XVIII
World Water Congress
International Water Resources Association(IWRA)
Beijing, China | September 11-15, 2023

Study on the variation of water resources and green regulation measures in the Yangtze River Basin

长江流域水资源演变规律与绿色调控对策研究

Reporter (报告人)： Jijun Xu (许继军)

Institution (单位)： Changjiang River Scientific Research Institute (长江科学院)

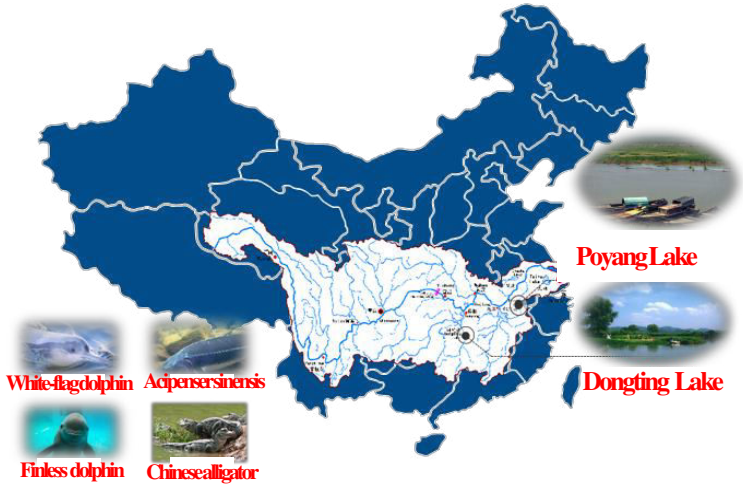
Sep. 2023

2023年9月

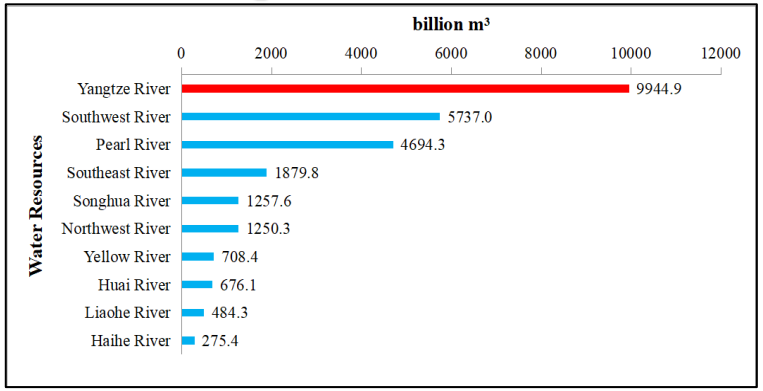
CONTENTS

1、Background(研究背景)

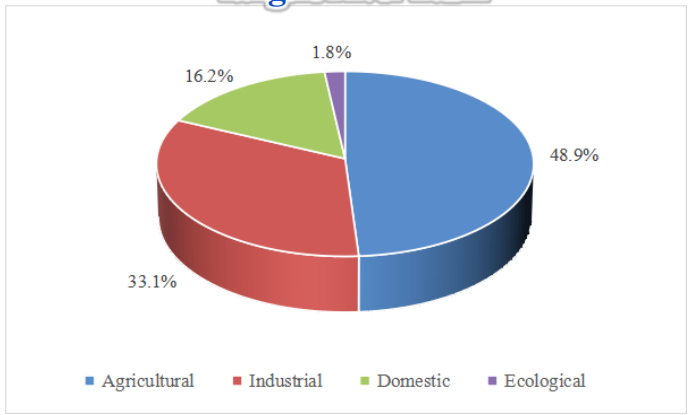
- The average annual total water resources in the Yangtze River basin is 994.5 billion m^3, accounting for 36.9% of the total water resources in China, of which the surface water resources is 982.3 billion m^3 and the groundwater resources are 12.2 billion m^3.
- The average annual total water use is 203.9 billion m^3, accounting for 19% of the total water resources.
- Water consumption of agricultural , industrial, and domestic are 99.2 billion m^3 (48.9%), 70.6 billion m^3(33.1%), and 31.3billion m^3 (16.2%) , respectively.



Comparison of total water resources in major river basins in China



Average annual water Consumption Structure of the Yangtze River Basin



- 长江流域多年平均水资源总量为9945亿m^3，占全国水资源总量的36.9%，其中地表水资源量9823亿m^3,地下水资源量122亿m^3。
- 年均取用水总量约为2039亿m^3,占水资源总量的19%。其中，农业用水量992亿m^3（48.9%），工业用水量706亿m^3(33.1%)，生活用水量313亿m^3（16.2%）。

1、Background(研究背景)

◆ In the past decades, the rapid economic and social development has brought serious problems of water environment pollution and water ecology degradation. In addition, water shortage, flood and drought disasters caused by climate change have become more prominent.

Irrational utilization of water resources

Causing ecological and environmental crisis in the Yangtze River

Some areas lack water conservancy projects, making it difficult to withstand floods and droughts

Water Disasters

- Frequent drought-flood abrupt turn events
- Lack of storage projects to withstand floods and droughts

Flood and drought disasters are frequent

With the rapid economic and social development, the rigid demand for water resources is increasing

Water shortage

- Rapidly increasing water demand
- Over-reliance on surface water and foreign water
- Lack of alternate urban water sources

The rigid demand for water resources has increased

The problem of water shortage caused by water pollution is becoming more and more serious

Water pollution

- Poor water quality in some tributaries and urban river sections of the Yangtze River
- Serious eutrophication in some lakes

The water environment in rivers and lakes has deteriorated

The irrational exploitation and utilization of water resources have degraded the ecological functions of the Yangtze River

Ecological damage

- Deterioration of aquatic habitat functions
- Decline of aquatic flora and fauna
- Some rare plants and animals are in danger of extinction

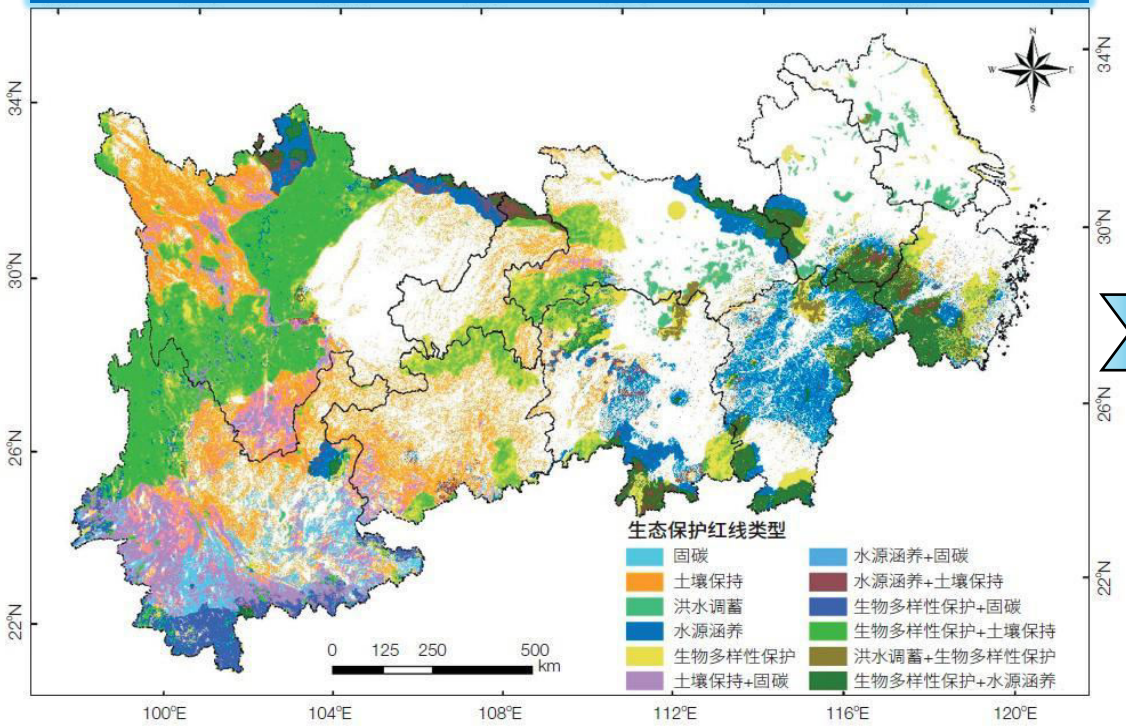
Degradation of river ecological functions

◆ 近些年来的经济社会快速发展给长江流域带来了严重的水环境污染、水生态退化等问题，此外气候变化导致的水资源短缺和水旱灾害问题也较为突出。

1、Background(研究背景)

- The government has put forward the concept of ecological priority and green development, and has implemented the "To step up conservation of the Yangtze River and stop its over development", and carried out actions to treat the water environment and restore water ecology in the Yangtze River Basin.

