several key factors are determined as shown in Table 5-4.

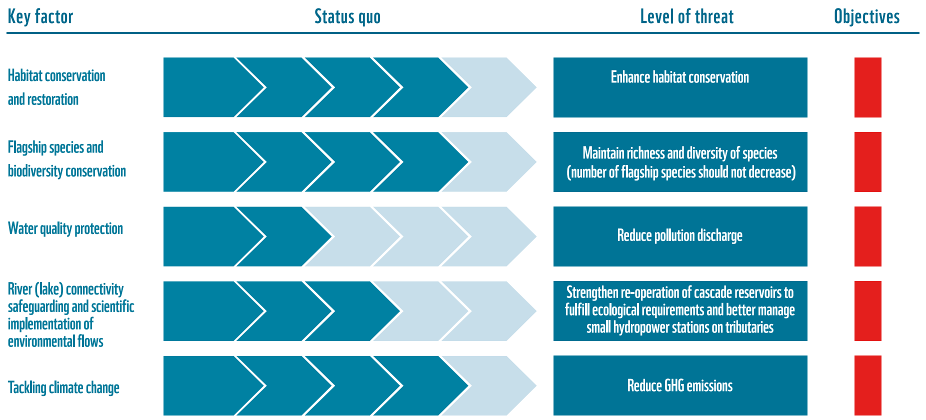


Table 5-4 Objectives of key factors in the Middle Yangtze

The Report offers multiple recommendations for action in the middle reaches of the Yangtze River. Sewage treatment capacity should be expanded, and management of livestock and poultry breeding industries in Hunan and Hubei Province should be strengthened, which includes advocating for the recycling of livestock and poultry manure, and encouraging specialized and centralized treatment of this manure. Green development of fisheries should be promoted, partly by actively directing fishermen to switch to other industries, but also by directly bolstering fish proliferation and monitoring the effects of fish releases. The natural shorelines and wetlands of the mainstem of the Yangtze River should be restored and protected and Poyang Lake and Dongting Lake should remain connected with the Yangtze River, while sand mining should be limited. Safe construction and land use management in flood catchment areas should be strengthened, and a joint management system for controlled water conservancy projects should be established. The ecological service capacity of reservoir dispatch, urban flood control capacity, management of excessive flood diversion channels and temporary flood storage and detention areas as determined in the planned flood control reserve zones should all be improved.

The Dongting Lake basin should maintain connectivity and its original hydrological rhythm of rivers and lakes. The basin should control the amount of pollutants entering the lake, improve the collection and treatment of urban sewage, control agricultural non-point source pollution discharge, increase vegetation coverage of natural lake shoreline, and strictly control development and utilization of the lake itself.

The Poyang Lake basin should focus on species diversity conservation, habitat preservation and management and oversight of the nature reserves. Recommended measures include reducing the interference of human activities in key habitats, controlling the use of pesticides and fertilizers in the surrounding areas, implementing centralized restoration of the rural environment, reducing the volume of nitrogen and phosphorus pollution, and improving control of soil erosion in mountainous areas and areas where landslides occur.

Lower Yangtze – Reducing pollution and increasing vegetation coverage

In the Lower Yangtze, the aquatic biota suffers the greatest strain, followed by hydrological processes and water quality. This can be attributed to over exploitation of natural resources, and the large proportion of cultivated and built-up land in the region, combined with a relatively high nitrogen and phosphorus output load and intense human activity. Due to global warming, the frequency and intensity of extreme rainstorms has increased, which in turn leads to an increase in the frequency and intensity of floods and storm surges. It should be noted that the pressure on Taihu Lake and Chaohu Lake mainly comes from pollution.

Based on the evaluation results of the LYI for the Lower Yangtze, the current status, threat level, and objectives of several key factors are determined as shown in Table 5-5.

