# Water Resources Management of Changjiang River Basin Under Changing Environment

Yan Huang

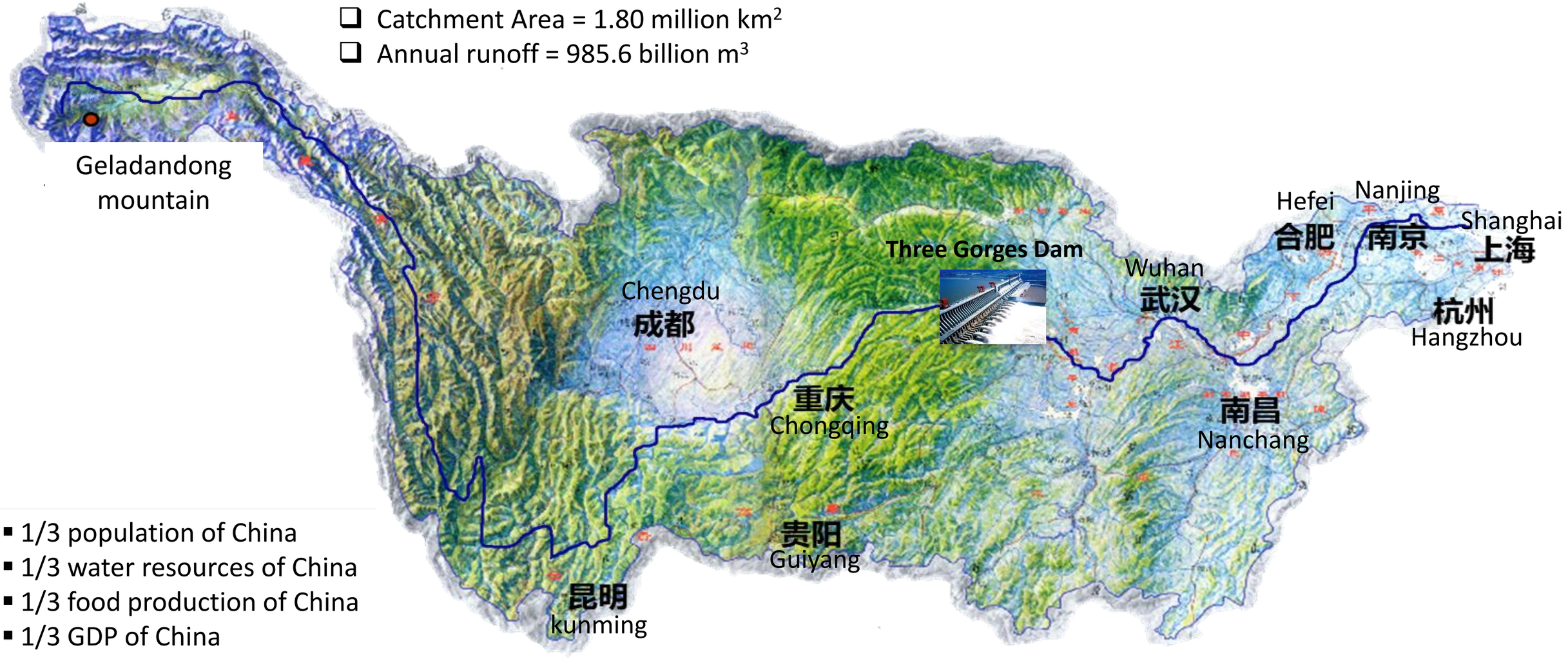
Changjiang Water Resources Commission
Ministry of Water Resources
China

# Contents

# Introduction

# Changjiang River – also known as Yangtze River

- Originates from Geladandong mountain of Qinghai-Tibet Plateau in southwest China
- River length = 6300km
- Catchment Area = 1.80 million $km^2$
- Annual runoff = 985.6 billion $m^3$

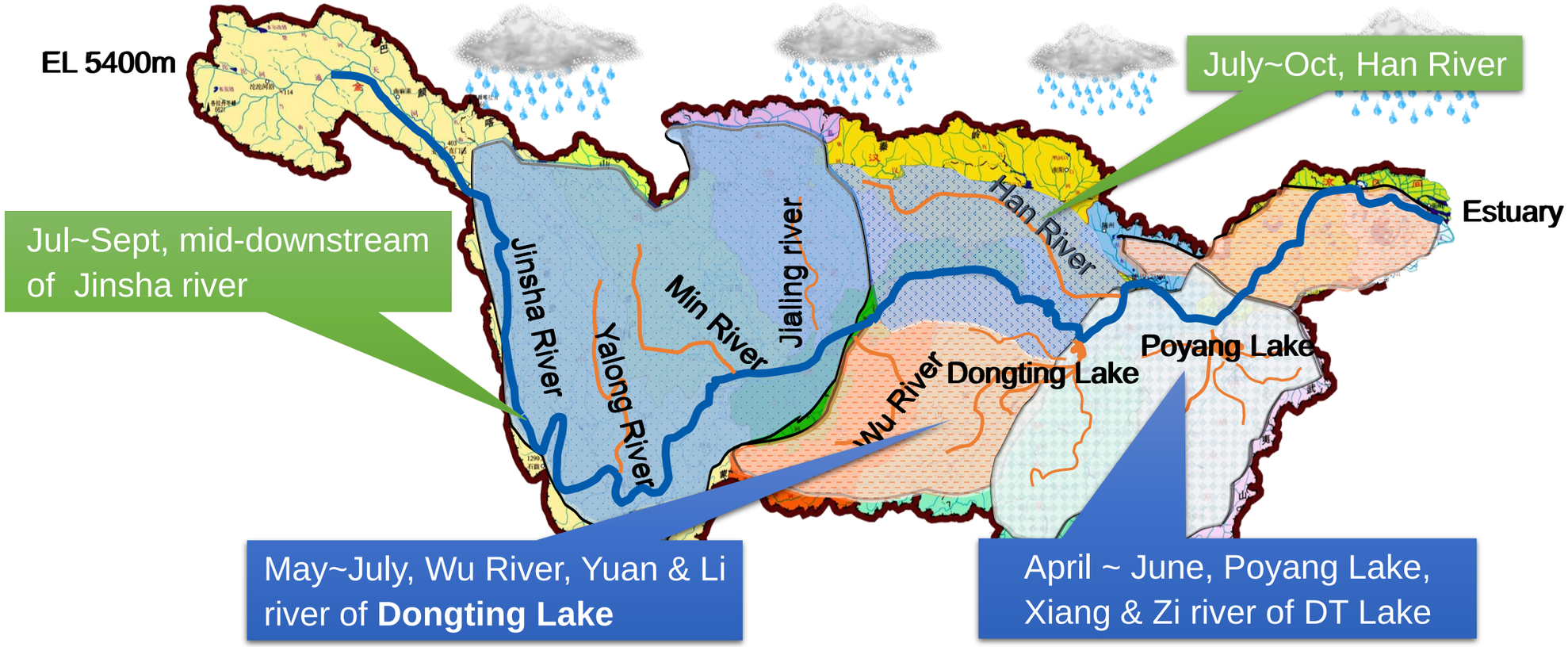



- 1/3 population of China
- 1/3 water resources of China
- 1/3 food production of China
- 1/3 GDP of China

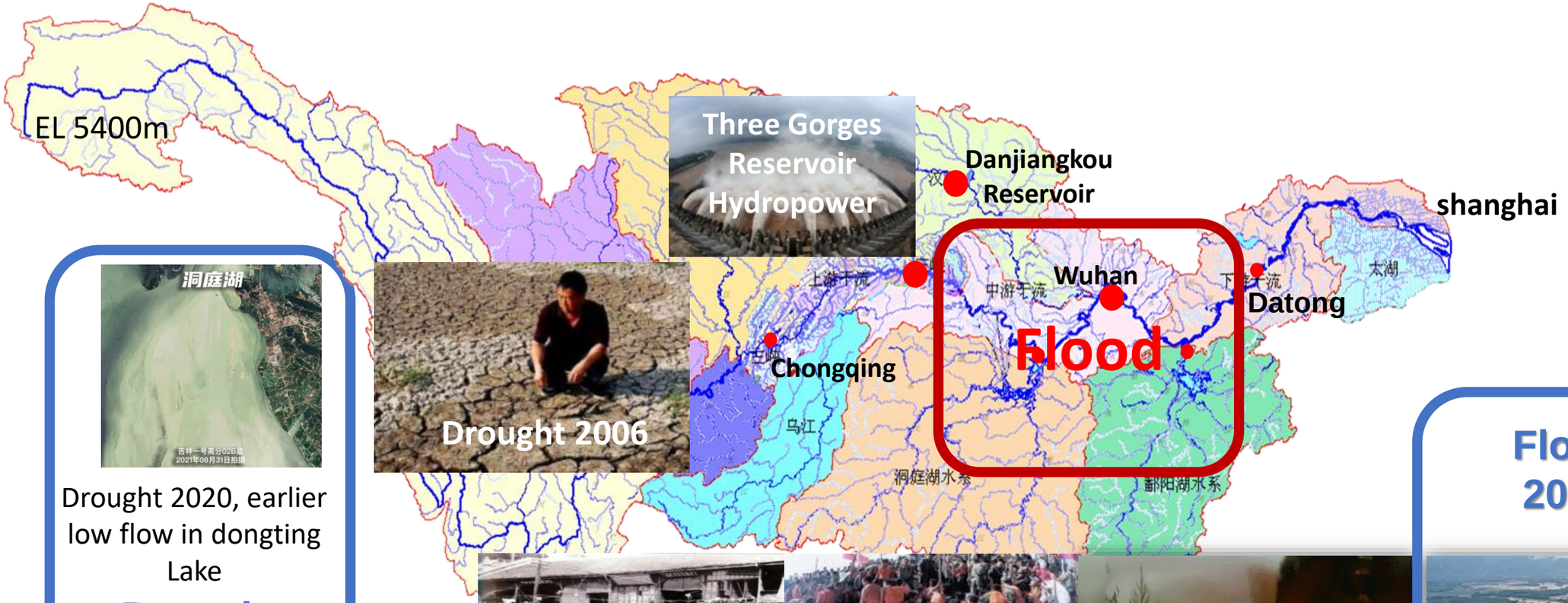
# Uneven spatial-temporal rainfall distribution

**Wet season: May–October** **Dry season: Nov-April**

Earlier rainfall in the middle-lower reaches than the upper areas, in south than north



# Suffers from frequent floods & drought







Drought 2020, earlier low flow in dongting Lake

**Drought 2022**




Flood 1935
145,000 dead

Flood 1998
$Q_{wuhan}$= 71100$m^3/s$

2016, flood in mid-downstream

**Flood 2020**

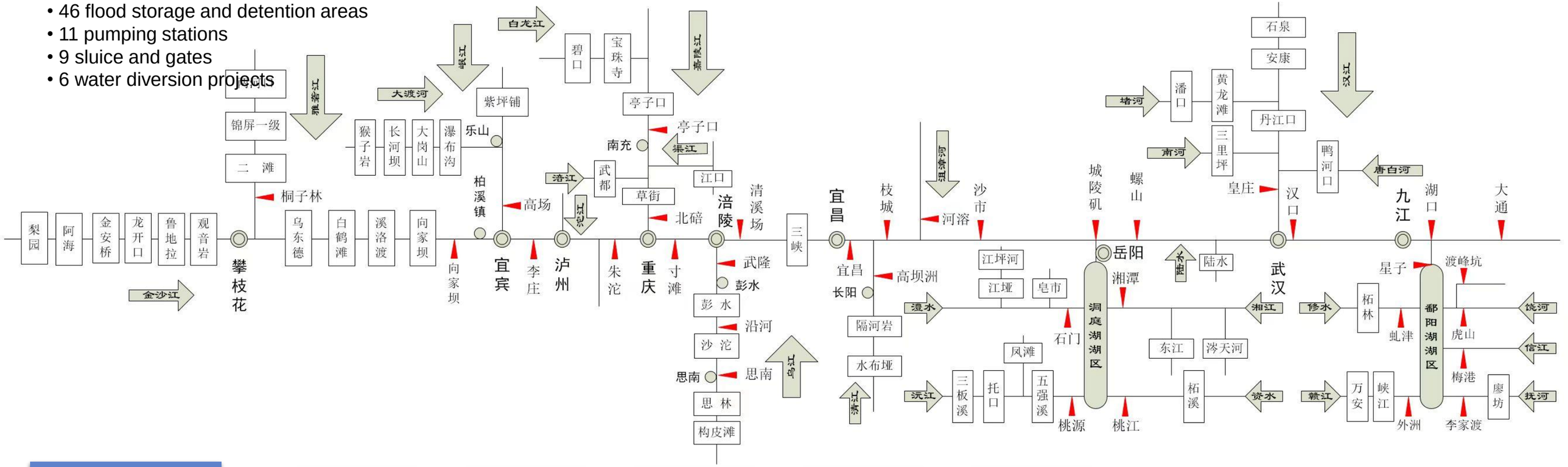
2020, basin scale large flood

# Joint regulation of engineering works is the key for river management capacity

Joint regulation scheme of engineering measures, increased projects gradually. Now there are 125 water projects involved.