Building a green and ecological "corridor" for the Yangtze Economic Belt

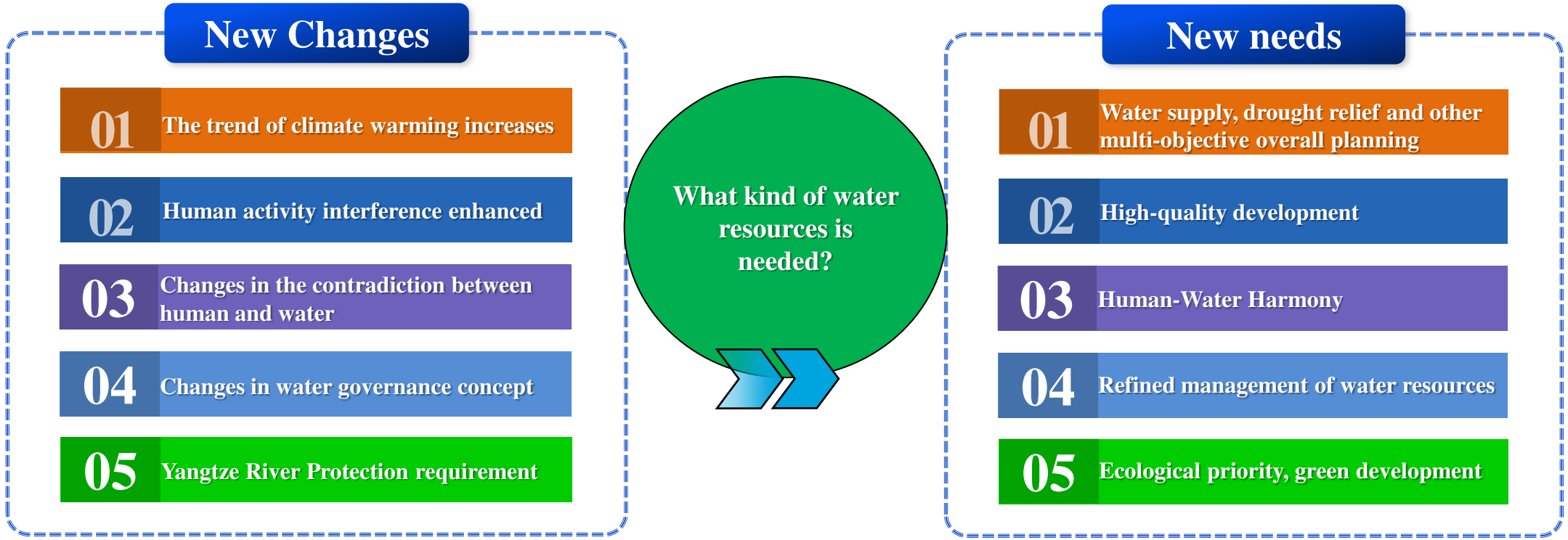


The ecological environment of the Yangtze River has been significantly improved

- 为此，国家提出了生态优先、绿色发展的理念，并针对长江实施了“共抓大保护，不搞大开发”，并由此开展了长江流域水环境治理和水生态修复行动。

1、Background(研究背景)

◆ The harmonious relationship between the development and protection of water resources is one of the keys to coordinating the Yangtze River Protection and the development of the Yangtze River Economic Belt. And, this requires careful consideration of the new changes , in particular what kind of utilization and management of water resources is needed to support the policy of ecological priority and green development.



◆ 处理好水资源开发与保护关系，是协调长江大保护和长江经济带发展的关键之一，这需要慎重考虑当前长江流域面临的新变化和新需求，尤其是要考虑生态优先和绿色发展需要怎样的水资源支撑。

1、Background(研究背景)

◆ In the past, it is more concerned with the utilization, allocation, regulation of the blue water resources in rivers, lakes, and reservoirs, and paid little attention to the green water, especially the management and utilization of productive green water resources.

Shortage

- The traditional development and utilization of water resources focuses on the blue water in river , lake and reservoir and aquifer, ignoring the green water in soil layers and underestimating the availability of water resources.

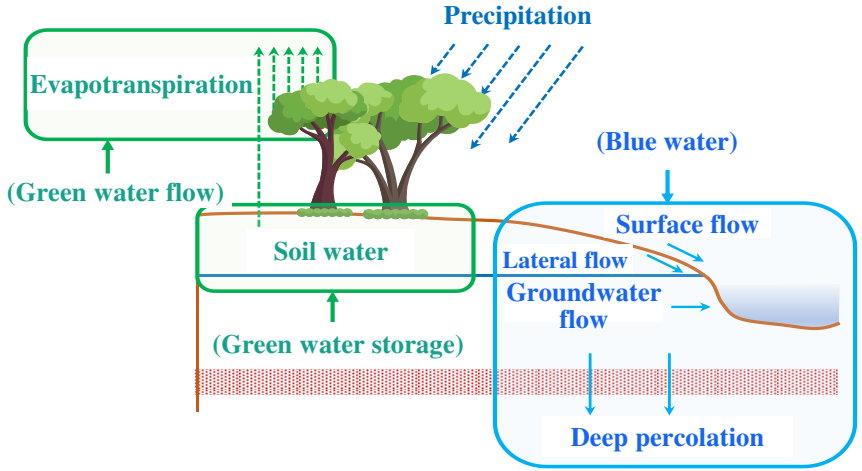
It can not meet the scientific and technological needs of the Yangtze River protection and the high-quality development of the Yangtze River Economic Belt

New Idea

Focusing on

the generalized water resources

(Blue water + green water)



Green water

- Water supplied to plant growth by precipitation infiltrating into **soil layers** (e.g. soil evaporation, vegetation transpiration)

Blue water

- **Surface water** and **groundwater** formed by precipitation (e.g. river, lake and aquifer)

◆ 在以往，长江流域更多关心的是江河湖库中的蓝水资源的开发利用、分配调控和管理保护，对流域面上的绿色资源情况关注不多，尤其是忽略了生产性绿水资源的管理与利用。

1、Background(研究背景)

- **It has been found that 65 % of the global precipitation is returned to the atmosphere (green water) through the evaporation of forests, grasslands, wetlands and farmland, and only 35 % of the precipitation is stored in rivers, lakes and aquifers (blue water).**

The role of green water

- Green water is the vital source to support **terrestrial ecosystems** and **rain-fed agriculture**.
- It has been found that about 80% of the precipitation on global farmland downs through the soil and is converted into green water, which is ultimately dissipated into the atmosphere through vegetation transpiration and soil evaporation.
- How to fully utilize the water for **agricultural production** is an issue worth to study.

Blue water: 22.27% Green water: 77.73%	Blue water: 16.59% Green water: 83.41%	Blue water: 19.53% Green water: 80.47%	Blue water: 18.18% Green water: 81.82%
International Food Policy Research Institute	University of Twente, The Netherlands	University of New Hampshire	Stockholm University, Sweden
Potsdam Institute for Climate Impact Research, Germany	University of Bonn, Germany	National Institute for Environmental Research,Japen	Beijing Forestry University, China
Blue water: 19.96% Green water: 80.04%	Blue water: 17.65% Green water: 82.35%	Blue water: 21.61% Green water: 78.39%	Blue water: 15.61% Green water: 84.39%

Research results of some domestic and foreign institutions on the proportion of blue water and green water of the global cultivated land

(Rost et al.,2008; Hoekstra and Chapagain,2008; Rockström et al., 2009; Wisser et al.,2010; Liu et al.,2010; Hanasaki et al.,2010; Siebert and Doll,2010; Rosegrant et al.,2016)

- 相关研究表明：全球总降水的 65%通过森林、草地、湿地和农田的蒸散返回大气（绿水），仅有 35%的降水储存于河流、湖泊以及含水层中（蓝水）。
- 绿水是支撑陆地生态系统和雨养农业生产的主要水源。全球耕地上的降水中约有80%进入土壤转化成了绿水，最终通过植被蒸腾和土壤蒸发耗散到大气中。如何充分利用这些水分用于农业生产值得深入研究。

CONTENTS

2、Variation of blue and green water resources in the Yangtze River basin

- To simulate the conversion process of blue and green water in the Yangtze River Basin.
- To reveal the spatial and temporal distribution of blue and green water based on statistical analysis and time series analysis.
- To analyse the effects of measures, e.g. vegetation cover, soil and water conservation, reservoir regulation, on blue-green water change.

Method

- To build the GLDAS_NOAH model
- Blue water is the sum of surface runoff, groundwater and snowmelt

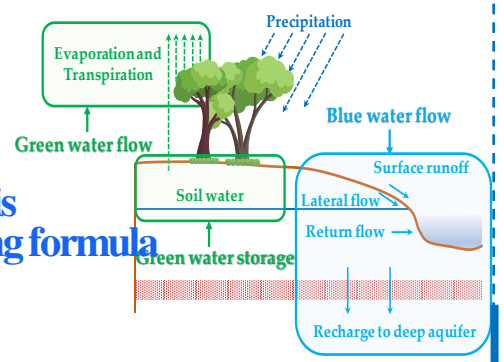
$$BWF = Q_s + Q_{sb} + Q_{sm}$$

- Green water is the actual evapotranspiration

$$GWF = E_{vap}$$

- The green water coefficient is calculated using the following formula

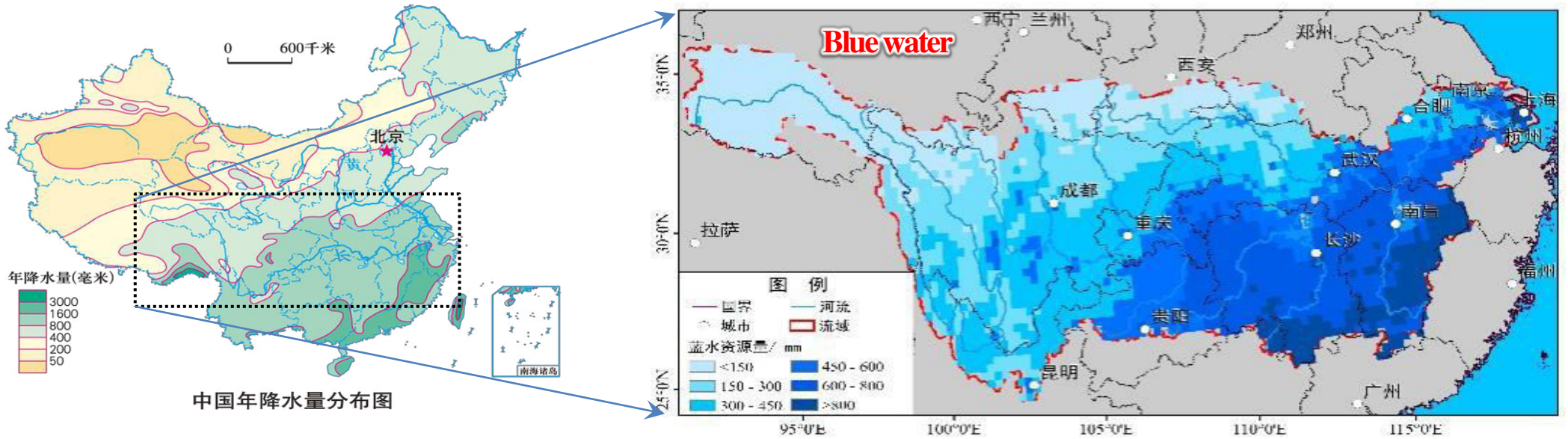
$$GWC = \frac{GWF}{GWF + BWF}$$



- 模拟长江流域蓝绿水资源转化过程， 基于统计分析与时序分析，揭示蓝绿水资源量的空间分布格局及时间规律， 分析植被覆盖、水土保持、水库调蓄等多种调控措施对蓝绿水变化的影响
- 构建GLDAS_NOAH水文模型，通过地表径流，地下径流和融雪径流模拟结果计算蓝水， 通过实际蒸散发模拟结果计算绿水，再计算绿水系数