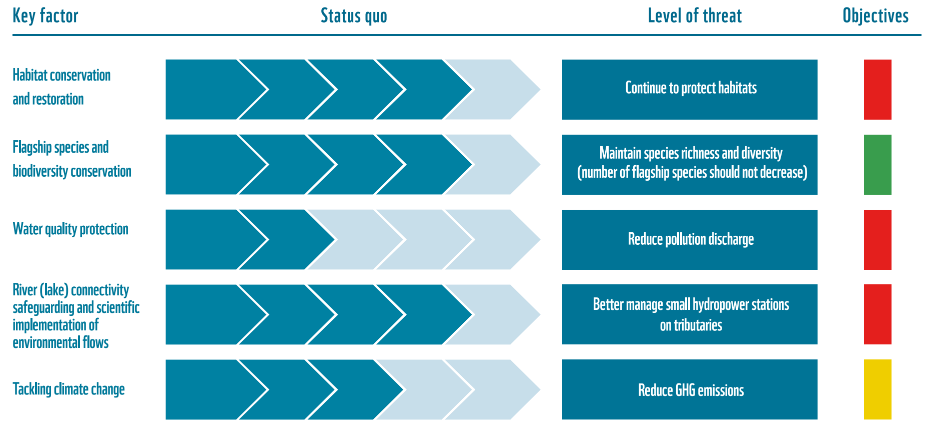


Table 5-5 Objectives of key factors in the lower reaches of the Yangtze River

The Report recommends that the lower reaches, with a focus on Anhui and Jiangsu Provinces, should improve sewage management, specifically the construction of urban sewage collection and treatment facilities, the renovation and repair of old sewage networks and building more capacity. Industrial pollution control should be strengthened, supervision and inspection of industrial discharge should be improved and the expansion of the chemical belt along the river should be controlled. The downstream shoreline should not be further occupied and developed, the infringement of the shoreline of rivers and lakes and reclamation of lakes should be refrained, buffer zones for lakes and rivers should be developed, and great efforts need be made to protect and restore the wetland ecosystems along the rivers and the lakes, as well as expand species conservation, including Yangtze finless porpoise and endemic fish, and ecological restoration efforts.

The Taihu Lake basin should tighten control over the discharge of pollutants, limit the flow of phosphorus into the lake, accelerate the reduction in chemical fertilizer use, promote sewage and rainwater collection and treatment in cities around the lake, expand the range of water conservation forests, strengthen the restoration of riparian zones of lakes and rivers, enhance control over cyanobacterial blooms in the lake area, properly allocate the water volume of Taihu Lake, strictly control water use, scientifically identify the maximum water resources utilization in the river basin, establish coordination of water transfer between the upper and the lower reaches, and strengthen the unified dispatch of the water resources in the basin.

The Chaohu Lake basin should control pollution of the Nanfei River, the Shiwuli River and the Pai River. The construction of urban environmental infrastructure in Hefei City should be promoted, the collection rate of sewage and removal rate of nitrogen and phosphorus should be increased, non-point source pollution control and endogenous pollution control around the Chaohu Lake need to be improved, development and utilization of the lake shoreline should be restricted, vegetation coverage of the lakeshore zone should be increased, monitoring of cyanobacterial bloom should be strengthened, and an early warning mechanism should be established in the Chaohu Lake.

5.3 ESTABLISHING A SET OF INSTITUTIONS AND MECHANISMS

Based on the key factors identified to improve the health of the Yangtze River, in addition to location specific recommendations mentioned above, the Report also acknowledges that the problems faced by the Yangtze can be effectively addressed through policy formulation and implementation, strengthening law enforcement and risk prevention, as well as utilizing the input of scientific research and data sharing.

Implementing policies and improving regulations

The Report recommends that local governments should take on the responsibilities for protecting the Yangtze environment and strengthen organizational leadership. Based on the Chinese river and lake chief system, they should establish and improve the coordination of jointly organized Yangtze River protection activities, accelerate industrial restructuring, effectively reduce carbon emissions by encouraging the upgrade and transformation of high energy consumption industrial enterprises, and implement necessary environmental protection, habitat conservation and water resources management measures. They should establish a clear division of tasks, in order to form an effective and united force.

The Report suggests that, while actively responding to the promulgation and implementation of the Yangtze River Protection Law of the People's Republic of China, local governments should emphasize the protection of habitats, flagship species and biodiversity, and develop supporting rules and regulations. These may be based on local realities and relevant national laws and regulations, for instance for areas with a small environmental capacity or areas that have a significance for the state and the society. Special limits for relevant indicators and environmental standards can be developed.