**In 2023, 125 water works:**

- 53 reservoir, Regulatory storage: 116 billion m3, Flood control storage: 70.5 billion m3
- 46 flood storage and detention areas
- 11 pumping stations
- 9 sluice and gates
- 6 water diversion projects

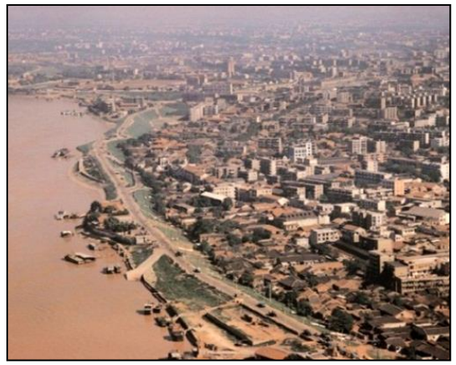



**Annual Joint regulation scheme**

| 年份 | 2012年 | 2013年 | 2014～2016年 | 2017年 | 2018年 |
|---|---|---|---|---|---|
| 水库数量 | 10 | 17 | 21 | 28 | 40 |

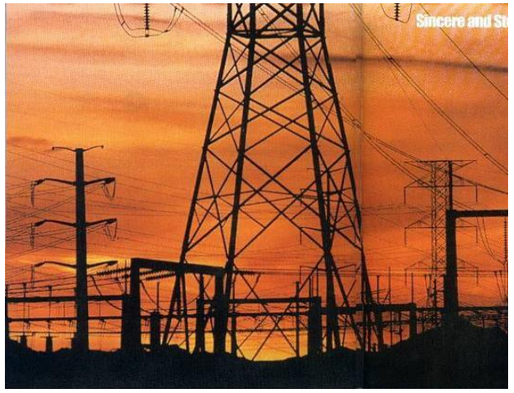
Start from 2019, not only reservoirs but also retention basins, pumping stations, water intake projects etc. were included in the scheme

# Reservoir become the most valuable engineering measure for IWRM



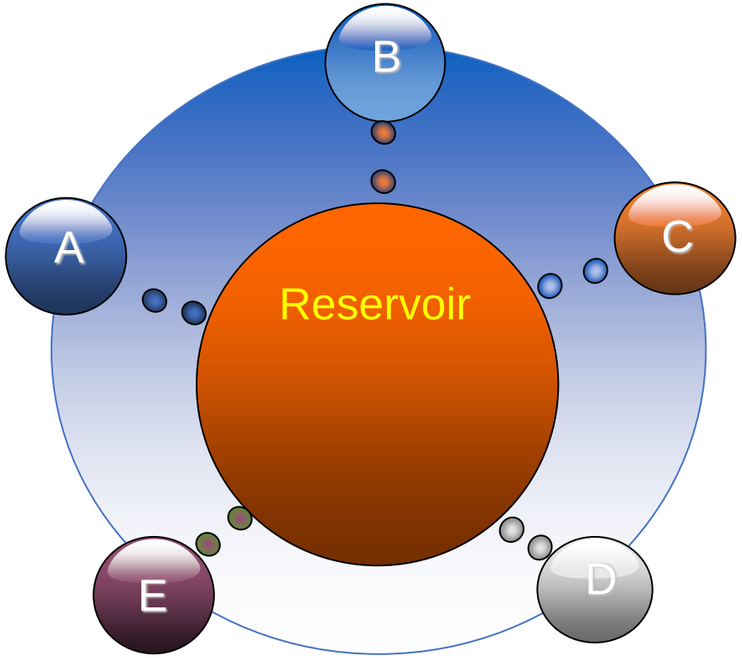
Flood management

Irrigation & water supply



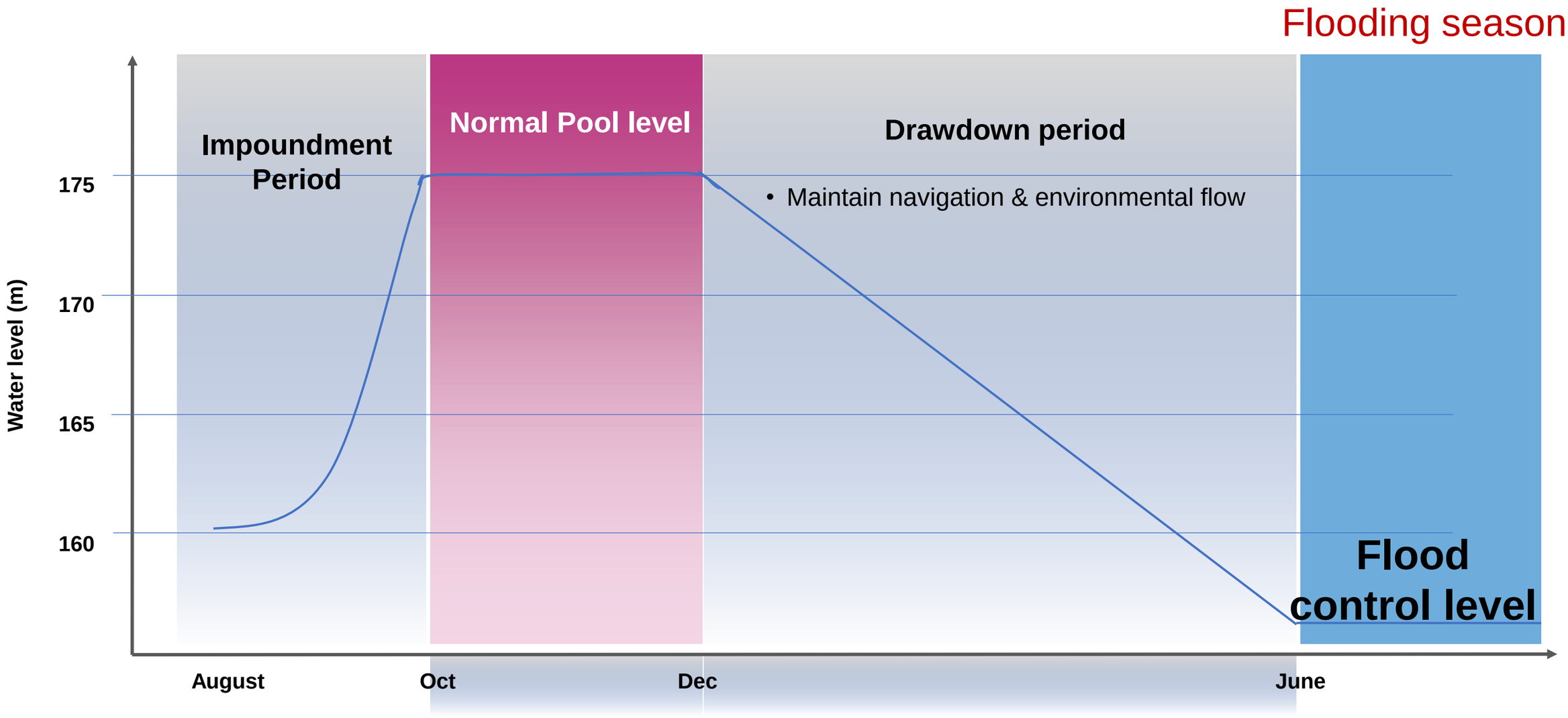
Generate hydropower

Protect ecosystem & environment




Improve navigation

# How to achieve multiple-objectives - Reservoir regulation



# Reservoir regulation is the main measure for river management


Natural reproduction of 4 major domestic carps in Shashi river reach



## Ecology restoration

- Since 2011, CWRC carried out ecological regulation of multiple reservoirs, to create artificial flood to promote fish production

## Water supply

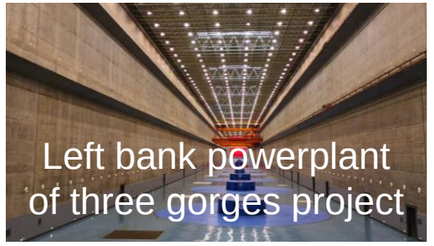
- Store water by the end of flooding season and release water to compensate downstream and reduce impacts from salt water intrusion at the estuary area
- From Danjiangkou reservoir diverse water to north Chin, for both domestic use and ecological restoration (groundwater recharge)

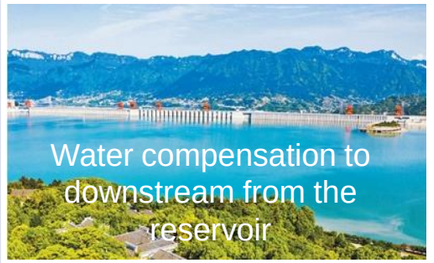
## Hydropower

- Is essential for sustainable and green development
- In 2021, the Three Gorges Reservoir created a world-record for single project power generation: produced 103.6 billion kw.h

## Shipping

- Improved significantly both water way at the downstream of the reservoir and downstream particularly in dry season.
- In 2021, the shipping throughput of the Three Gorges Hub exceeds 150 million tons (the design capacity is 100 million tons, and it was reached in 2011).

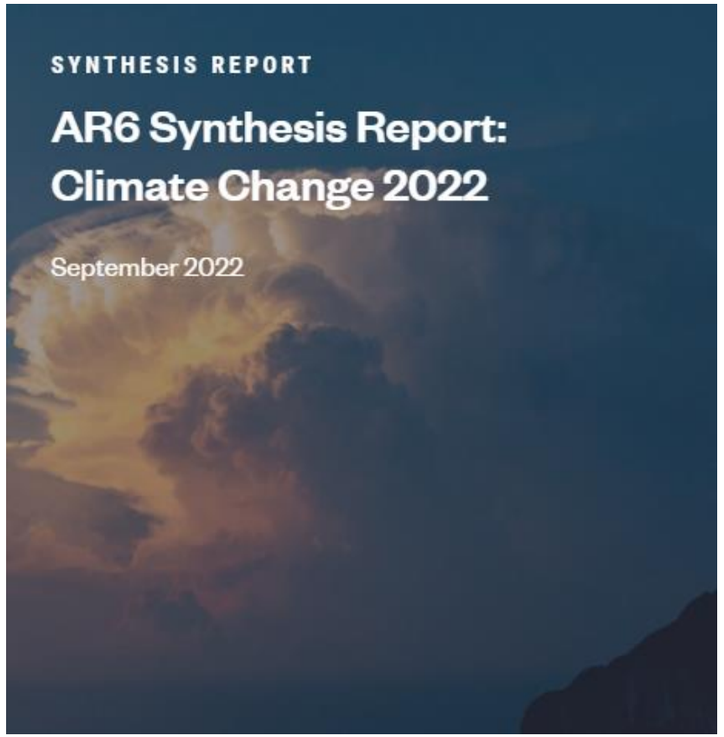




# Changes and Challenges

# Global climate will likely enter a period of significant changes in the future

- **6th IPCC report**: the warming range of **land** will continue to be **higher** than that of the sea, and the warming range of the **Arctic** will be significantly higher than the **global average**. The warming rate of the lower troposphere in the Arctic is likely to exceed the global average.

- Other researches also agree that the global climate **will enter a period of significant change** in the future, record-breaking **extreme events will occur frequently**.

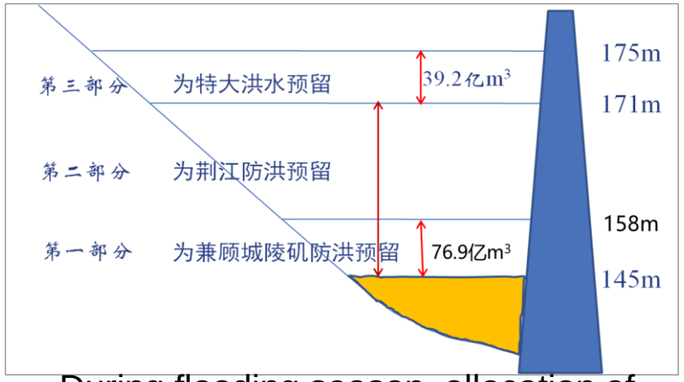


# Increased Urbanization impact

Due to **urbanization impact**, in the middle-downstream the duration of high water level is getting longer.


- Decreased floodway capacity.
- Increased draining capacity of cities resulted in higher water level.
- Flood transportation after reservoir operation is different from that of nature river.

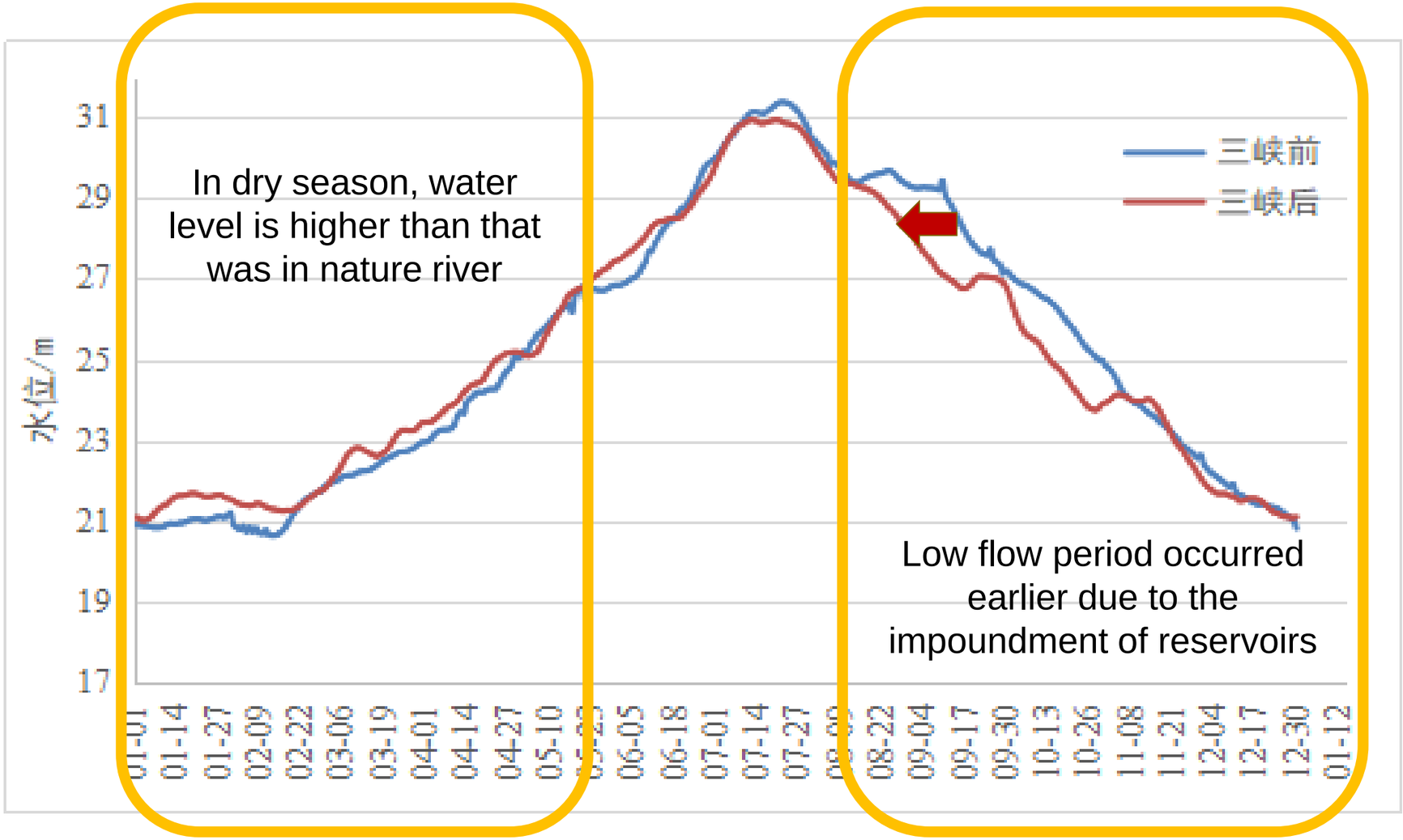
# Operation of large-scale water project caused profound impact