2、Variation of blue and green water resources in the Yangtze River basin

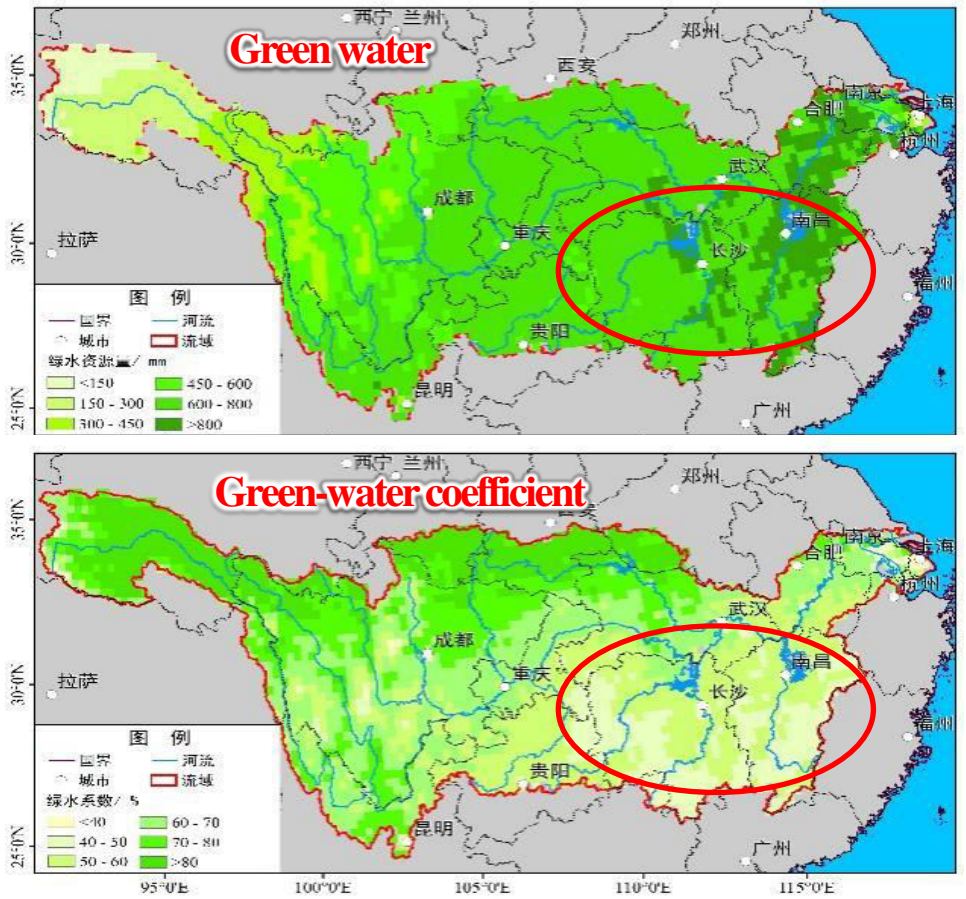
- The average annual blue and green water are **396.1mm** and **622.2mm**, respectively, and green water coefficient is **61.1%**. Green water is about **1.57** times of blue water, and **green water** is the main water resource in the Yangtze River basin.
- Blue water showed an increasing trend **from northwest to southeast**, which had a **strong correlation** with precipitation distribution. The blue water in the source regions of Yangtze river is **less than 150mm**, and the blue water resources in Hunan, Jiangxi and other places downstream are **more than 800mm**.



- 长江流域年均蓝绿水资源量（1960-2021年）分别为 396.1mm 和 622.2mm，绿水系数 61.1%，绿水资源总量约是蓝水的1.57倍，流域水资源总体以绿水为主。
- 蓝水资源量呈现自西北向东南增加趋势，与降水量分布具有较强的相关性；长江源区蓝水不足150mm，下游的湖南、江西等地蓝水资源量超过800mm。

2、Variation of blue and green water resources in the Yangtze River basin

- Green water increased from west to east. The green water in the source regions of Yangtze river is less than 300mm, while that in southern Anhui and northern Jiangxi exceeds 800mm.
- Green water coefficient showed a decreasing trend from northwest to southeast.
- Due to the abundant precipitation and high runoff coefficient in the southeastern part of the Yangtze River Basin, the green water coefficient in this area is relatively low, about 50%.



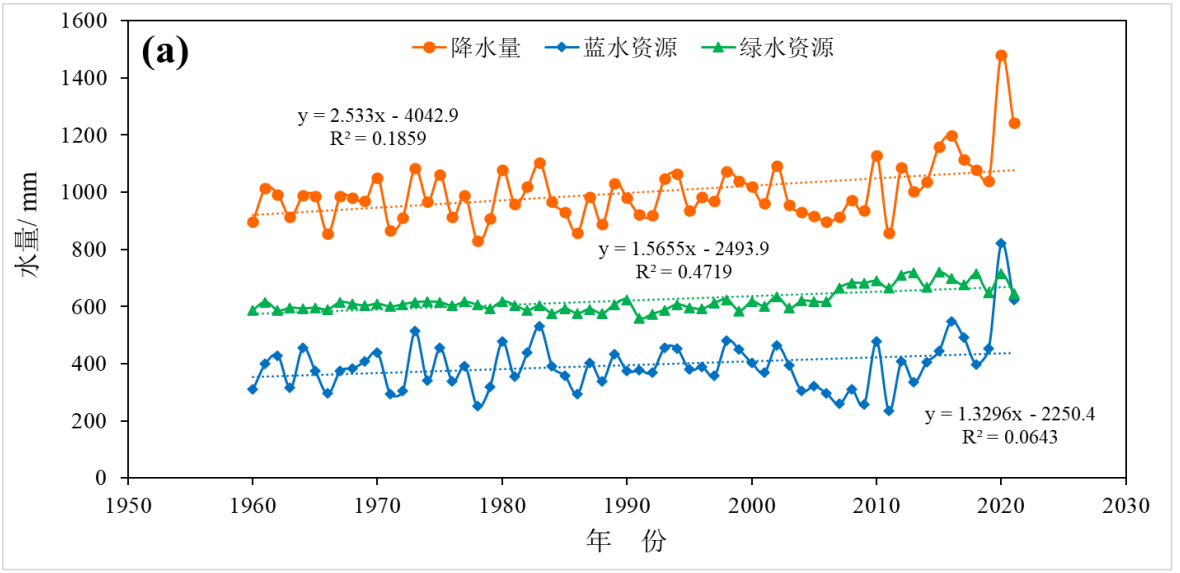
- 绿水资源量呈现自西向东增加趋势；长江源区绿水资源量不足 300mm，下游安徽南部、江西北部等区域绿水资源量超过 800mm。
- 绿水系数呈现自西北向东南减少趋势；长江源区、甘肃南部、陕西南部区域绿水系数超过 80%，而湖北、江西等地绿水系数低于 50%。这是因为长江流域东南部地区降水充沛，产水系数高，因此该地区的绿水系数相对较低。

2、Variation of blue and green water resources in the Yangtze River basin

- From 1960 to 2021, both blue and green water present rising trend with the increasing of precipitation.
  - Change rate of blue water is 1.33mm/a, highly positively correlated with precipitation change.
  - Change rate of green water is 1.57mm/a, positively correlated with precipitation change, but not significant.

- 1960-2021年，长江流域在降水量呈增加趋势的情况下，蓝水资源和绿水资源量呈现“双上升”趋势。
  - 蓝水资源量变化率为 1.33mm/a，与降水量变化高度正相关。
  - 绿水资源量变化率为 1.57mm/a，与降水变化成正相关关系，但不显著。

Interannual variation of blue and green water in the Yangtze River Basin



Correlation between blue and green water and precipitation

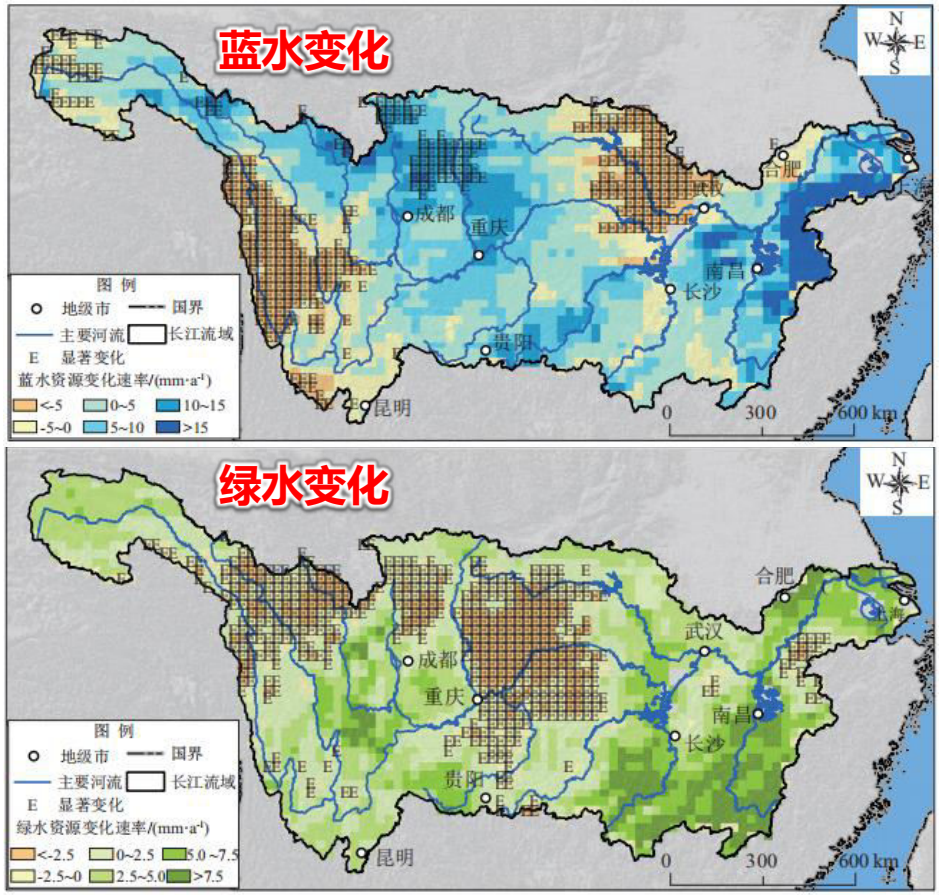
2、Variation of blue and green water resources in the Yangtze River basin

Blue water

- The Jinsha River basin showed a significant increasing trend.
- The regions of southern Shanxi, eastern Sichuan, northern Guizhou, and southern Jiangxi and Anhui showed an insignificant increase trend.
- In contrast, the regions of southern Sichuan, Yunnan, Hunan, and Hubei showed an insignificant decrease trend.