Raising awareness and encouraging collaboration

Public awareness is key for environmental protection. Local governments and relevant departments should make full use of social media channels such as Weibo and Wechat to promote awareness, increase the channels for public participation, and step up efforts in promoting Yangtze River protection and restoration, for instance by establishing an incentive scheme. Such schemes could encourage the public to pro-actively supervise the Yangtze River protection work and report on violations of standards and rules. At the same time local governments and relevant departments can firmly establish ecological civilization concepts such as "Respecting nature, conforming to nature and protecting nature", "Mountains, rivers, forests, farmlands, lakes, and grasslands are a living community", and "Clear waters and lush mountains are invaluable assets".

Civil society and other stakeholders all have a role to play in protecting the Yangtze. Local governments should facilitate social collaboration and strengthen the sense of responsibility of enterprises. To this end they can make full use of the guiding role of the media, motivate NGOs to engage in environmental protection, deploy practical education activities in schools and training institutions at all levels, and generally facilitate more organizations, institutions and individuals to participate in social activities for Yangtze River protection and restoration.

Preventing risks and enhancing law enforcement

The Report's recommendations include the preparation of risk contingency plans, regular training on the plan's implementation, and standardizing the layout of enterprises and docks along the river. Local governments need to enhance safety supervision of the transportation of hazardous chemicals by water, prevent oil spills from ships, combat the illegal transportation of hazardous chemicals, and promote and encourage the use of standardized and eco-friendly ships.

Local governments are recommended to implement the basin-wide environmental protection laws, with severe penalties for violations. They should strive to solve environmental destruction and hazardous risks in the Yangtze River basin through clearly setting, monitoring and enforcing standards. Polluters must be held accountable with appropriate penalties for violations.

Data sharing and improving scientific research input

Based on existing practice, the Report suggests that the monitoring of ecological protection and restoration in the Yangtze could be improved, particularly with regard to interdepartmental data sharing mechanisms. The development of an open database system and information sharing platform needs to be explored. This would facilitate information exchange, enable mutual recognition of evaluation results (including mutual recognition and use of the evaluation results on environmental credit), and share information regarding companies that breach environmental laws.

The Report recommends local governments should strictly implement the 10-year fishing ban starting in 2021. In addition, local governments have a role in providing more support for basic research on the aquatic ecology of the Yangtze River basin, improving the aquatic environment monitoring system and supporting and facilitating scientific surveys by relevant research institutions in order to promote the development of ecological conservation and restoration technologies. In addition, systematic control of regional sources of pollution and innovations in technological integration and risk management should be promoted. Objectives of these innovations should include the protection and restoration of the main river and tributaries of the Yangtze River, the protection and restoration of the natural state of the shoals and coastal zones of the main Yangtze River, the hydrological connectivity of the main Yangtze River with Dongting Lake and Poyang Lake, and the restoration of the main habitats of the lakes connecting to the Yangtze River, the restoration of aquatic biological resources, and the scientific release of water resources. Endangered species should be prioritized for protection as much as possible, with the limited resource inputs. At the same time, research on technologies for the protection of rare and endangered species and the restoration of key habitats, innovative scientific and technological approaches and the promotion of scientific research uptake into policy should be promoted.

Systematic Planning

In recent decades, 15 per cent of inland waters have been placed under different forms of protection. The number of Ramsar sites (i.e. wetlands of international important under the Ramsar Convention) has increased to 2341 across 170 countries, protecting 25,000 km^2 of inland waters, But freshwater biodiversity across the world is still rapidly decreasing, and improving planning and management of protected areas is crucial to bending the curve.