During flooding season, allocation of flood control storage for different protecting targets


Operation of reservoirs upstream of three gorges reservoir

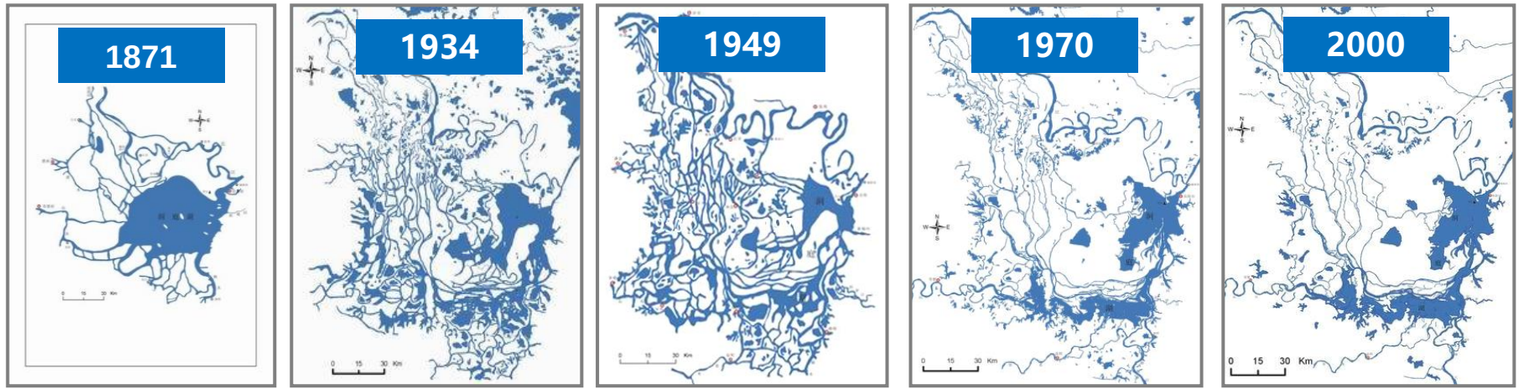
Water level at Chenglingji station – a gauge station at middle-downstream

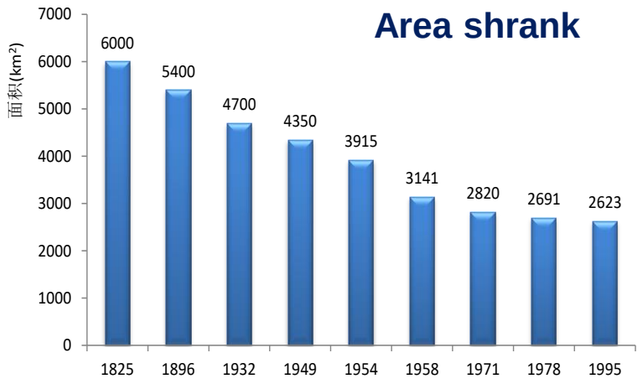


# Human activities have a profound impact on the hydrological regime

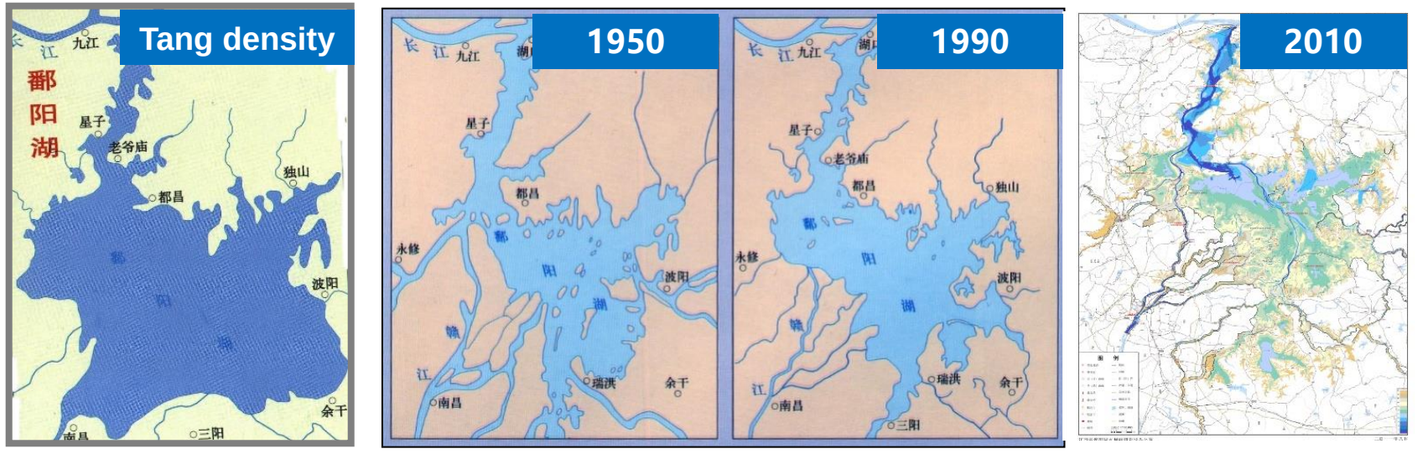
- The exchange of **water and sand** between the Changjiang River, Dongting Lake, and Poyang Lake. Due to the joint impacts of natural factors and human activities, the relationship between the rivers and lakes continues to change.
- Historically, natural factors such as tectonic subsidence and sediment deposition were the dominant factors, but the influence of human activities (such as reservoir operation at the upper Changjiang River) has gradually become dominating in recent years.

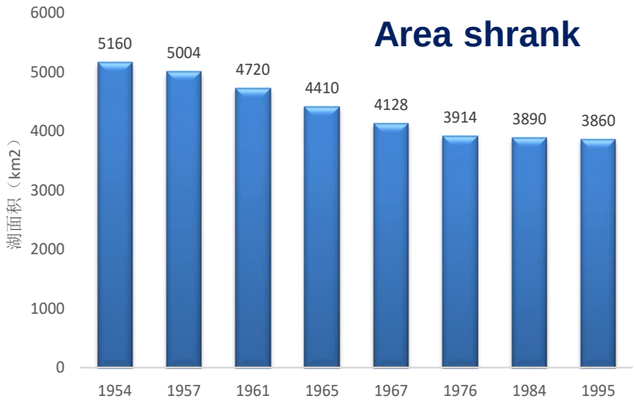
Dongting Lake



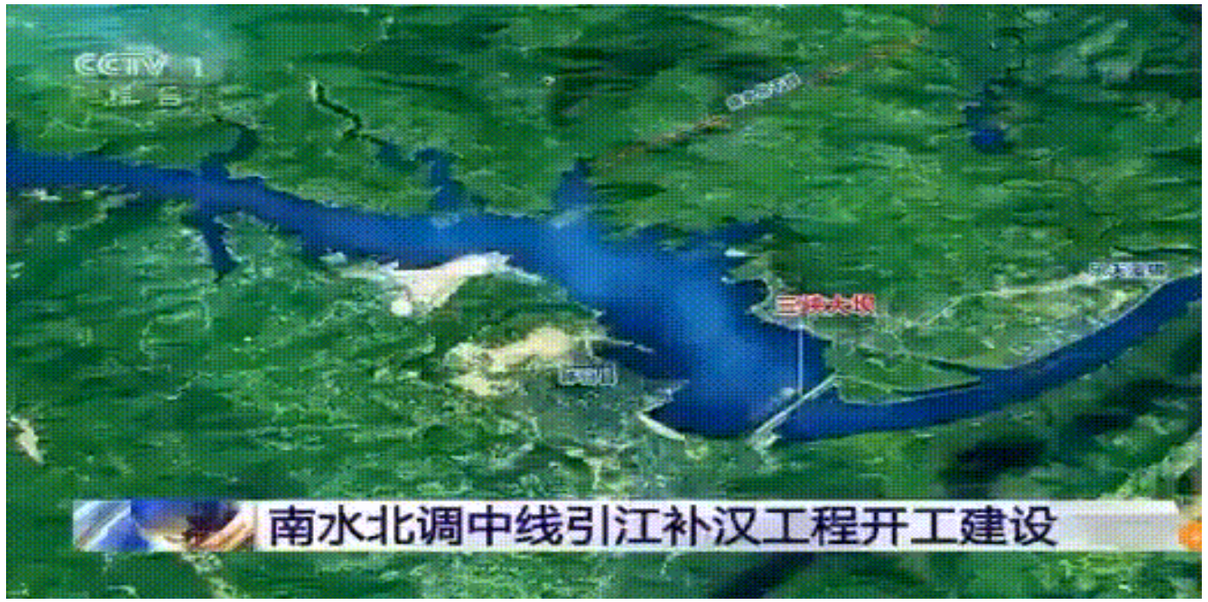

Poyang Lake

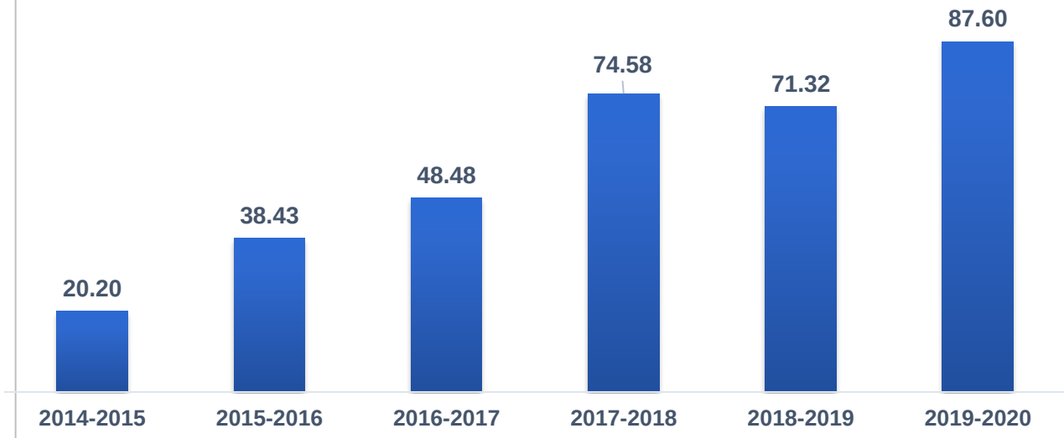


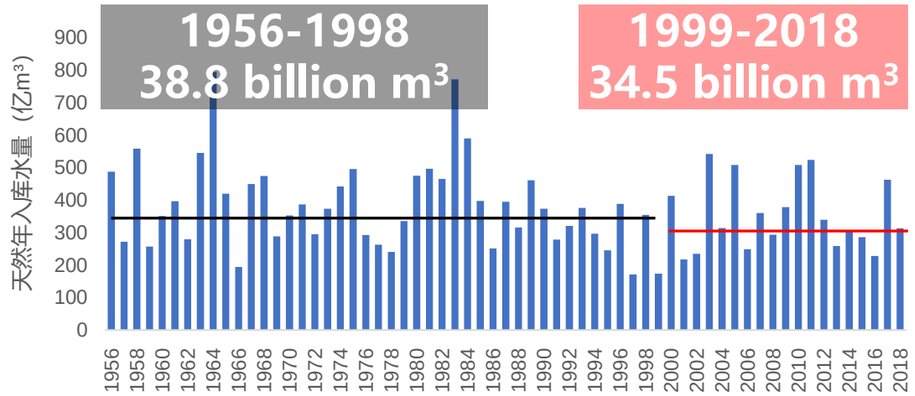
# Increasing demand to the water network development – e.g. middle route

- Runoff decreased and dry years happened more often in Han River. **Too much dependability to this project might not be wise**.
- The currently under-construction follow-up Project - the water diversion project from the Three Gorges Reservoir to the lower reaches of the Danjiangkou Reservoir, will increase the water diversion volume from **9.5 billion $m^3$ to 11.7 billion $m^3$.**




Water transferred from Danjiangkou reservoir to North China (100 million $m^3$)