Green water

- A decreasing trend was observed in the source regions of Yangtze river and in Yunnan, Guizhou and Sichuan;
- All other regions showed a significant increasing trend.



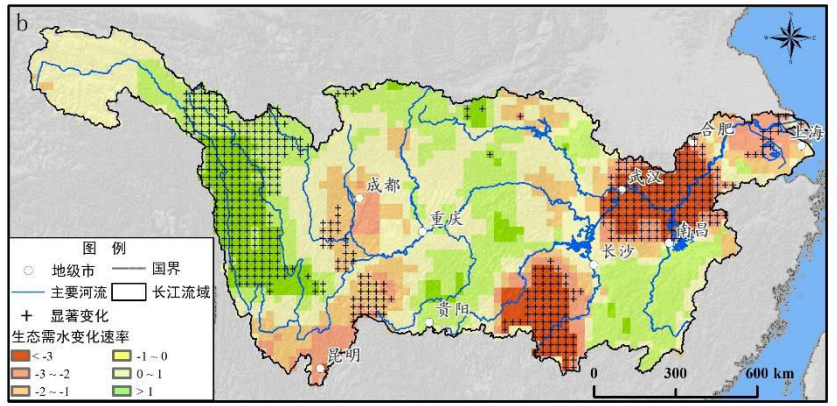
- 蓝水空间变化特征
  - 金沙江流域呈显著增加趋势；
  - 陕西南部、四川东部、贵州北部以及下游江西、安徽南部等地呈增加趋势，但趋势不显著；
  - 四川南部、云南、湖南、湖北区域呈不显著减少趋势。
- 绿水空间变化特征
  - 源区和云、贵、川等地呈减少趋势；
  - 其余区域均呈显著增加趋势。

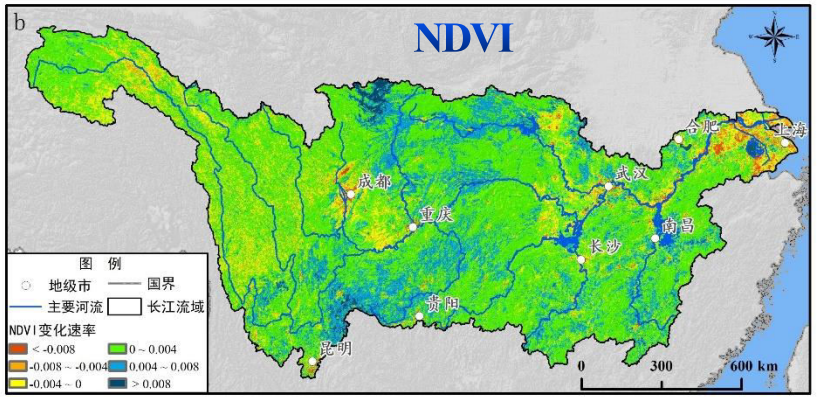
2、Variation of blue and green water resources in the Yangtze River basin

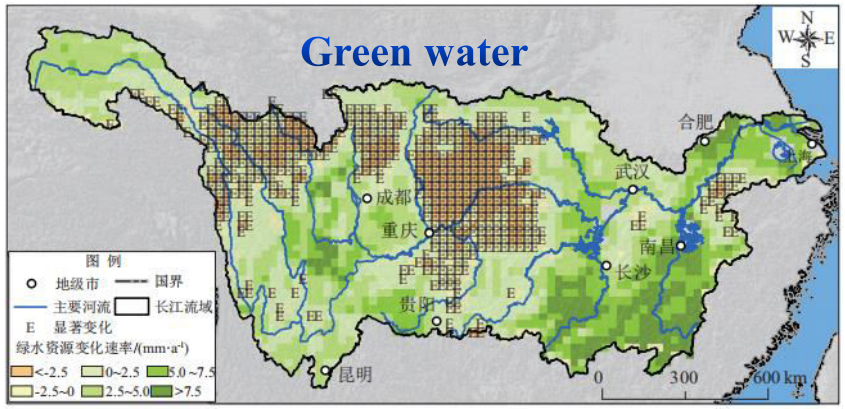
◆ Relationship between green water change and vegetation change

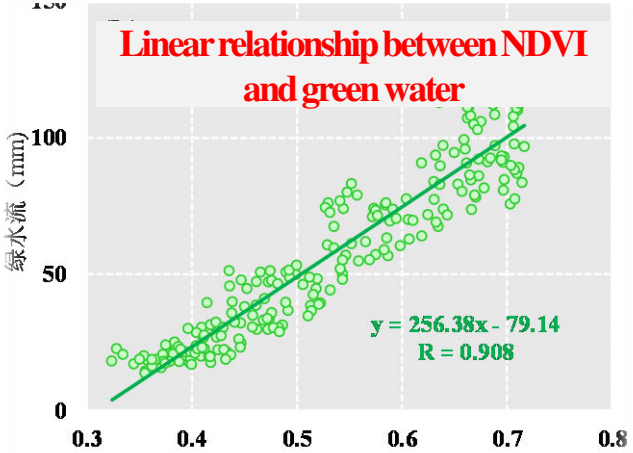
- The change of green water in the Yangtze River Basin is highly correlated with vegetation, and the correlation coefficient between green water resources and NDVI is 0.908. The contribution of green water to the water demand of the ecosystem is more than 90%.
- If the green water cannot meet the water demand of vegetation, it will threaten the ecosystem security (ecological drought). Especially in Jinsha River and Yalong River Basin, the ecological water demand shows a rapid increase, and the vegetation ecosystem in this area is more sensitive to the changes of green water.

Ecological water demand









- 绿水资源量与NDVI相关系数为0.908，呈现高度正相关关系。可以看出，长江流域绿水资源变化与植被变化高度相关，绿水对生态系统需水的贡献达到90%以上；
- 当绿水不能满足植被需求， 就会导致生态干旱，危及生态系统安全。尤其金沙江、雅砻江流域，生态需水呈现快速增长，该地区植被生态系统对绿水的变化更加敏感。

2、Variation of blue and green water resources in the Yangtze River basin

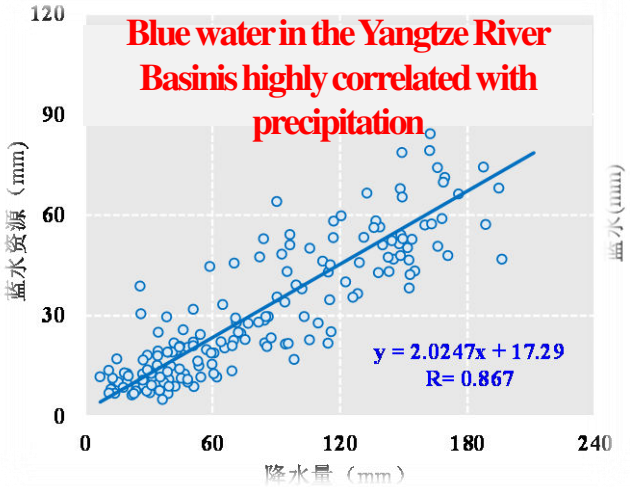
◆Seasonal changes in blue water

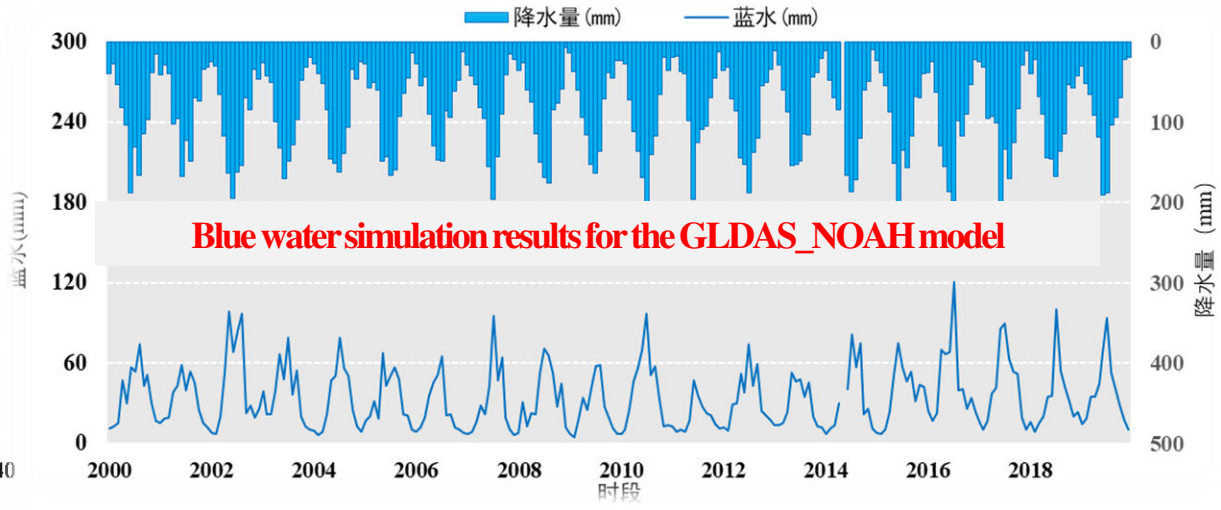
- It is showed a highly positive correlation between blue water and precipitation in the Yangtze River Basin, with obvious seasonal abundance and depletion patterns with precipitation changes.
- The flow of the main stream of the Yangtze River shows the trend of decreasing in the abundant water period (summer and fall) and increasing in the dry water period (spring and winter).