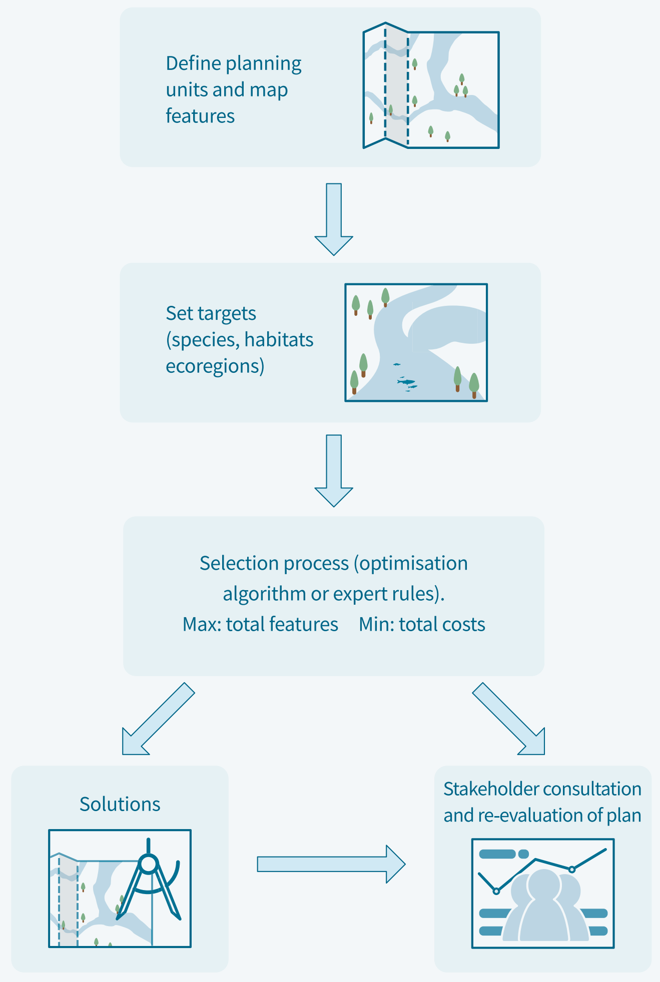
Over the past two decades, the number and coverage of protected areas in China have rapidly increased and management capabilities have been steadily improved. Innovative approaches were trialed along the Yangtze River (e.g. the establishment of the Yangtze Wetland Network) and coordinated surveys on the water birds in the central and the lower reaches of the Yangtze River have been conducted. However, the process of economic development continues to pose serious, multiple and complex threats to the health of wetlands and aquatic wildlife.

"Ecological civilization" is widely understood and recognized by the Chinese public. Meanwhile, China is active on international conventions and will host a number of important global environmental conferences in 2021, including the Convention on Biological Diversity (CBD) and the Ramsar Convention.

It is reasonable to expect that the Chinese government, at national, provincial and local levels, will continue to strive to protect the Yangtze River for the long-term. One key question is about how to allocate the resources for the best results in terms of maximizing the conservation of freshwater biodiversity. Therefore, WWF partnered with several research institutions and universities in China, as well as Griffith University in Australia, to systematically map out the optimal combination for conservation along the Yangtze River. Based on the HydroBASINS setting, the river basin was divided into 2700 sub-catchments, open access data were used for species distribution, and ecosystem services such as carbon sequestration, food production, water and soil conservation were also considered. The algorithm provided models based on the status of habitat and infrastructure in order to identify priority combinations for protection and intervention. Results from the software Marxan were evaluated and assessed by experts, so that the data input could be improved and the data processed by the algorithm could represent the reality of each sub-catchment. Eventually, a plan was developed.

Whilst the final results of this planning process are not included here as they are yet to be published, it is noteworthy that the plan clearly identified several areas for prioritized protection, including Dongting, Poyang, upper Jinsha River, etc. This plan will be published in an academic journal and the summary will be shared with relevant national and provincial governmental departments as a planning reference.

The process of Systematic Planning in the Yangtze basin



The Yangtze River is a complex ecosystem and is affected by social, economic and natural factors. The strategic guideline promoting the development of the YREB in China is to step up conservation of the Yangtze River and prevent over-development. The Chinese government is determined to restore a clean and beautiful Yangtze River, even if there are huge challenges during this process. A basin protection campaign of this scale is highly dependent on wide participation and effort from all levels of society.

The Living Yangtze Report 2020 is designed to offer practical and actionable steps to enable comprehensive management of the Yangtze River basin, and is a new offering from WWF-China based on twenty years of experience. By using the Living Yangtze Index, we are able to track the status of the River in an objective way. This Report aims to strengthen the general understanding of the Yangtze River freshwater ecosystems, and also enable the government, enterprises and society to share risks and benefits, coordinate actions and jointly participate in protection of the basin.