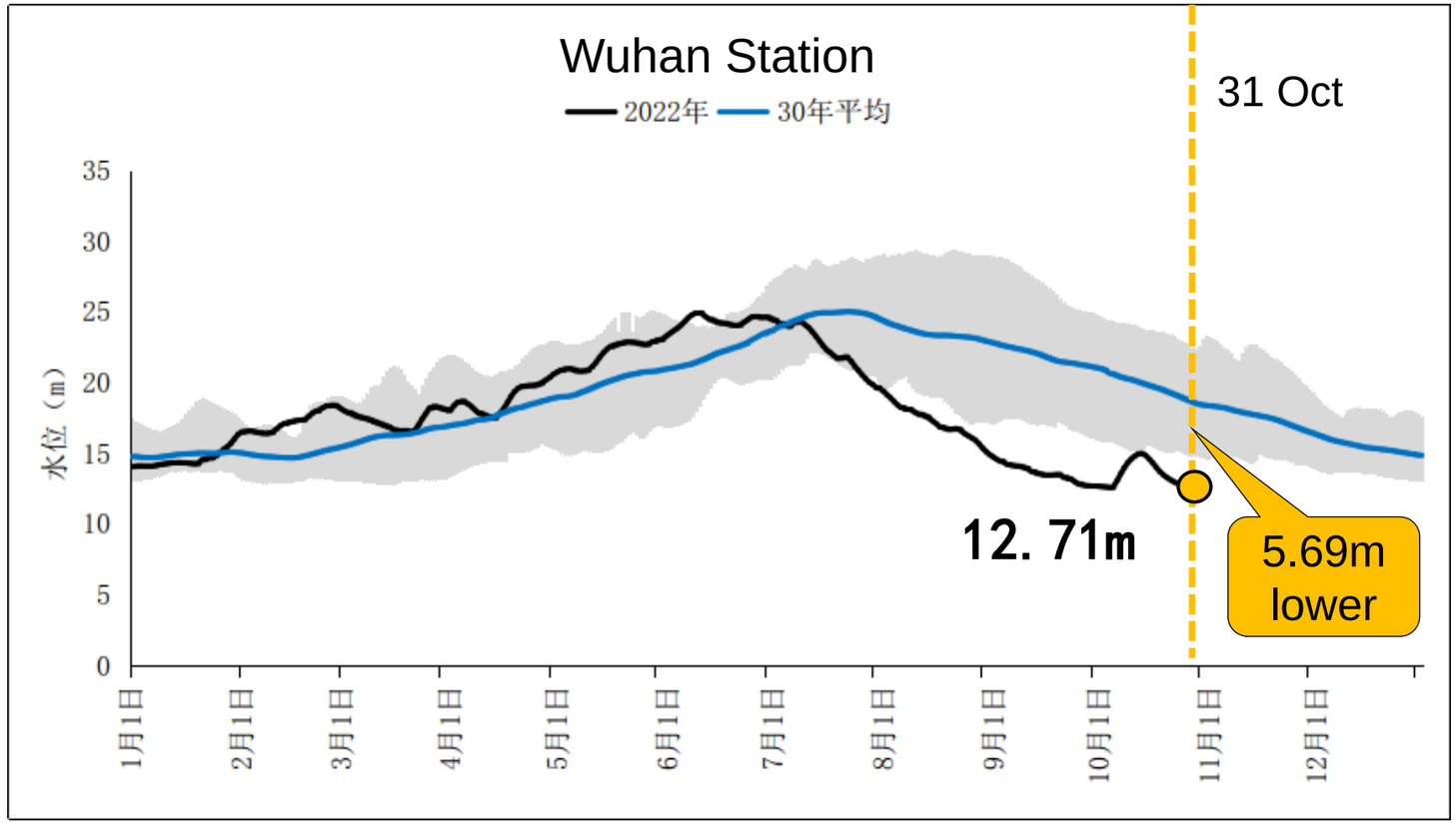


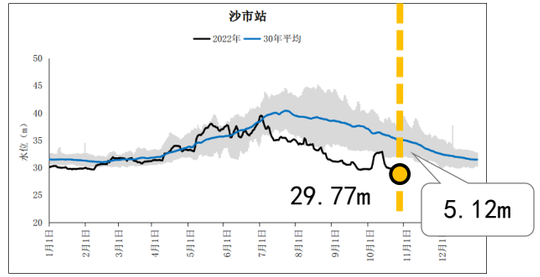

Declined reservoir inflow

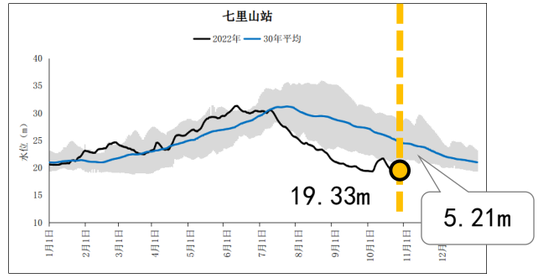
# New situation – basin-scale drought in 2022

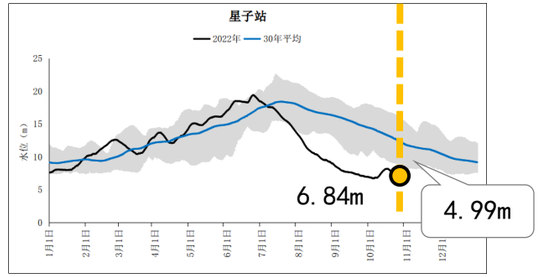
- Aug ~ Oct, 2022, the main stations in the middle and lower reaches of the Yangtze River recorded the lowest water levels in the same period in history since the measured records.
- Dongting Lake and Poyang Lake entered the dry season ahead of schedule on August 4 and 6, and the links between the river channel and Dongting Lake were cut off by an average of 3 months earlier than in the past 5 years.

Dry Poyang Lake



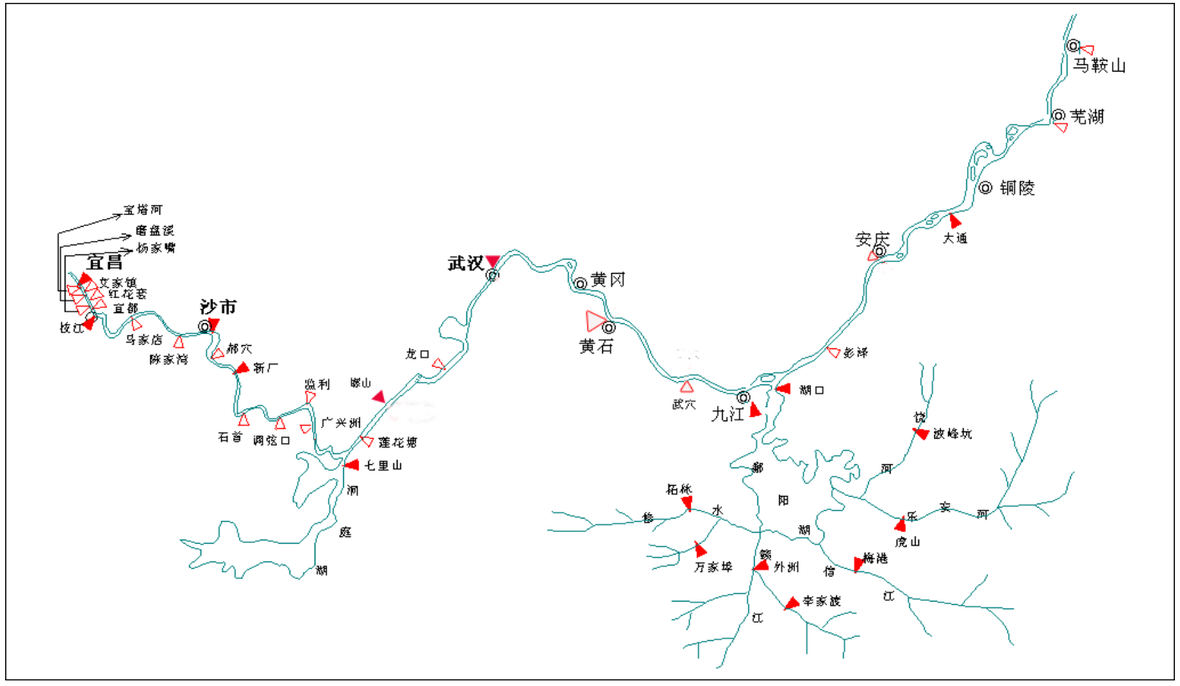



# Water resource allocation capacity downstream becomes insufficient

- The operation of large group of reservoirs upstream has caused **significant reduction of sedimentation** to the downstream areas, the middle and lower reaches of the river have been scoured along the way, and the water level has been reduced.
- The low water level caused serious impact on the **water supply** at the middle-downstream of the main stream (engineering water shortage).




Gauge stations at middle-downstream of Changjiang River

Water level Changes at downstream stations

| Stations | Discharge ($m^3/s$) | The cumulative decrease in water level in 2016 compared to 2003 (m) |
|---|---|---|
| Yichang | 6000 | **0.74** |
| Zhicheng | 7000 | **0.59** |
| Shashi | 6000 | **1.74** |
| Luoshan | 10000 | **0.91** |
| Hankou | 10000 | **1.10** |

# Problems with water intake & water use management

## Water resources demonstration

- Mechanism of carrying out **water resources demonstration** for planning project needs to be established.

## Water right trading

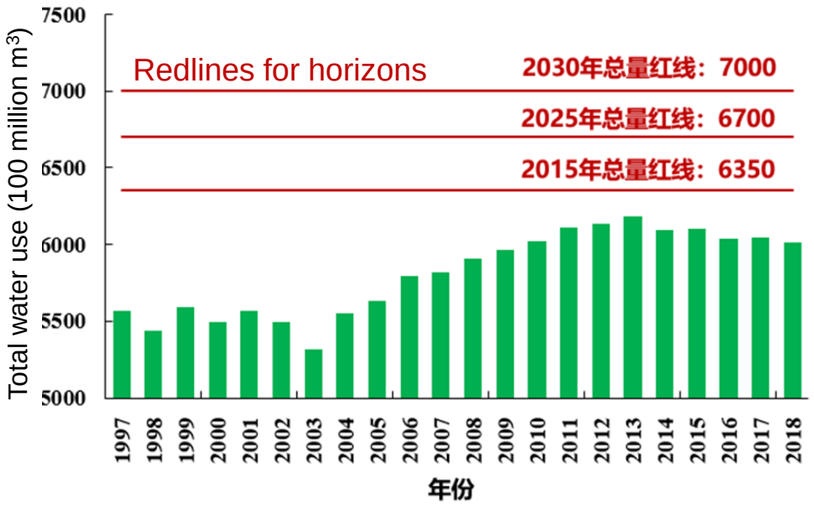
- lack of endogenous motivation for water rights trading.


## Online monitoring of water intake

- Water intake monitoring is not fully covered.

# It is difficult to apply water saving in Changjiang River

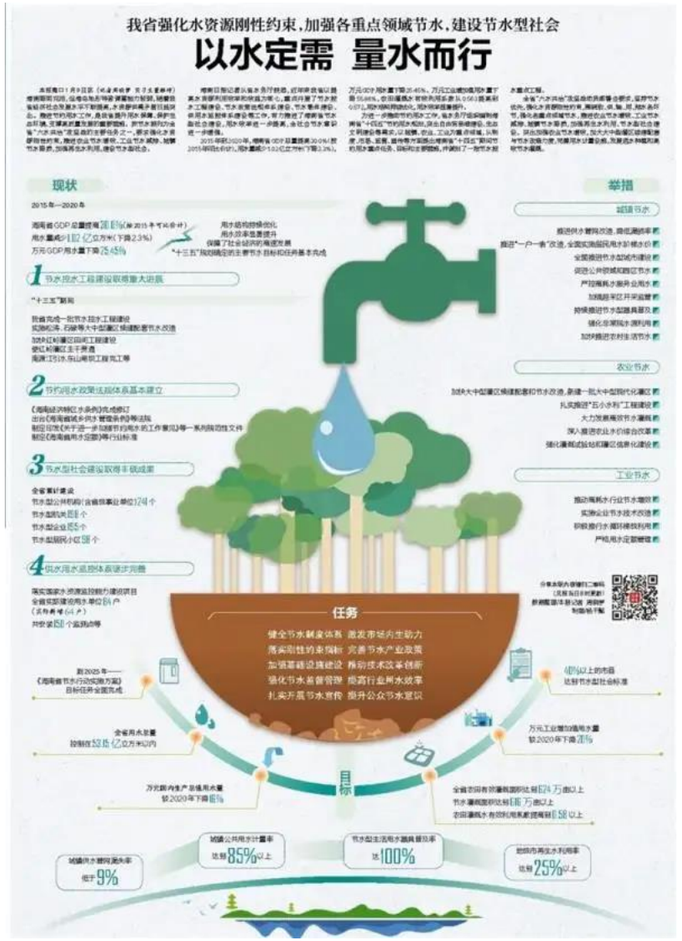
- Implement the **4 principles** in development planning and project construction: city development, population growth, land use plan, industrial and agriculture production, shall be determined **according to water availability**.
- Need to continuously promote saving water and reducing emissions, using **renewable water**, and improving water resource carrying capacity, increasing water use efficiency…




Water demand and utilization

Indicators of 3 red lines for Changjiang river

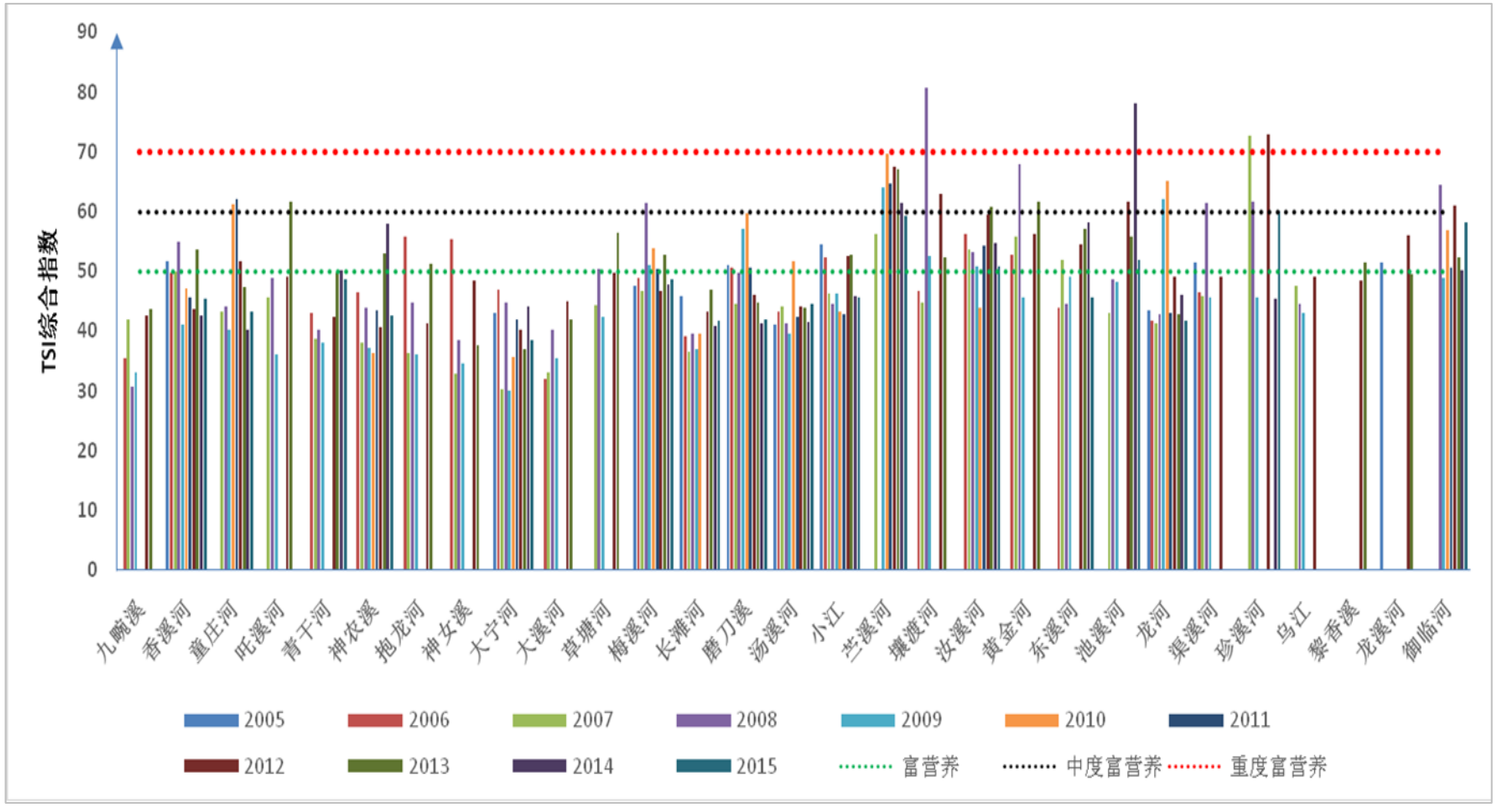
| Year | Water use (mill $m^3$) | Water consumption per unit industrial added value ($m^3$/RMB 10,000 Yuan) | Irrigation coefficient | Water quality compliance rate of important water function area |
|---|---|---|---|---|
| 2017 | 1760 | 69 | 0.5 | 93% |
| 2020 | 1921 | 50 | 0.53 | 90% |
| **2030** | **1970** | **40** | **0.6** | **95%** |