Seasonal runoff changes

站点	春季（3—5月）		夏季（6—8月）		秋季（9—11月）		冬季（12—2月）	
	变化趋势 /$m^3 \cdot s^{-1}$	多年均值 /$m^3 \cdot s^{-1}$	变化趋势 /$m^3 \cdot s^{-1}$	多年均值 /$m^3 \cdot s^{-1}$	变化趋势 /$m^3 \cdot s^{-1}$	多年均值 /$m^3 \cdot s^{-1}$	变化趋势 /$m^3 \cdot s^{-1}$	多年均值 /$m^3 \cdot s^{-1}$
屏山	10.73**	1805.19	-13.04	7910.50	-7.91	6507.94	5.73**	1837.18
朱沱	13.29**	3920.53	-43.24*	15337.80	-21.60	11001.76	10.05**	3289.77
寸滩	10.65	5245.10	-44.04*	20013.12	-37.08*	14393.90	12.43**	3899.04
宜昌	30.73**	7788.62	-47.91*	24431.97	-82.62**	17085.95	23.06**	5018.17
汉口	13.91	17800.32	-18.42	36517.47	-107.69**	25305.80	46.72**	9710.54
大通	12.85	24851.76	9.54	44486.67	-116.63**	30713.45	62.37**	12845.45

- 长江流域蓝水资源与降水量相关系数为0.867，呈现高度正相关关系，随降水变化具有明显的季节性丰枯规律。
- 长江干流流量整体呈丰水期（夏季、秋季）下降与枯水期（春季、冬季）上升的趋势

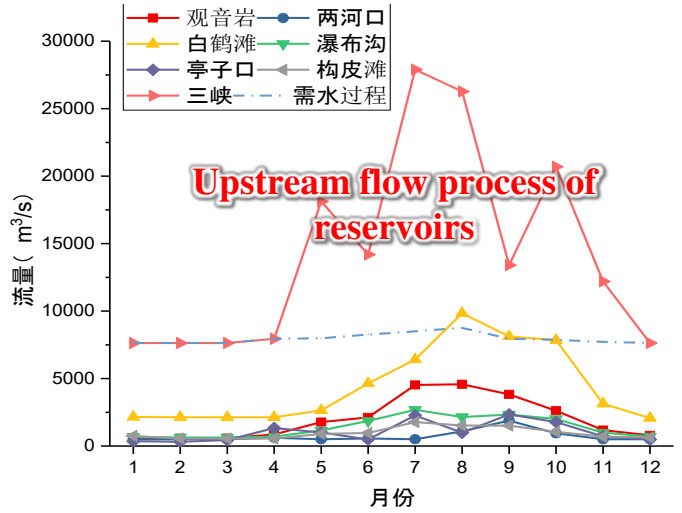




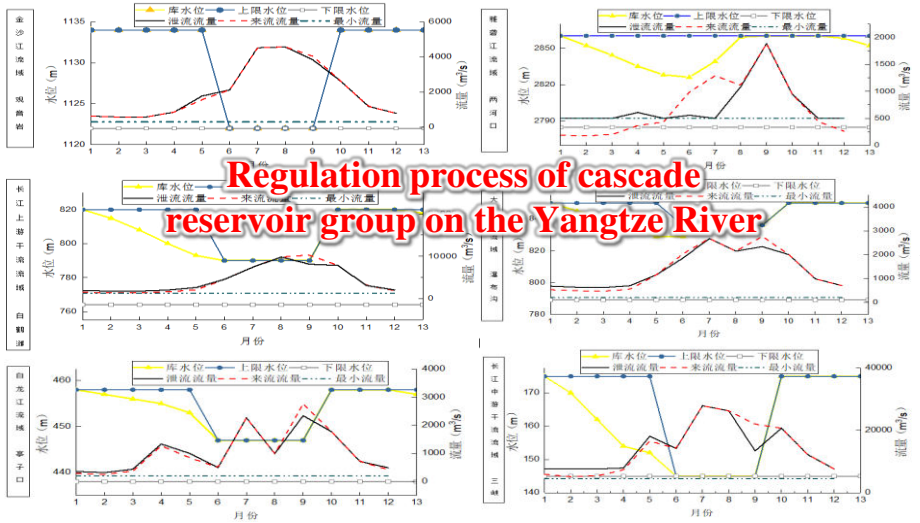
2、Variation of blue and green water resources in the Yangtze River basin

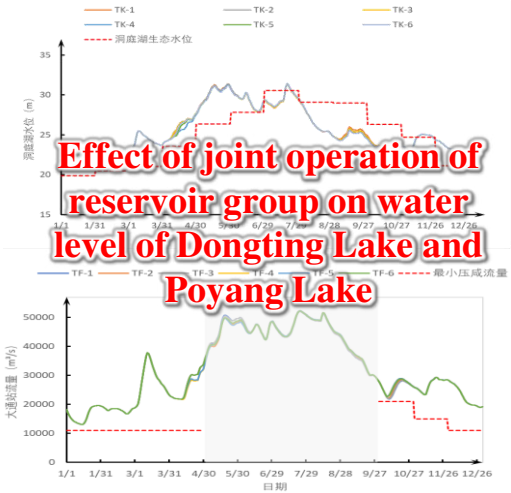
◆ The relationship between seasonal variation of blue water and reservoir regulation

- The seasonal operation of the cascade reservoir in the Yangtze River significantly deviates the discharge runoff from the natural runoff condition, as well as the downstream runoff process.
- The regulation of the Yangtze River cascade reservoir is of great significance to ensure the safety of downstream water supply and ecological security.



Upstream flow process of reservoirs

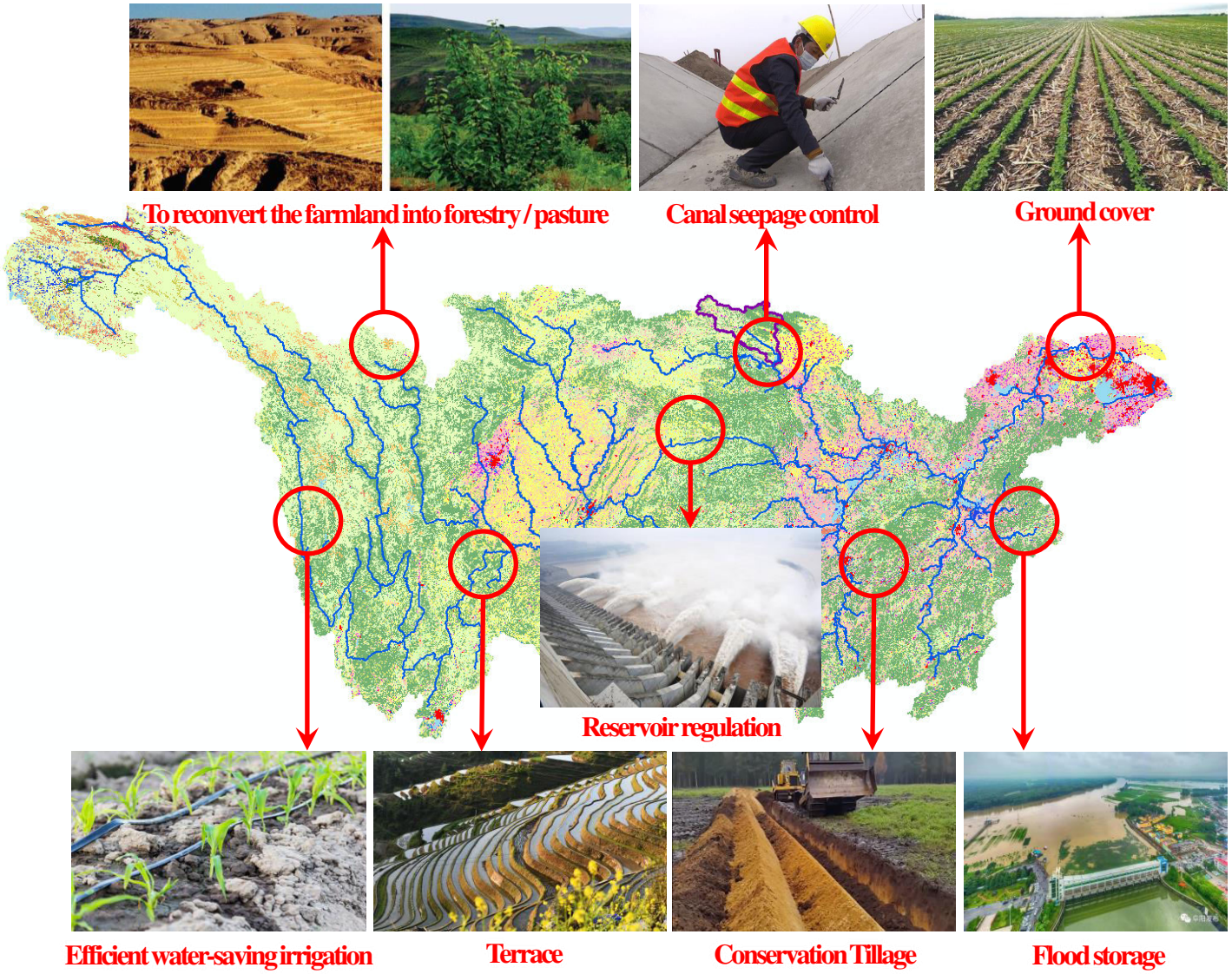

Regulation process of cascade reservoir group on the Yangtze River


Effect of joint operation of reservoir group on water level of Dongting Lake and Poyang Lake

- 针对洞庭湖和鄱阳湖在 8 月-10月可能会出现生态缺水的情况，综合考虑气象、流量等多源信息，通过长江梯级水库群联合调蓄，提升对两湖地区生态需水的保证程度。
- 长江梯级水库季节性调度使出库径流明显偏离天然蓝水情况，显著改变了下游蓝水过程。
- 长江梯级水库的蓄丰补枯调节对保障下游供水安全和生态安全意义重大。