Lessons learned from efforts to protect the massive and complex ecosystems of the Yangtze basin can be shared globally to promote more comprehensive and integrated water basin management around the world.

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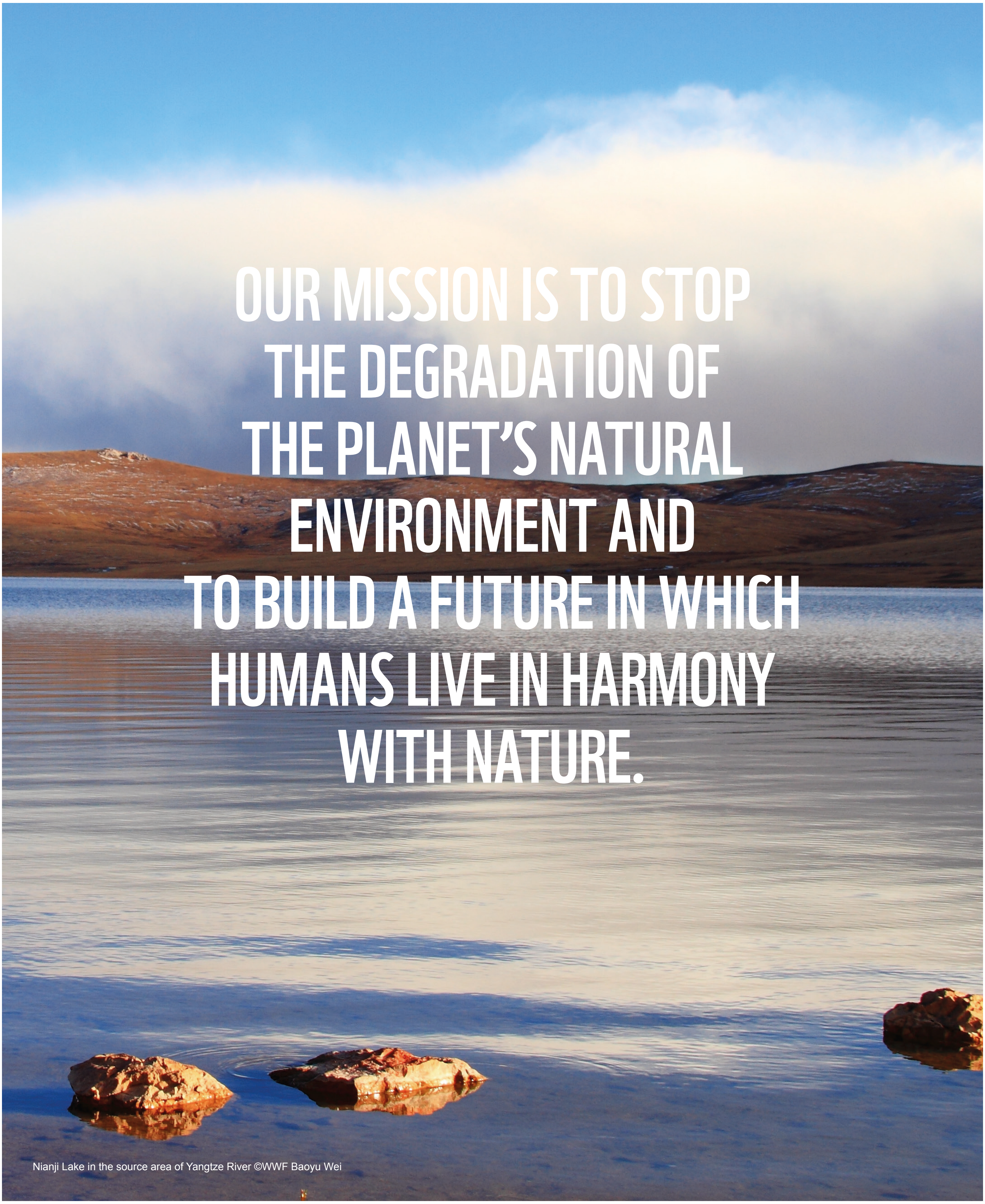

Nianji Lake in the source area of Yangtze River ©WWF Baoyu Wei

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