Rigid constraint mechanism of WRM

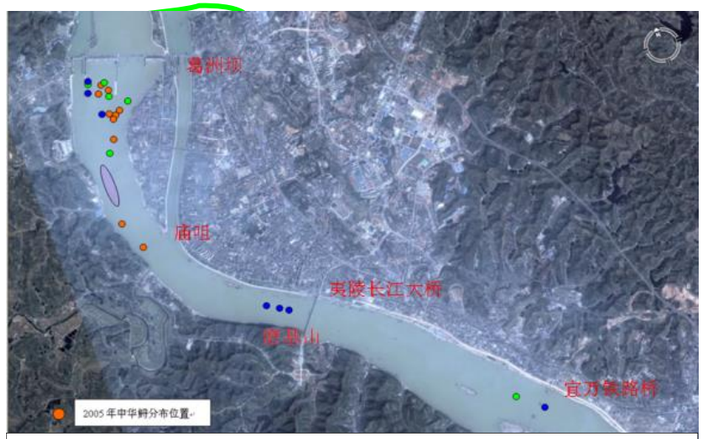
# Eutrophication causes frequent algal blooms in some rivers/lakes

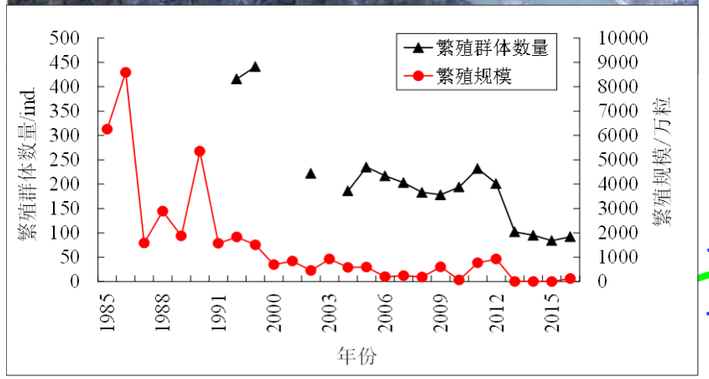
- The eutrophication level of 29 tributaries in the **Three Gorges Reservoir** area in the past 10 years shows that: 8 tributaries are eutrophic, and 21 tributaries are mesotrophic.
- Recent observation shows that risk of algal bloom is increasing in **Han River** – downstream of water diversion reservoir.

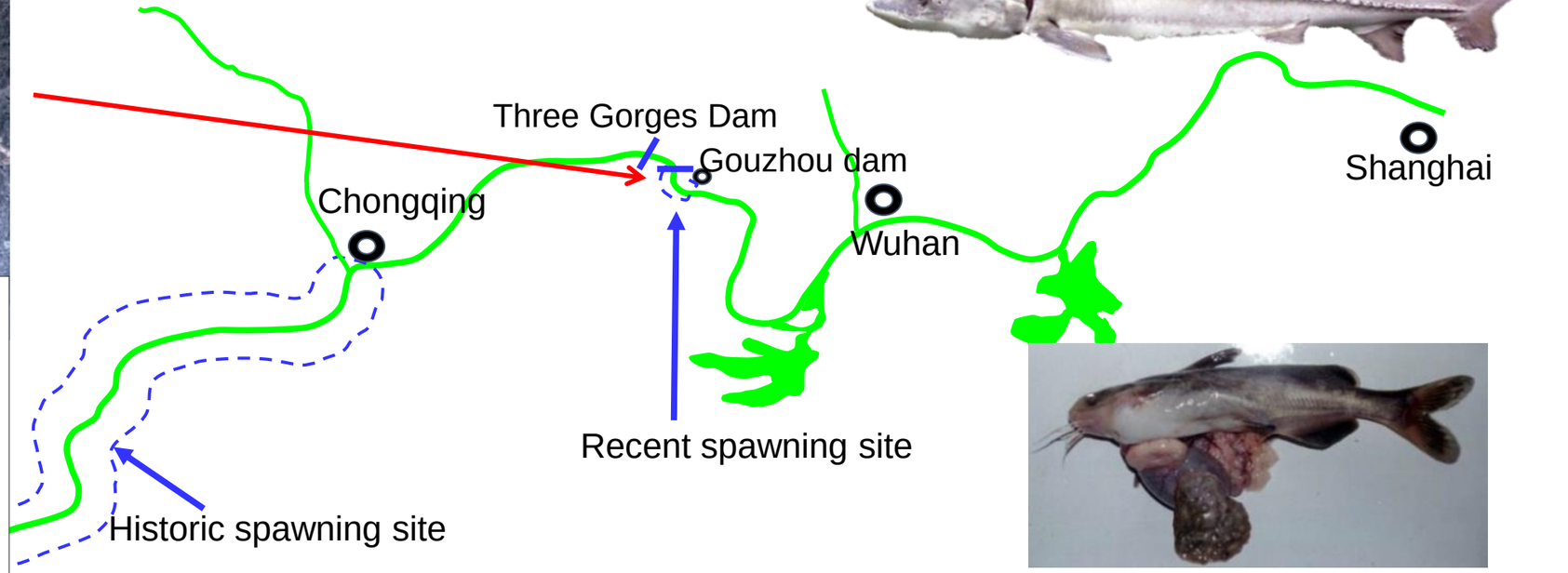


# Biodiversity and resources decline

- The **Chinese sturgeon – a migratory fish**, no natural breeding activities have been found **since 2017**.





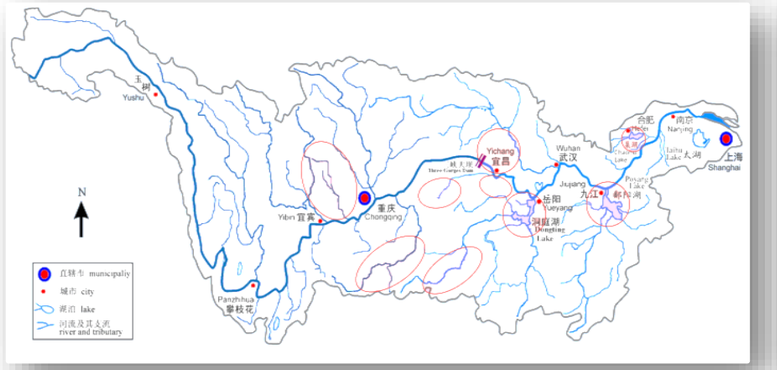

Egg predator

# Difficulties in meeting the minimum flow requirement

- ❑ During dry year it is difficult for some sections to meet demands
- ❑ Management issues – not fully understand the importance
- ❑ Lack of monitoring capacity

# Difficulties in environment protection and eco-system restoration

- ❑ The guarantee system of **environment flow** → to be established
- ❑ Lack of **monitoring system** of eco-system
- ❑ The **means** of ecological protection and restoration are relatively **limited** (artificial proliferation and release)
- ❑ The scope of ecological **regulation** → to be further improved




Distribution of rivers and lakes with excess total phosphorus


There are more than 400,000 chemical companies along the river

# Demands to navigability increased dramatically

The navigation reaches its design capability at three gorges ship lock 20 years earlier than the plan

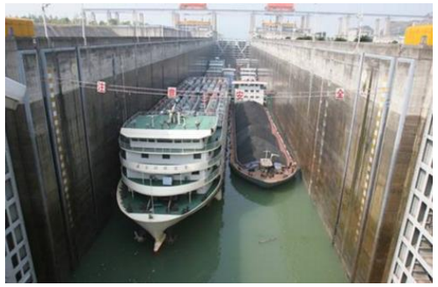
2003
- 34.3 million t

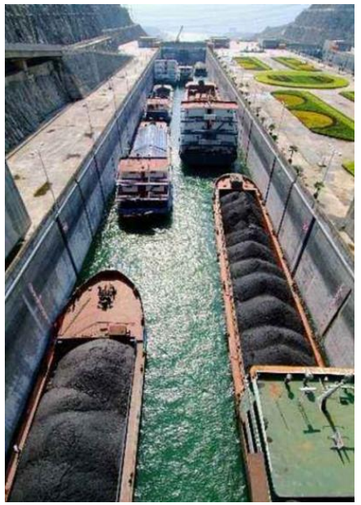
2011
- Exceeded 100 million t

2016
- 4 times Exceeded 100 million *t*

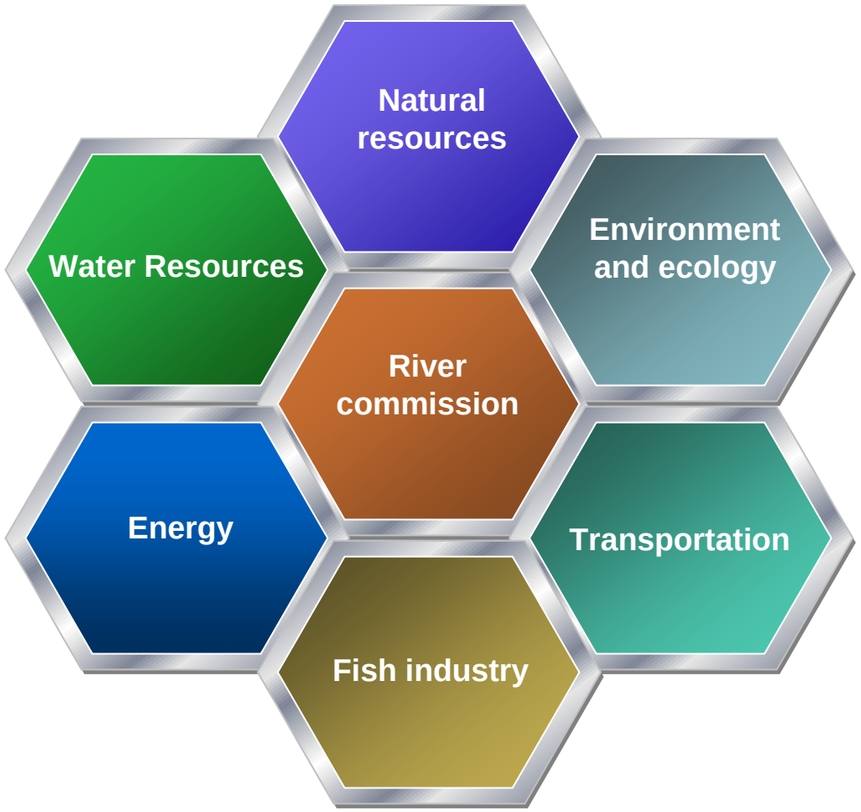
Now
- 150 million t Insufficient navigation

**Need to improve navigation capability**





# Management capacity need to be improved




Multi-player coordination mechanism need to be established


Decision support system need to be improved

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# Water Resources Management in Changjiang River

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# Planning & Practices

# Three stages governance and protection


荆江分洪闸

**Start (1949-1977)**

- Built > 40,000 large, medium and small reservoirs, including Danjiangkou, Yahekou and Bailianhe.
- Constructed flood storage and reclamation projects such as the embankment blockage of the Yangtze River and the flood diversion project of the Jingjiang River, cut straight at the lower Jingjiang River reach.
- **Lay a good foundation for the River water conservancy construction.**


三峡

**Reform & improve (1978-2011)**

- Built a number of backbone projects that have a major impact on economic and social development, such as the Ertan, Gezhouba, and the Three Gorges.
- Constructed the embankment of the middle and lower reaches **up to the standard**, the improvement of the main stream of the middle and lower reaches, flood storage and detention areas, the treatment of Dongting Lake and Poyang Lake, the embankment of important tributaries, the flat embankments for returning floods to fields and lakes, etc.
- Flood control capability has been significantly improved.


南水北调工程

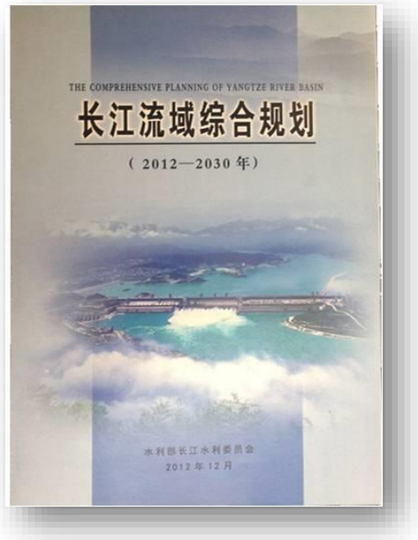
**High quality development and protection (2011~)**

- The planning system has been continuously improved.
- A large number of regional water diversion projects have been implemented successively, such as the first phase of the east-middle route of the South-to-North Water Diversion Project, diversion from Han to Wei river, and water diversion from Jinsha river to central Yunnan province.
- Key projects such as Xiluodu and Xiangjiaba were put into operation.
- The flood control and drought relief command system and the hydrological monitoring station network system have been improved.
- The protection of water resources and water ecology has been continuously strengthened.