CONTENTS

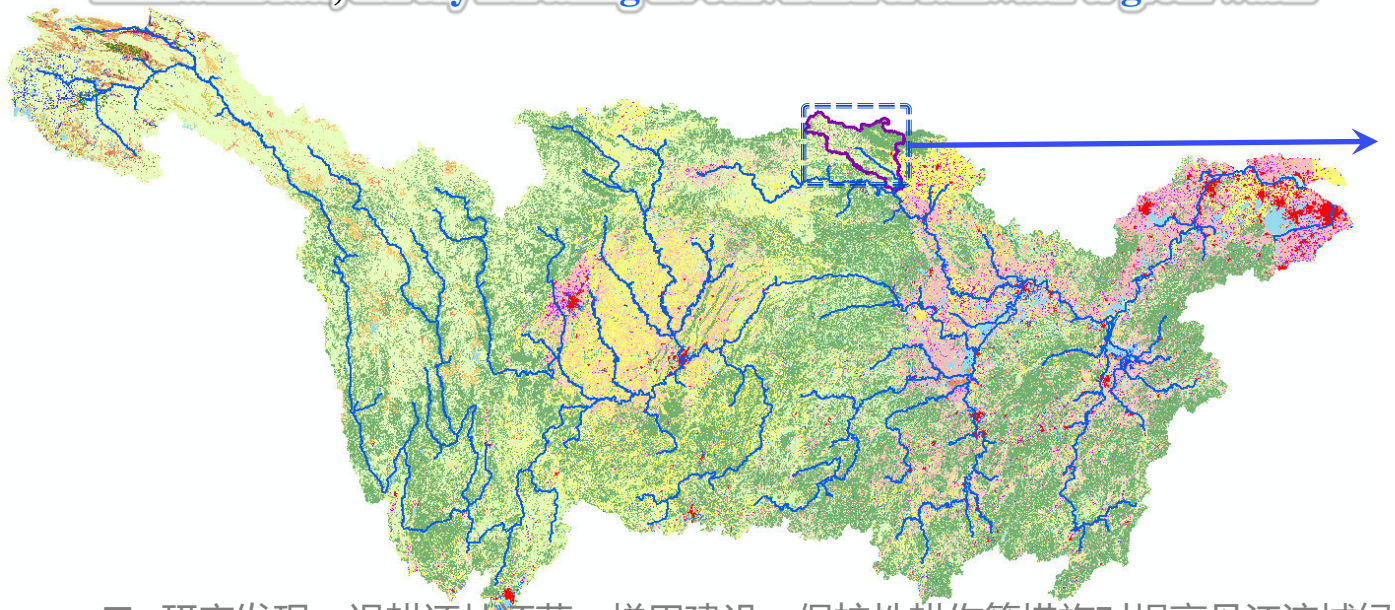
3、Regulation measures of blue and green water resources in the Yangtze River basin

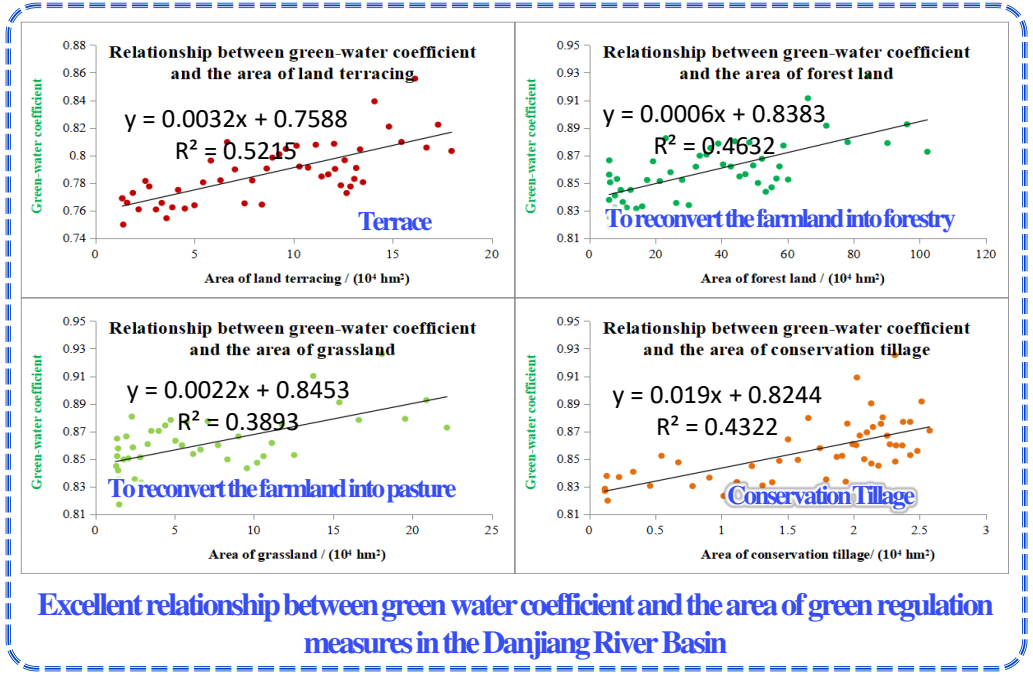


- In recent years, the ecological environment protection in the Yangtze River Basin has been strengthened continuously.
- The government has implemented a series of water management and water-saving measures, as well as soil and water conservation measures and new tillage modes, which has effectively improved and restored the water ecology and environment.
- 近些年来长江流域流水资源及生态环境保护力度不断加强，实施了一系列的水资源管控、调度和节约利用措施，以及水土保持、采用新耕作方式等，优良生态得到有效维系，长江流域水生态与环境得到了有效改善与修复。

3、Regulation measures of blue and green water resources in the Yangtze River basin

- It is found that the measures of returning farmland to forest and grassland, terracing and conservation tillage have excellent effects on improving the green water coefficient of Danjiang River Basin.
  - There was a significant positive correlation between terrace area and green water coefficient (R^2 = 0.52). After slope land was changed to terrace land, rainfall infiltration was increased, and green water coefficient was significantly increased.
  - Forest and grassland can increase the surface roughness of slope, slow down the runoff rate, prolong the confluence duration, and increase the infiltration amount during the runoff process.
  - The correlation coefficient between conservation tillage area and green water coefficient was 0.43. Conservation tillage loosens the soil and increases the infiltration rate, thereby increasing the conversion of rainwater to green water.





Excellent relationship between green water coefficient and the area of green regulation measures in the Danjiang River Basin

- 研究发现：退耕还林还草、梯田建设、保护性耕作等措施对提高丹江流域绿水系数有极好的效果。
- 梯田面积与绿水系数之间呈显著的正相关关系(R^2 = 0.52)，坡地改为梯田后，增加了降雨入渗，显著增大绿水系数。
- 林草地可以增大坡面地表糙率，减慢径流速率、延长汇流历时，从而增加径流过程中的下渗量。
- 保护性耕作面积与绿水系数的相关系数为0.43。保护性耕作疏松土壤，提高下渗速率，从而增加雨水到绿水的转化。

3、Regulation measures of blue and green water resources in the Yangtze River basin

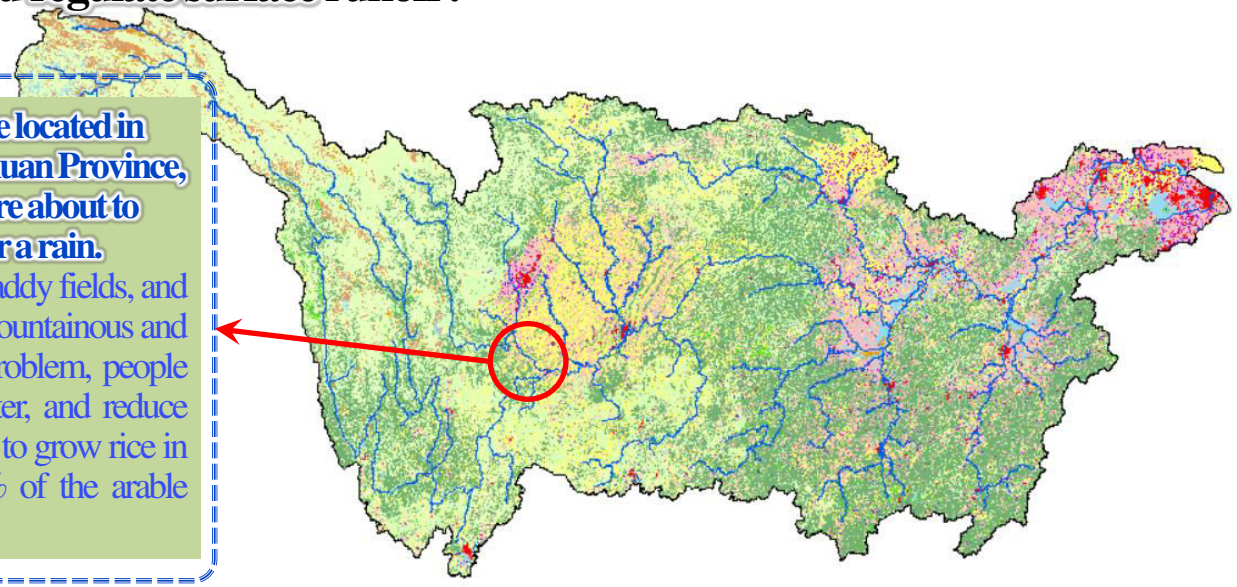
◆ For green water regulation, it important to store more green water for watershed and vegetation systems, and improve the efficiency of productive green water resources.

■ In hilly and mountainous regions

- For areas with slopes of less than 25°, terraces are constructed to retain rainwater, increase soil water storage, and improve the green-water coefficient.
- For areas with slopes greater than 25°, the implementation of the project of returning farmland to forest/grassland is used to increase surface vegetation cover, curb soil erosion, and regulate surface runoff .

The Gaokan Village terraces are located in Junlian County, Yichang City, Sichuan Province, China. In May 2021, farmers are about to transplant rice seedlings after a rain.

Rice needs to be planted in leveled paddy fields, and southern China has more hilly and mountainous and less plains. In order to solve food problem, people constructed terraces to store rainwater, and reduce soil erosion, which makes it possible to grow rice in mountainous areas. More than 25% of the arable land in the YRB is terraced.