# Master planning of Changjiang river basin – upgraded regularly



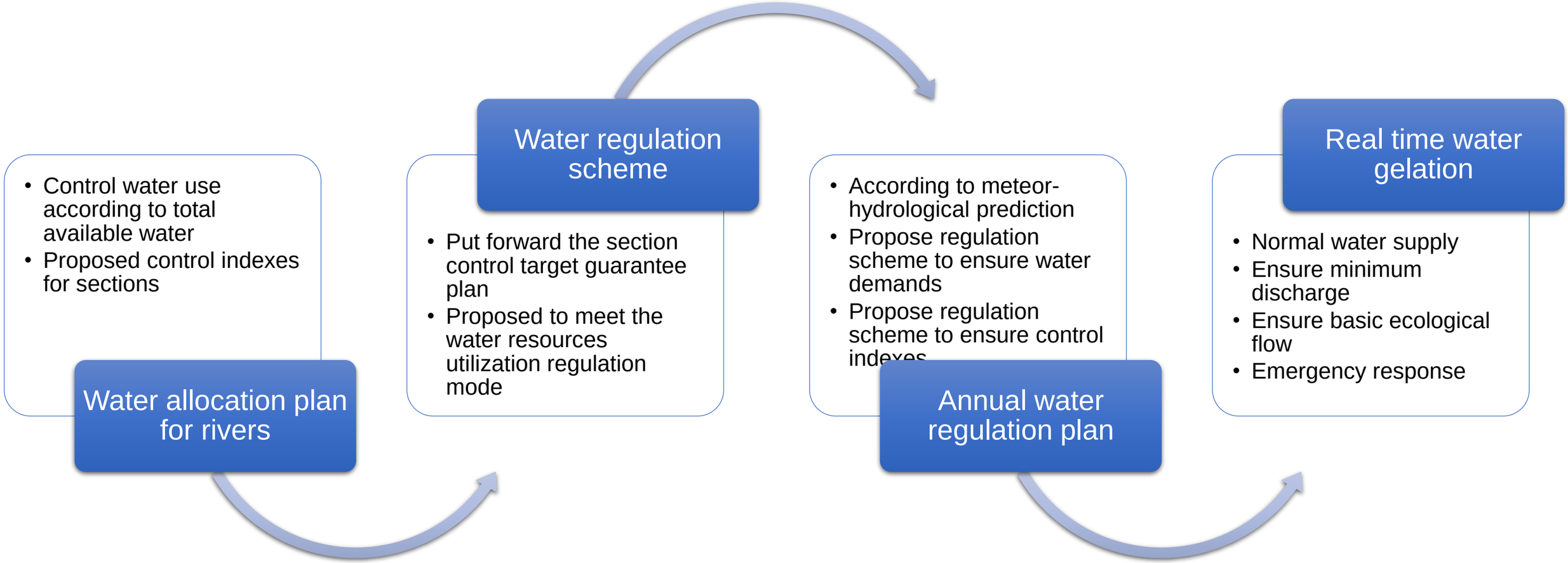
- Approved by the state council
- Guiding document for basin development & protection
- Update regularly:
  - ❑ 1st edit - 1956
  - ❑ 2nd edit - 1990
  - ❑ **3rd edit – 2012**
  - ❑ 4th edit – 2022, **flood & Drought** management




## Planning of Changjiang River Basin

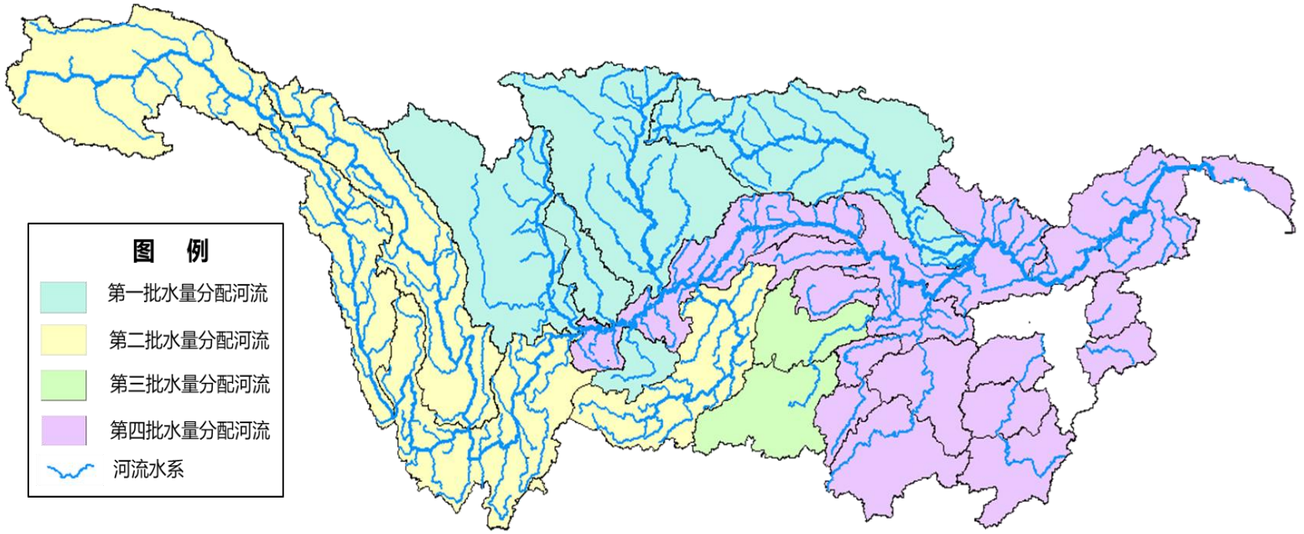
- **Flood management & hazard mitigation**
  - Flood Control
  - Waterlogging control
  - River regulation
- **Integrated Water Resources utilization**
  - Water resources assessment and allocation
  - Water supply
  - Irrigation
  - Hydropower
  - Inter-basin water diversion
  - Navigation
- **Protection of water, environment and ecology**
  - Water resources protection
  - Environment & ecology protection
  - Water & Soil conservation
- **Integrated basin management**
  - Planning management
  - Flood control & drought relief
  - Water resources management
  - Water resources protection
  - Water & soil conservative
  - River channel management
  - Project construction and operation management
  - Supervision and management of gauge cross section
  - Integrated operation of key engineering measures
  - Emergency response

# Implement WRM based on the water allocation plan



# Compilation and approval of water allocation plans for cross-provincial rivers

- Since 2011, CWRC completed water allocation plans for 23 rivers, among which 21 were approved, 2 on the mainstream remain in reviewing process.

# Implementation of water allocation plan - 2022

- **50 sections** are included in the assessment in the **most rigid water resources management system**, involving
  - **7 river basins**: Han River, Jialing River, Wu River, Niulan River, Min River, Tuo River, Chishui River
  - **8 provinces (**municipalities): Sichuan, Chongqing, Yunnan, Hubei, Guizhou, Gansu, Shaanxi, Henan.
- **Evaluation**
  - **index**: the **minimum flow** and the **daily average** flow of the section shall be not less than 90%.
  - **Results -** the satisfaction degree: **47 sections** >90%, 3 sections < 90%.

| 序号 | 流域 | 断面名称 | 最小下泄流量考核目标（$m^3/s$） | 考核省份 |
|---|---|---|---|---|
| 1 | 汉 江 | 汉 中 | 9.48（枯水期，11-5月）22.4（丰水期，6-10月） | 陕西省 |
| 2 | | 安 康 | 80 | 陕西省 |
| 3 | | 白 河 | 120 | 陕西省 |
| 4 | | 黄家港 | 490（日均） | 湖北省 |
| 5 | | 皇 庄 | 500 | 湖北省 |
| 6 | | 仙 桃 | 500 | 湖北省 |
| 7 | | 大竹河 | 5.89 | 重庆市 |
| 8 | | 鄂 坪 | 3.46 | 湖北省、陕西省 |
| 9 | | 黄龙滩 | 17.70 | 湖北省 |
| 10 | | 荆紫关 | 5.10 | 陕西省 |
| 11 | | 鸭河口 | 2.66 | 河南省 |
| 12 | | 新店铺 | 6.92 | 河南省 |
| 13 | | 郭 滩 | 5.85 | 河南省 |
| 14 | 嘉陵江 | 茨 坝 | 1.86 | 陕西省 |
| 15 | | 白水江(谈家庄) | 4.15 | 甘肃省 |
| 16 | | 亭子口 | 124 | 四川省 |
| 17 | | 武 胜 | 188 | 四川省 |
| 18 | | 北 碚 | 327 | 重庆市 |
| 19 | | 成 县 | 1.08 | 甘肃省 |
| 20 | | 谭家坝（镡家坝） | 6.26 | 甘肃省 |
| | | 白 云 | 6.15 | 甘肃省 |
| 21 | | 白水街（碧口） | 83.9 | 甘肃省 |
| 22 | | | | |
| 23 | | 三磊坝 | 85.1 | 四川省 |
| 24 | | 文 县 | 7.24 | 甘肃省 |
| 25 | | 罗渡溪 | 61.9 | 四川省 |
| 26 | | 潼南（小河坝） | 85.5 | 四川省 |
| 27 | 岷 江 | 紫坪铺 | 129 | 四川省 |
| 28 | | 高 场 | 635 | 四川省 |
| 29 | | 大 金 | 52 | 四川省 |
| 30 | | 峨 边 | 366 | 四川省 |
| 31 | | 福禄镇（沙湾） | 400 | 四川省 |
| 32 | | 绰斯甲 | 39.2 | 四川省 |
| 33 | | 夹 江 | 103 | 四川省 |
| 34 | 沱 江 | 富 顺 | 35.2 | 四川省 |
| 35 | 赤水河 | 赤水河 | 11 | 云南省 |
| 36 | | 茅 台 | 23 | 贵州省 |
| 37 | | 赤 水 | 59（有通航要求时为83） | 贵州省 |
| 38 | 乌 江 | 乌江渡 | 112 | 贵州省 |
| 39 | | 构皮滩 | 190（日均） | 贵州省 |
| 40 | | 思南（思林水库） | 195 | 贵州省 |
| 41 | | 沿河（沙沱水库） | 228 | 贵州省 |
| 42 | | 彭 水 | 280 | 重庆市 |
| 43 | | 武 隆 | 345 | 重庆市 |
| 44 | | 鸭池河 | 40 | 贵州省 |
| 45 | | 洪家渡 | 14.4 | 贵州省 |
| 46 | | 贵 阳 | 1.23 | 贵州省 |
| 47 | | 大河边 | 3.09 | 湖北省 |
| 48 | | 浩 口 | 21.5 | 重庆市、贵州省 |
| 49 | 牛栏江 | 黄梨树 | 16 | 云南省 |

# Middle route of south to north water diversion project

Approval of water regulation plan for next year – end of Oct each year

Prepare the pre-flood water level drawdown plan of Danjiangkou Reservoir when needed

Refined monthly (10 days) water supply regulation plan for the reservoir and adjust water supply for each user

Provide extra water for groundwater recharge in North China


水利部长江水利委

长水资管〔2022〕12号

长江水利委员会关于报送丹江口
汛前水位消落计划的

水利部：

根据《水利部关于印发南水北调中线一
水量调度计划的通知》（水南调函〔2021〕1
计划》）、《水利部南水北调司关于进一步加
程水量调度监督管理工作的通知》（南调运
委组织开展了南水北调中线一期工程2021-
作，截至1月6日8时，丹江口水库水位1
限制水位160m偏高7.38m，待消落库容65.
划》实施供水，丹江口水库6月20日水位
高于夏汛期汛限水位160m，存在较大弃水风

水利部长江水利委员会文件

长水资管〔2022〕242号

长江水利委员会关于丹江口水库2022年5月下旬供水计划的批复

汉江水利水电（集团）有限责任公司、南水北调中线水源有限责任公司、中国南水北调集团中线有限公司：

中华人民共和国水利部办公厅

办资管函〔2021〕170号

水利部办公厅关于印发2021年度华北地区地下水超采综合治理河湖生态补水方案的通知

部机关有关司局，部直属有关单位，北京市、天津市、河北省水利（水务）厅（局）：

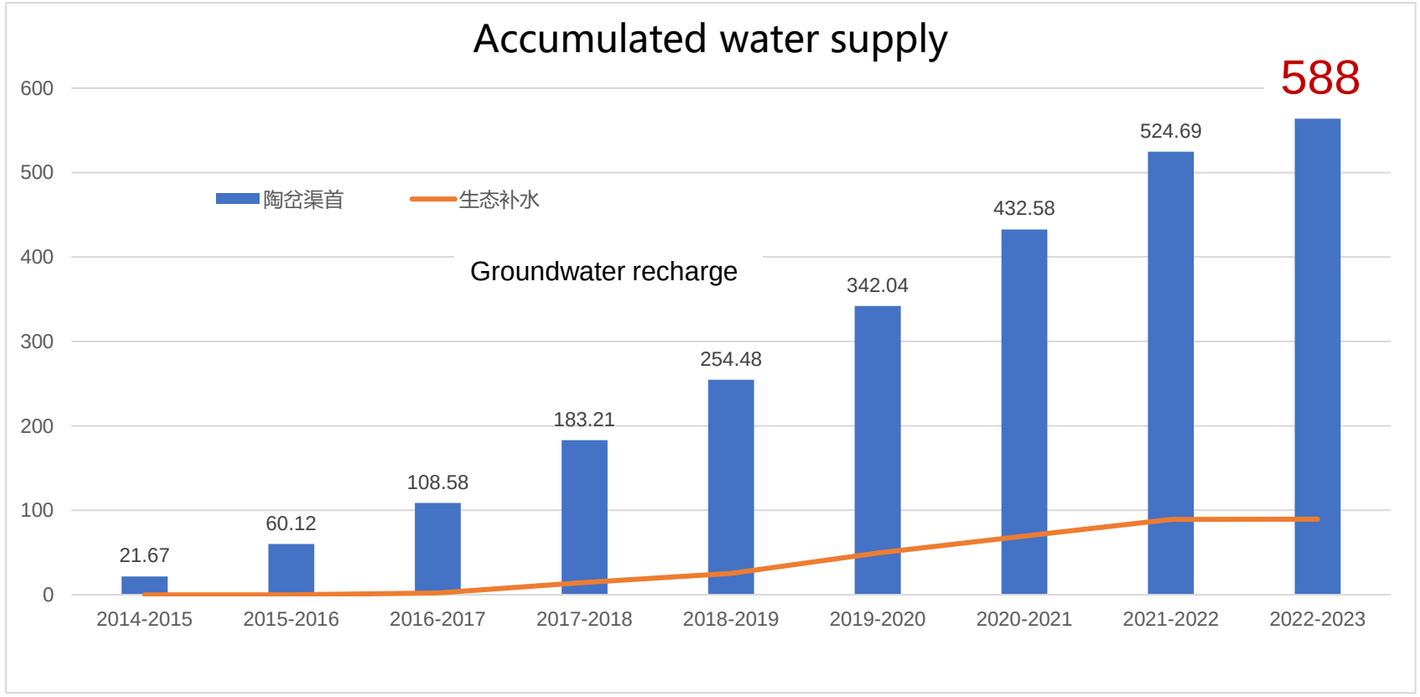
为进一步推动华北地区地下水超采综合治理工作，现将《2021年度华北地区地下水超采综合治理河湖生态补水方案》印发给你们，请按照职责分工，认真落实各项工作任务，并视水源条件力争多补水。