◆ 绿水调控: 山地丘陵区

- 对坡度低于25°的山区，建设等高梯田，截留雨水，增加土壤蓄水量，提高绿水系数。
- 对坡度大于25°的山区，实施退耕还林/还草，增加地表植被覆盖度，遏制水土流失，调节径流。

3、Regulation measures of blue and green water resources in the Yangtze River basin

◆Green water regulation

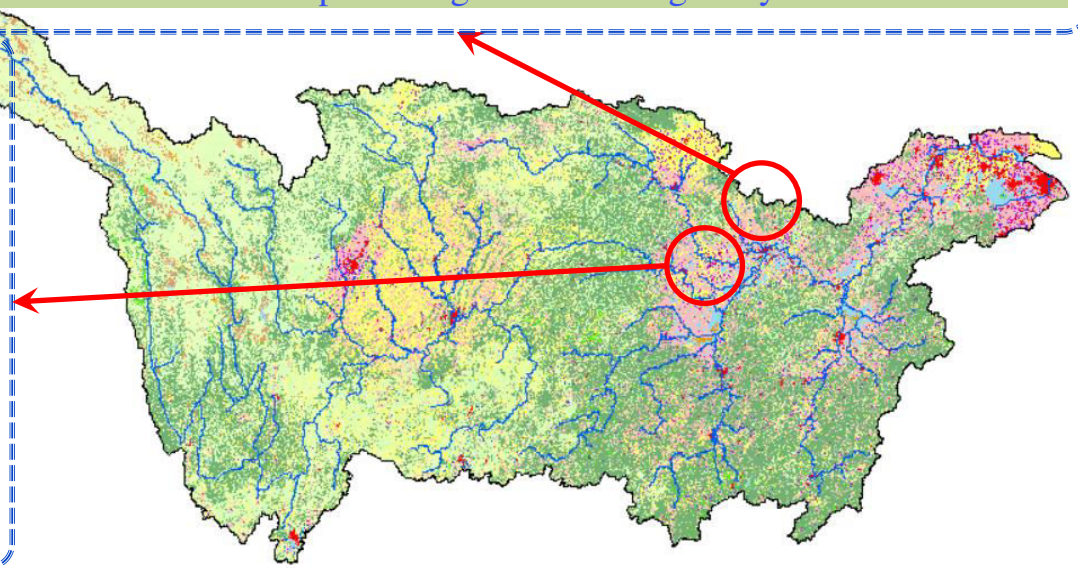
- ■ In Plain regions
  - ➢ **Ground cover**: Some measures, e.g. returning straw to the field and plastic mulching, can control soil evaporation (**ineffective green water**).
  - ➢ **Conservation Tillage**: Ridge cultivation can reduce soil evaporation ; deep plowing can chessom and increase **effective green water**.

In August 2023, Xiaogan City, Hubei Province
The villagers are crushing the harvested rice straw and laying it to the field

In April 2022, the Xiaogan Municipal government issued the green agriculture development plan, formulated relevant subsidy policies and standards to encourage farmers to return straw to the field, reduce fertilization and increase the effect, and promote the green, sustainable and circular development of agriculture in Xiaogan City.

In August 2021, Fuhe Village, Yunmeng County, Hubei Province.
The villagers are planting potatoes on the land where the white radish has been harvested.

Ridge plowing has been practiced in China for more than 2,000 years, this method is conducive to both ventilation among crops and water storage in the soil. It is still widely used around the world today. It is no exaggeration to say that ridge plowing is the most important guarantee of high agricultural yields, apart from irrigation.



◆ 绿水调控: 平原区

➢ 地面覆盖：秸秆还田或地膜覆盖等措施，控制非生产性土壤蒸散发损耗。

➢ 保护性耕作：垄耕种植，削减作物棵间蒸发损耗（无效绿水）；深翻深耕，可以疏松土壤，增加有效绿水。

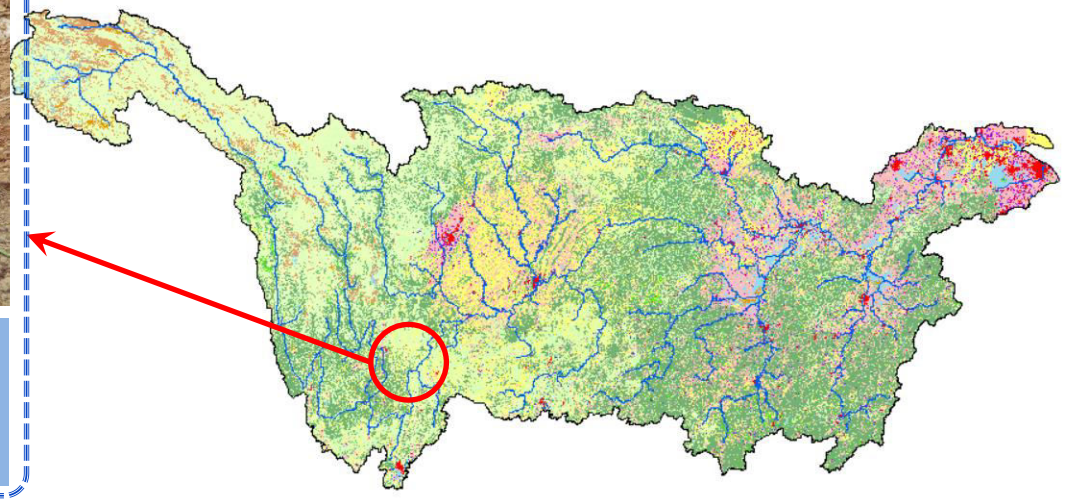
3、Regulation measures of blue and green water resources in the Yangtze River basin

◆ **For blue water regulation , we suggest to store more blue water in the river and lake . It is also important to store blue water in flood season and make full use of it in dry season. In addition, supply more blue water to aquatic ecology in dry season is essential for ecosystem conservation.**

- **Water-saving irrigation——reduce the water use of agriculture**
  - **Efficient water-saving irrigation projects, e.g. drip irrigation and sprinkler irrigation, can effectively improve the efficiency of agricultural irrigation.**
  - **Canal seepage control, a common water-saving irrigation measure that can effectively reduce water losses.**

In April 2023 Panzhihua City, Sichuan Province. Farmers in Xinzhuang Village is installing drip irrigation facilities in their mango orchards

Panzhihua city is near the Jinsha River. Due to the high terrain, it is very difficult to get water from the river, which is a typical engineering water shortage. Drip irrigation facilities have been installed in Xinzhuang Village, and the annual irrigation water per unit area is only 600m^3 / ha, with an annual water saving of more than 11,000 m^3.



- 节水灌溉
  - 高效节水灌溉，如滴灌、喷灌等，可以有效提高农业灌溉水利用效率
  - 渠道防渗，是一种普遍的节水灌溉措施，可以有效降低输水损耗。

3、Regulation measures of blue and green water resources in the Yangtze River basin

◆Blue water regulation

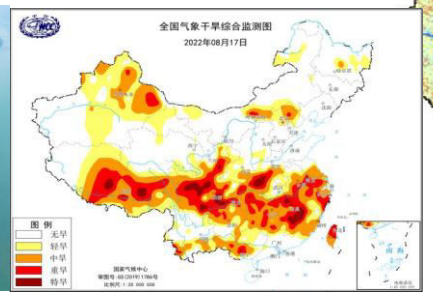
■ Engineering regulation

- Strengthening the capacity of water conservancy projects, e.g. reservoirs and dams, can play a key role in emergency water supply and flood peak reduction.
- The Three Gorges Reservoir can replenish 10~21.5 billion m^3 of water during the dry period, which is favorable for improving the water supply security and ecological environment during the dry period.

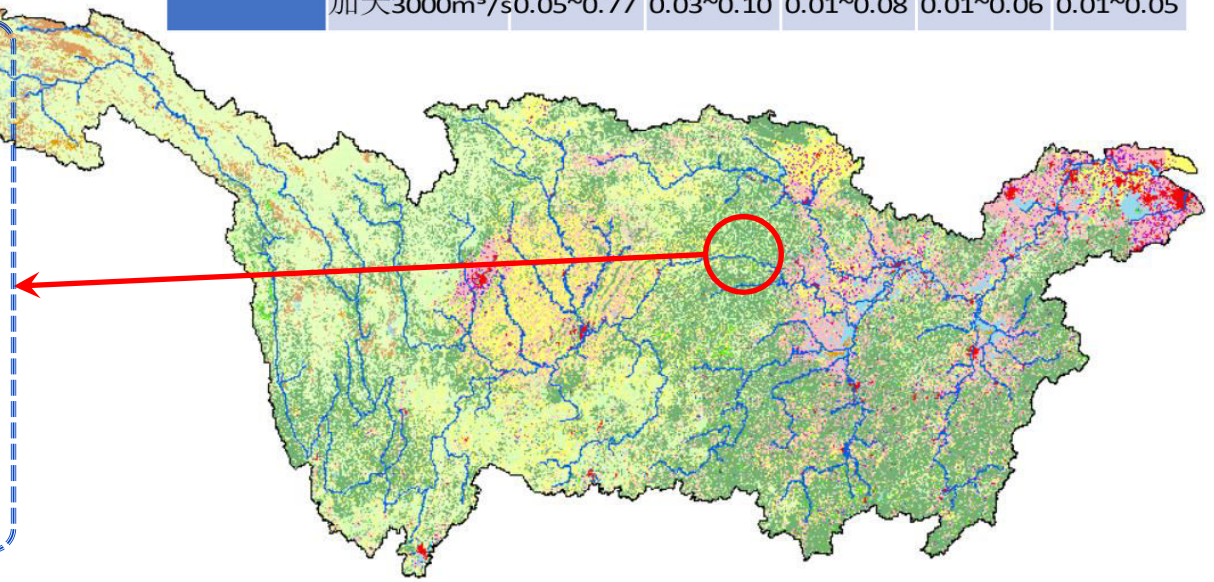
Response of water level at at hydrological stations in the lower reaches of the Yangtze River after recharging the Three Gorges Reservoir

宜昌流量量级（m^3/s）	水库补水方式	水位变幅（m）				
		沙市	城陵矶	汉口	九江	大通
≤6000	加大500m^3/s	0.08~0.13	0.03~0.08	0.02~0.03	0~0.02	0 ~0.01
	加大1000m^3/s	0.30~0.36	0.11~0.14	0.04~0.06	0~0.05	0.01~0.02
	加大2000m^3/s	0.71~0.76	0.21~0.27	0.09~0.10	0.02~0.09	0.02~0.03
8000 左右	加大1000m^3/s	0.02~0.22	0.01~0.06	0.01~0.05	0~0.02	0~0.01
	加大2000m^3/s	0.02~0.47	0.01~0.08	0.01~0.05	0~0.04	0~0.02
	加大3000m^3/s	0.05~0.77	0.03~0.10	0.01~0.08	0.01~0.06	0.01~0.05

In August 2022, Yichang City, Hubei Province, the Three Gorges Reservoir is ready for emergency water replenishment.



In 2022, the Yangtze RiverBasin appeared a rare event of 'returning to dry in flood season', there was a severe drought in the middle and lower reaches. The Yangtze River Water Resources Commission implemented drought contingency plan, increased the flow of the Three Gorges, and replenished 1.48 billion m^3 of water to the downstream.



■ 蓝水资源调控：工程调蓄

➢ 强化水利工程调蓄能力，如水库、大坝等，可以起到应急补水、消减洪峰等关键作用。

➢ 三峡水库在枯水期可补水100~215亿m^3。这对改善枯水期供水安全和生态状况是十分有利的。

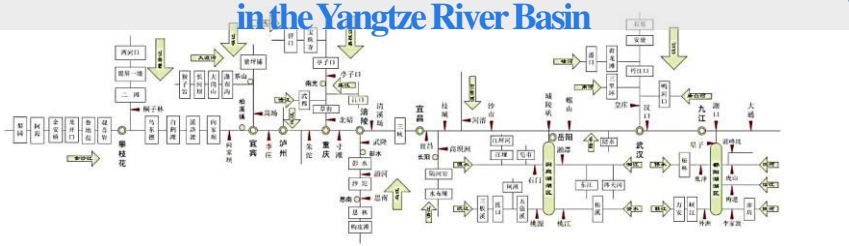
3、Regulation measures of blue and green water resources in the Yangtze River basin

◆Blue water regulation

■ Non-engineering regulation

- ➢ Developed the reservoir group collaborative optimization operation technology to cope with the drought-flood abrupt alternation events, and improve the operation and response ability of flood and drought disasters.
- ➢ During dry season, the average blue water resources in the Yangtze River Basin can be replenished by 16.758 billion m^3, and the proportion of runoff increased from 11.43% to 15.34%.

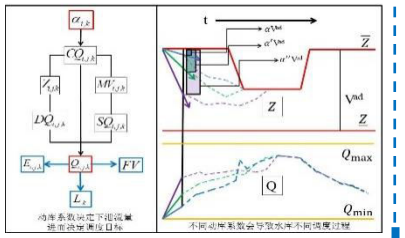
Joint operation model of reservoir groups in the Yangtze River Basin



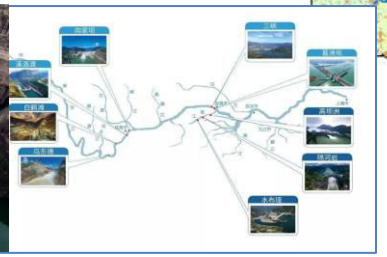
发电量最大
- 流域整体 $maxE_{total}=\sum_{k=1}^{K}\sum_{j=1}^{J}\sum_{i=1}^{I}f(Q_{i,j,k},h_{i,j,k},\eta_{i,j,k})\cdot\Delta t$
- 单个流域 $maxE_i=\sum_{k=1}^{K}\sum_{i=1}^{I}f(Q_{i,j,k},h_{i,j,k},\eta_{i,j,k})\cdot\Delta t$

宜昌断面累计缺水量最小 $minL=\sum_{k=1}^{K}(Q_k^{Need}-Q_k^{EXP})\cdot\Delta t \quad ,Q_k^{EXP}<Q_k^{Need}$

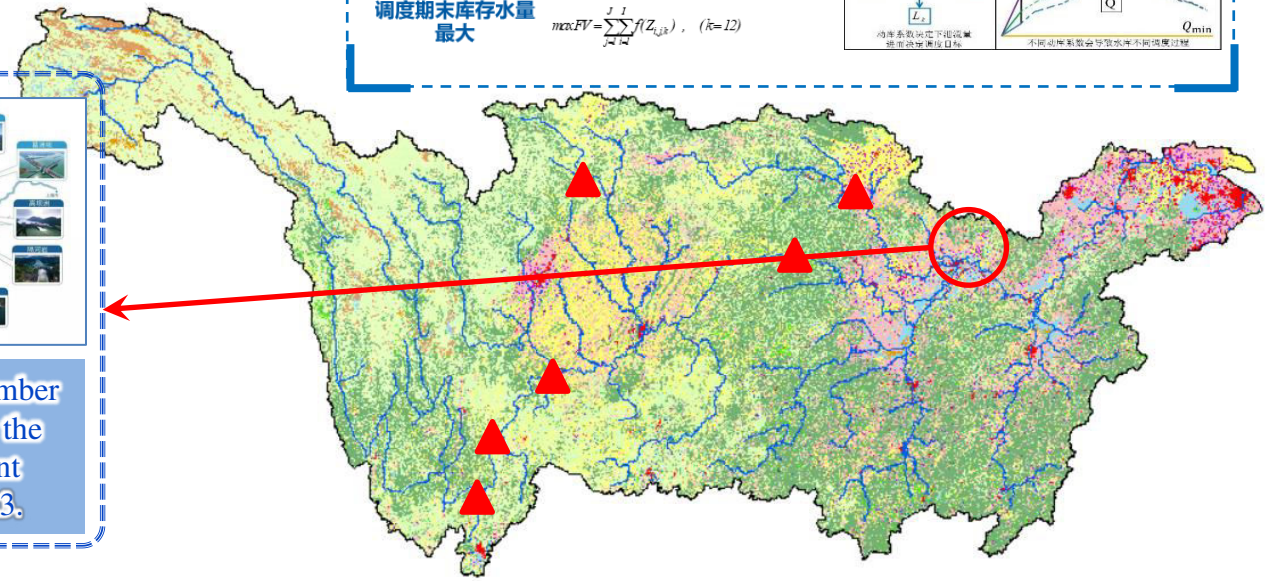
调度期末库存水量最大 $maxFV=\sum_{j=1}^{J}\sum_{i=1}^{I}f(Z_{i,j,k}) \quad ,(k=12)$



On June 29, 2023, The 2023 Plan for Joint Operation of water projects in the Yangtze River Basin was approved by the Ministry of Water Resources



The Plan further expands the scope of joint operation, increasing the total number of water projects included in joint operation from 111 to 125. Among them, the total regulation capacity of the 53 controlled reservoirs included in the joint operation is 116.9 billion m3, and the total flood control capacity is 706 m3.



■ 非工程调蓄

➢ 研发应对旱涝急转的水库群协同优化调度技术，提高洪旱灾害调度应对能力。

➢ 建立长江流域水库群供水调度模式，提高了下游用水安全保障水平。长江流域枯水期平均可补充蓝水资源167.58亿m^3，径流占比由11.43%提高至15.34%。

3、Regulation measures of blue and green water resources in the Yangtze River basin

◆Blue water regulation

■ Management of water intake permits

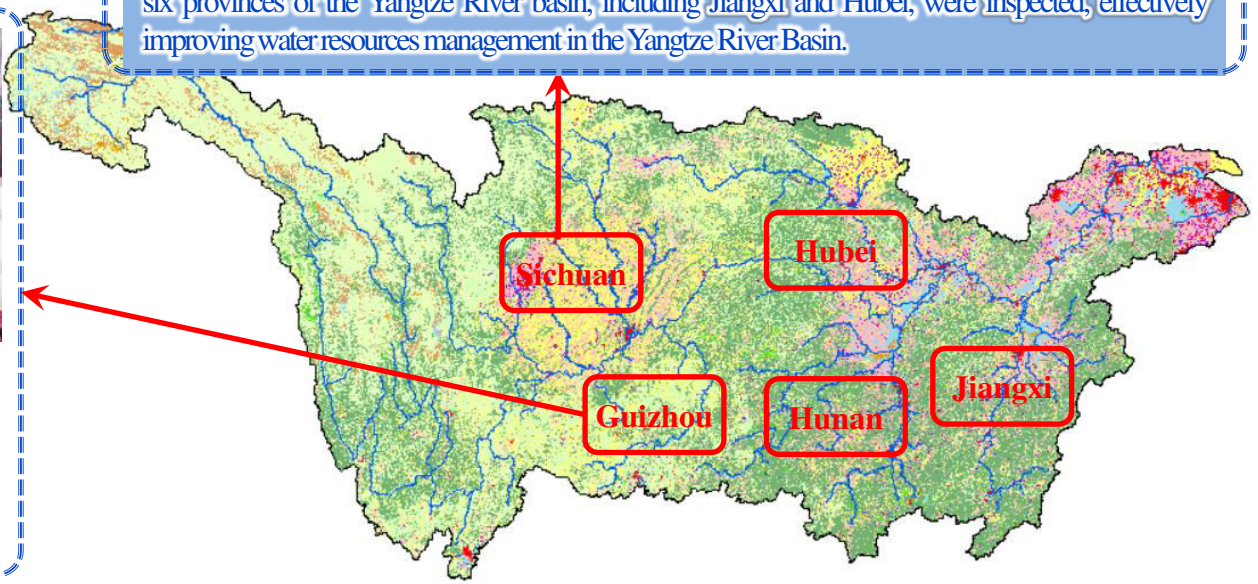
- ➢ to encourage the use of advanced water-saving technologies, reduces water allocation of industries with high water consumption and high pollution,
- ➢ to implement the strictest water resources management, and ensure the E-flow of rivers and lakes.

The inspection working group of the Yangtze River Water Resources Commission was sampling the rectification of water intake of Chongzhou Ni's Paper Co., LTD in Chongzhou City, Sichuan province, September 2020

In September 2020, the Yangtze River Water Resources Commission launched a special campaign to improve water consumption management in response to issues such as whether to reissue water permits and whether to standardize water consumption. A total of more than 1,800 water intake units in six provinces of the Yangtze River basin, including Jiangxi and Hubei, were inspected, effectively improving water resources management in the Yangtze River Basin.

The verification working group of the Yangtze River Water Resources Commission inspects materials related to the water abstraction license of Shuishenmiao Pumping Station in Xishui County, Guizhou Province, October 2019

In October 2019, the Yangtze River Water Resources Commission launched a verification and registration campaign for water intake projects (facilities) in response to prominent problems in water intake management such as whether to apply for water permits and whether to obtain water permits, and recorded a total of more than 20,000 water intake projects (facilities) in the Yangtze River basin. It also supervised local departments to rectify problematic water intake projects within a specified time limit.



■ 取水许可管理

➢ 通过取水许可管理，鼓励使用先进节水技术，减少高耗水高污染行业用水，施行水资源刚性约束管理制度、保障河湖生态环境需水。


Thanks for your attention