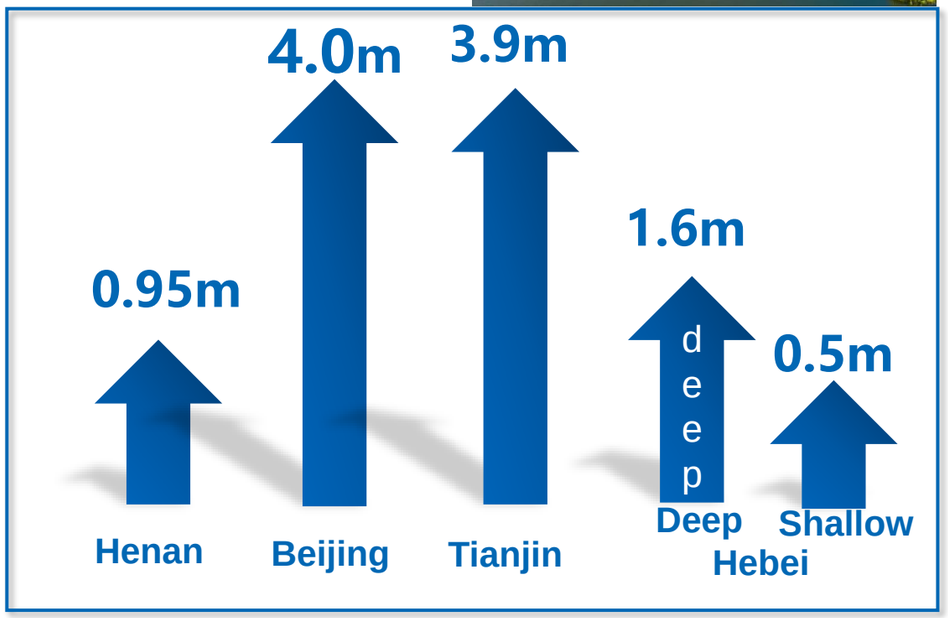
附件：2021年度华北地区地下水超采综合治理河湖生态补水方案

水利部办公厅
2021年3月11日

# Middle route of south to north water diversion project

- By end of Sept 2023, in total the project has transferred >**58.8 billion m³** of water, and implemented a total of about 9 billion m³ of **ecological water replenishment**
- The water supply have alleviated the water shortage in North China, and the groundwater level in the recharged areas has risen significantly.

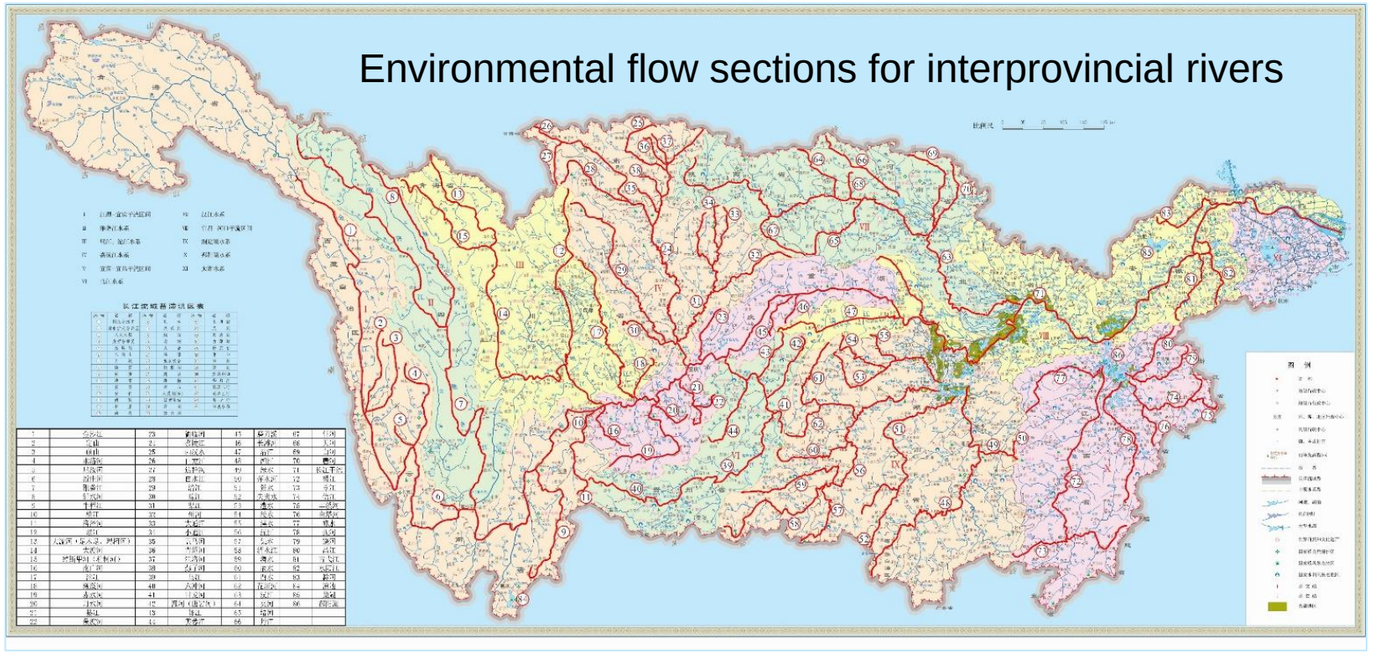



Groundwater level raised during 2015-2021

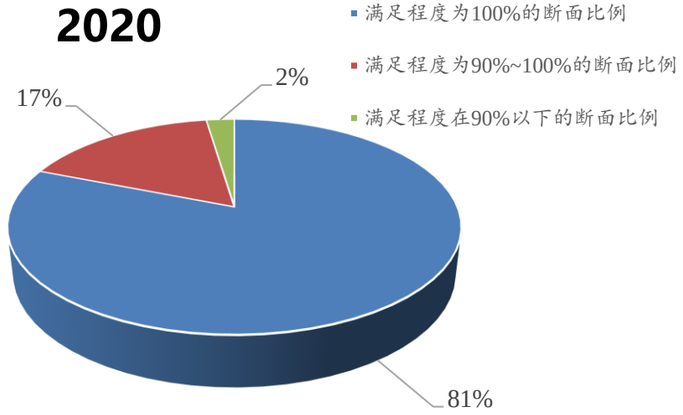
# Determine environmental flow indicators

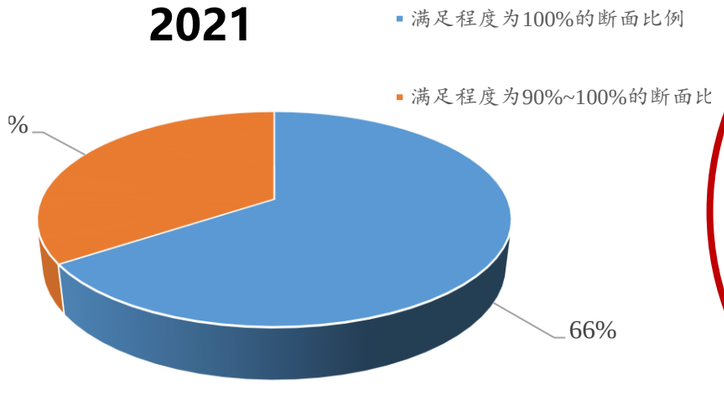
- Defined environmental flow management targets for **131 river sections** for **85 interprovincial river.**
- **Safeguard** measures for ecological flow scheduling are proposed

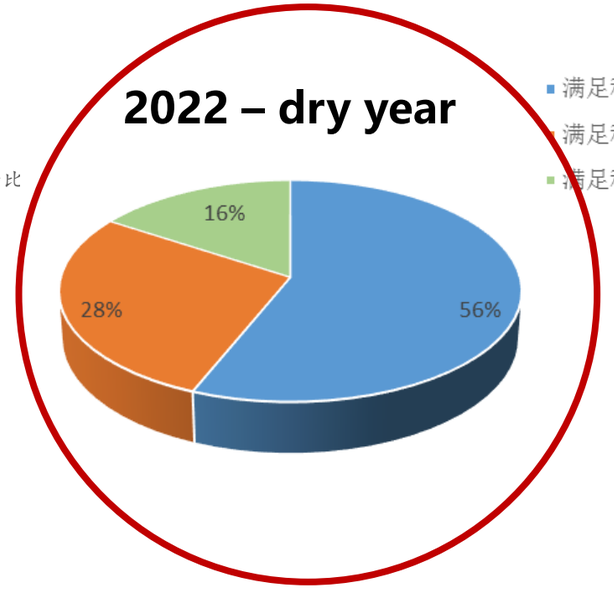



# Ecological flow in interprovincial rivers and lakes

The protection of the ecological flow of key inter-provincial rivers & lakes is generally good during 2020 ~ 2022.

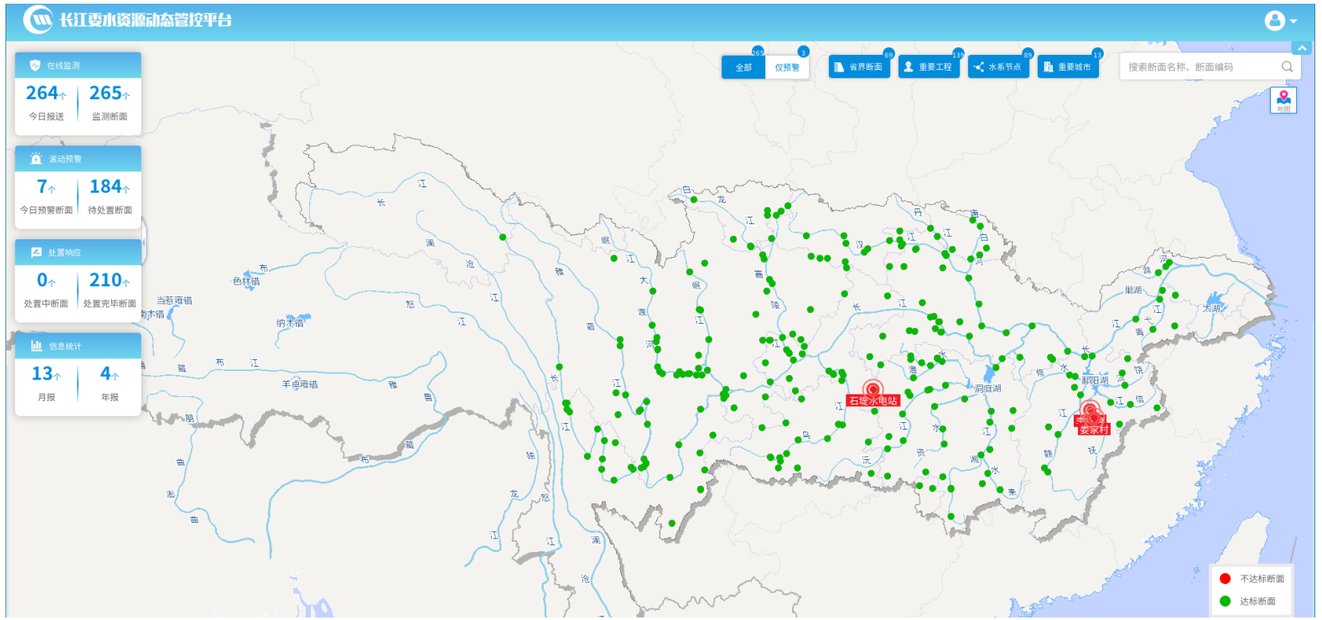


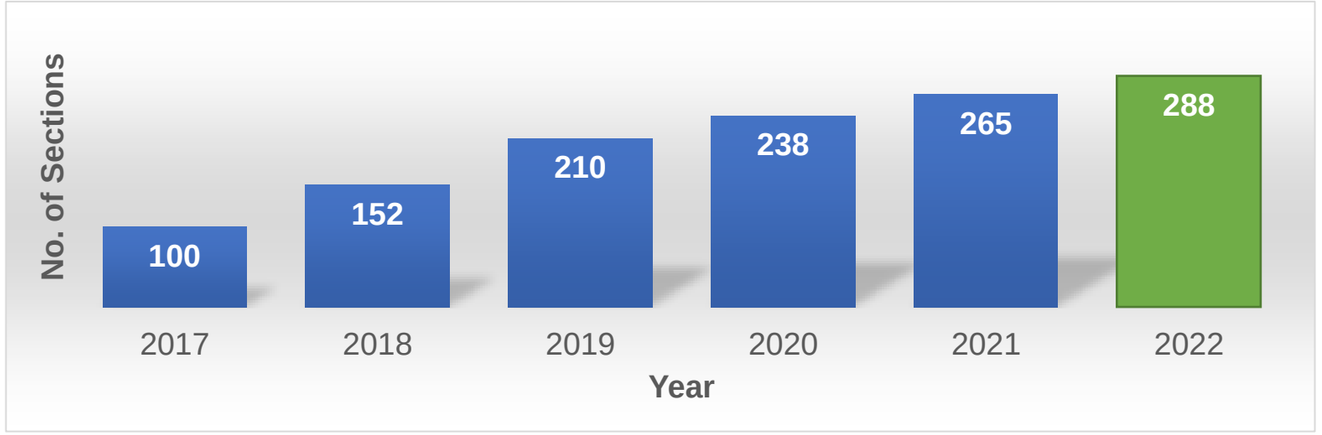



# Monitoring minimum flow for sections

- In total there are **288 sections** = **70 provincial** boundary sections + **99** water system node sections + **149** water project sections + **16 important city** sections
- **244** sections are of hourly data reporting (some stations reported manually).




| Meet demands | No. of sections (daily reporting discharge) | No. of sections (daily processed discharge) |
|---|---|---|
| 100% | 123 | 121 |
| ≥90% | 247 | **249 (86%)** |
| ≥80% | 265 | 269 |
| ≥60% | 282 | 282 |
| < 60% | 6 | 6 |



# Promote and improve water intake management

## Water resources demonstration

- Take imitative for water resources analysis and demonstration for planning project
- Continue promoting establishment of policy and mechanism.

## Water right trading

- For areas where the total water use amount reaches it upper limit index,  promote water right trading to solve the water shortage due to management index
- Continue pursuing establishment and development of water right trading system.

## Online monitoring of water intake

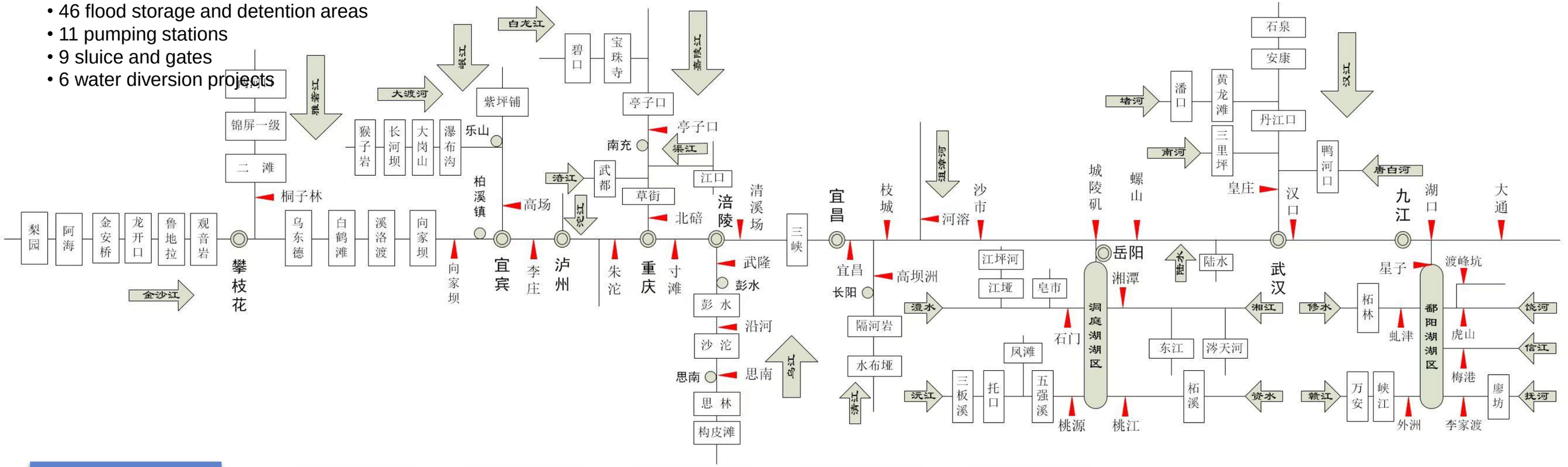
- Promote and support online monitoring at water intake facilities, important water diversion projects, large scale irrigation system etc.
- Invoke the measured data into data platform in river commission and ministry level.

# At real time, Joint regulation of engineering works is the key for river management

Joint regulation scheme of engineering measures, increased projects gradually. Now there are 125 water projects involved.

**In 2023, 125 water works:**

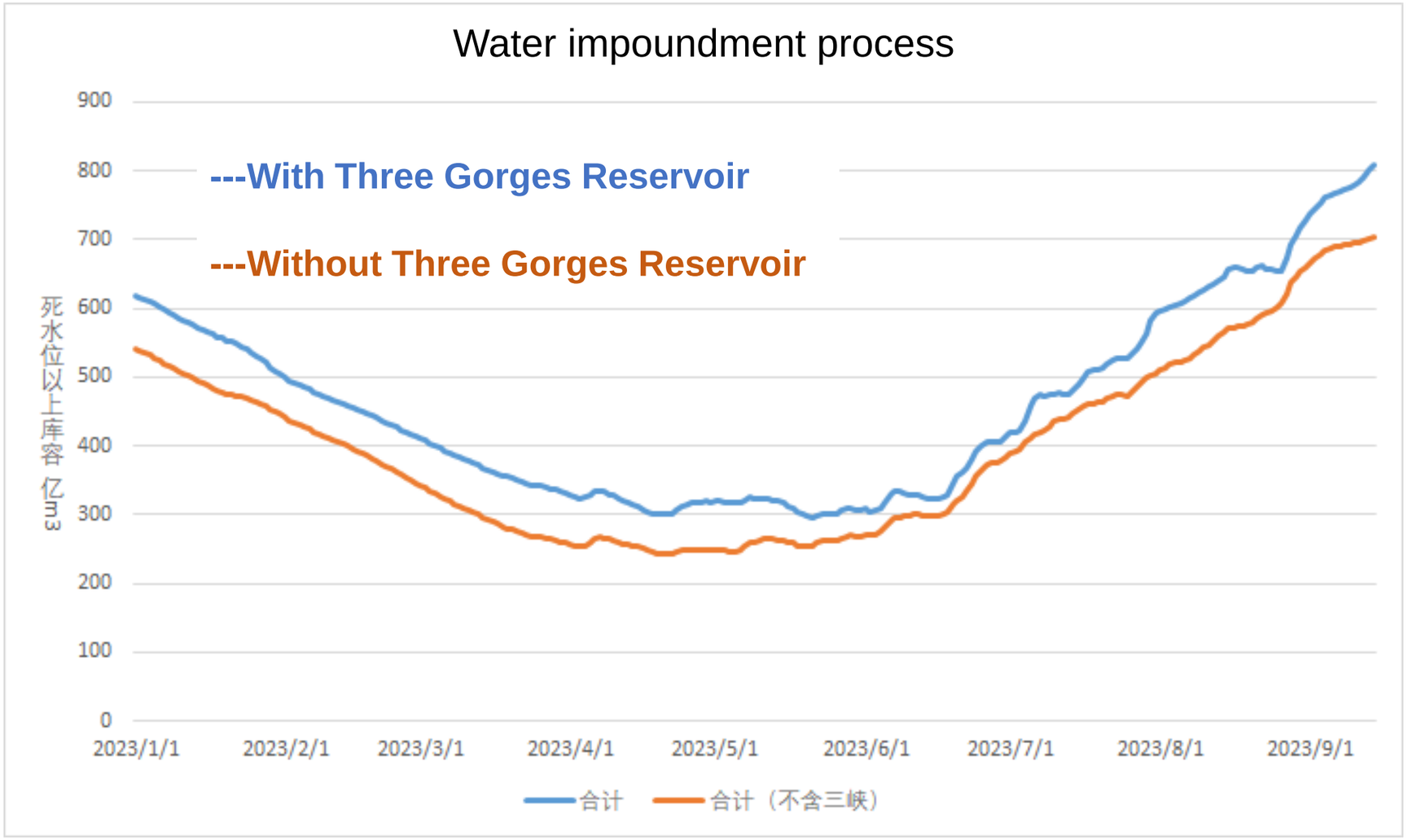
- 53 reservoir, Regulatory storage: 116 billion m3, Flood control storage: 70.5 billion m3
- 46 flood storage and detention areas
- 11 pumping stations
- 9 sluice and gates
- 6 water diversion projects




| Annual Joint regulation scheme | 年份 | 2012年 | 2013年 | 2014～2016年 | 2017年 | 2018年 |
|---|---|---|---|---|---|---|
| | 水库数量 | 10 | 17 | 21 | 28 | 40 |

Start from 2019, not only reservoirs but also retention basins, pumping stations, water intake projects etc. were included in the scheme

# At real time, Joint regulation of engineering works is the key for river management




- ❑ Start impoundment earlier than usual
- ❑ Kept higher level during summer season
- ❑ Decision was made base on short + long term meteorological and hydrological forecast

# Appy Integrated solution for River / Lake restoration

**灰色 Grey**

- ❑ Increase the flexibility of the drainage system
- ❑ Reduce initial rain and overflow pollution

**绿色 Green**

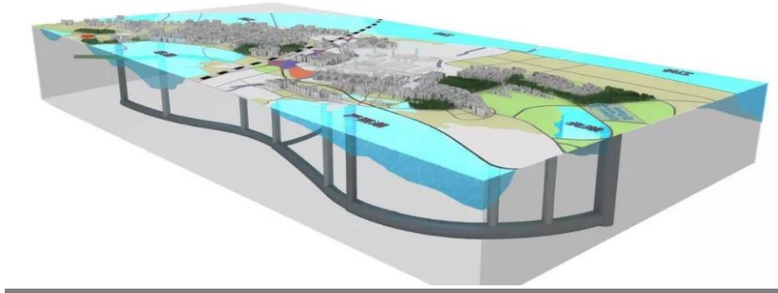
Build a green ecological barrier around East Lake to enhance the quality of the city

**蓝色 Blue**

Build an ecological water network to meet the multi-functional needs of urban natural ecology and social services

## Stop pollution discharge to the lake

Centralized wastewater treatment



Set up initial rainfall treatment system

## Apply sponge city concept

Built green road around the lake

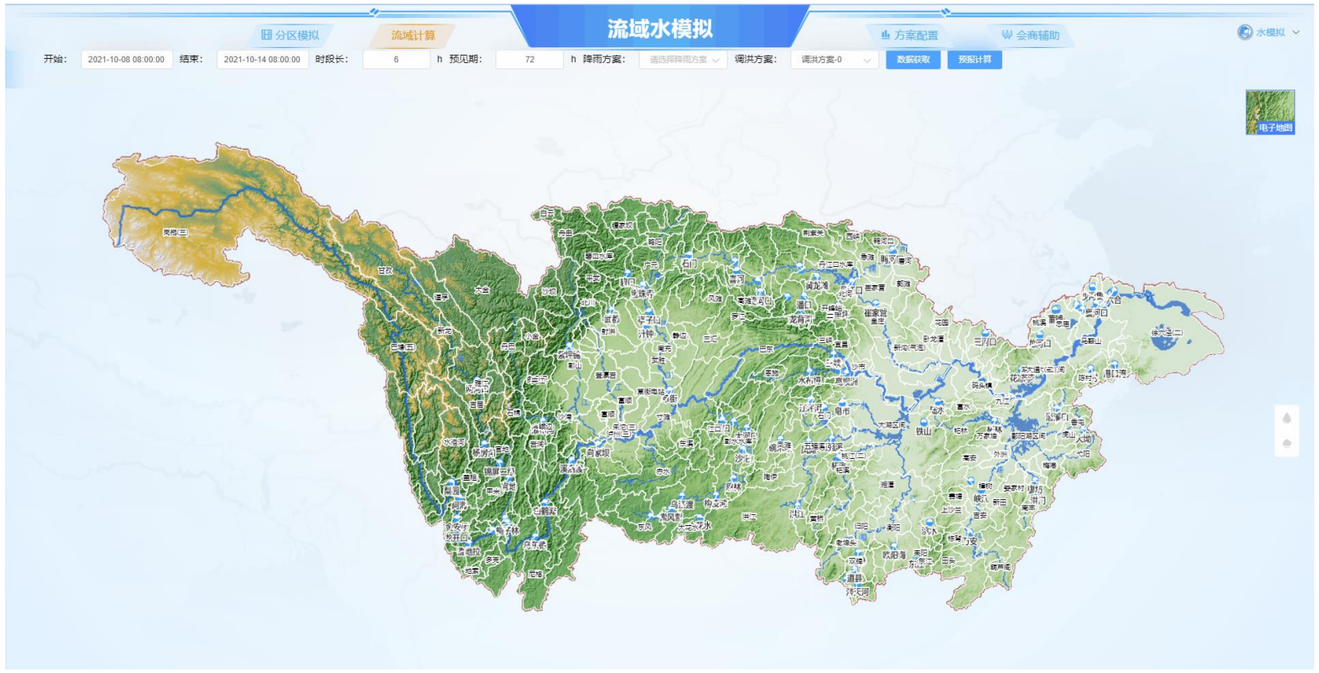
## Connect 6 lakes to build a eco-network

Zoning lake catchment for ecology, city and agriculture

Reduce internal pollution for eco-restoration

# Promote development for Decision Support System (DSS) for WRM

- Improve database with more information, develop special WRM **Information-Model**
- Incorporate the development of digital rivers, promote development of DSS with function of prediction-waring-analysis-action plan
- Some has been applied in the plan making and real time water supply for the water diversion project





| 方案对比 | 合计 (亿m³) | 流量(m³/s) 11月 | 12月 | 1月 | 2月 | 3月 | 4月 | 5月 | 6月 | 7月 | 8月 | 9月 | 10月 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 95% | 71.89 | 234 | 234 | 234 | 234 | 230 | 230 | 231 | 230 | 228 | 228 | 190 | 232 |
| 75% | 74.74 | 234 | 234 | 234 | 234 | 230 | 230 | 231 | 230 | 228 | 255 | 272 | 232 |
| 多年平均 | 93.05 | 234 | 234 | 234 | 234 | 244 | 270 | 350 | 350 | 375 | 366 | 373 | 272 |
| 预报下限 | 70.70 | 234 | 234 | 234 | 234 | 186 | 230 | 235 | 230 | 228 | 228 | 232 | 188 |
| 预报中值 | 78.86 | 234 | 234 | 234 | 234 | 230 | 230 | 231 | 243 | 294 | 268 | 259 | 232 |
| 预报上限 | 83.74 | 234 | 234 | 234 | 234 | 230 | 230 | 231 | 323 | 373 | 343 | 272 | 245 |

# Intelligent regulation

**Automatic regulation according to rules**

Computer alone

**Interactive regulation**

Man + computer

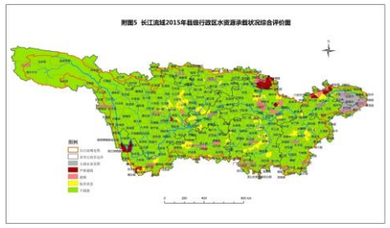
**Optimization according to goals**

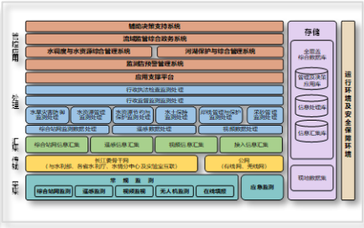
Computer receives goals and applies optimization procedure

# Next Steps

# To-do list

1. Implement **Changjiang River Protection Law**
2. Improve **flood** management capacity: upgrade flood management planning and improve the flood control systems
3. Enhance **water saving** through promotion, education, monitoring etc.
4. Improve and optimize **water network** construction
5. Enhance water resources management using water resources as **rigid constraints** for social-economic development
6. Ensure **environmental flow** and promote eco-system **restoration**, improve monitoring and assessment capacity
7. Enhance **river bank** protection
8. Improve capacity on **joint regulation of water projects**
9. Strengthen the **coordination** and **cooperation** with water-related affairs
10. Strengthen the construction of the **legal system** for development and protection
11. Improve informatics capacity – **develop smart water with the core of digital twin river**
12. Construct Yangtze River **water culture**
13. Carry out **researches & capacity building**

# THANKS