Water Security in China: Problems, Pathways and Practices

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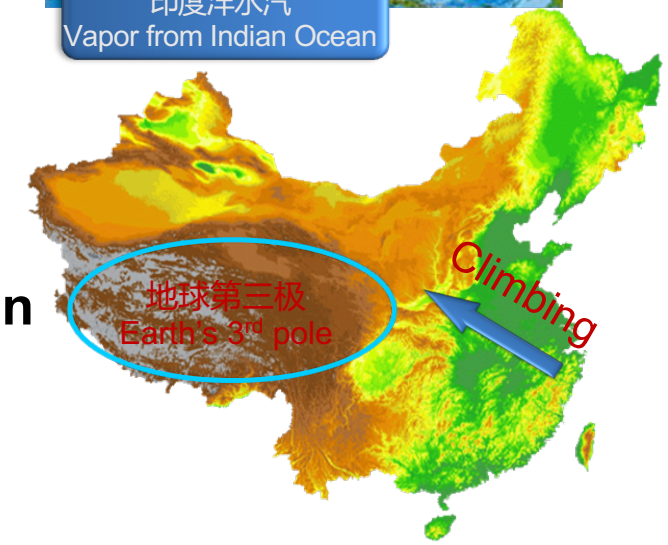
Water Security in China

Location

Elevation



Socio-economic development

→ Monsoon Climate

→ Uneven Spatial Distribution of Precipitation

→ Increasing of Water demand & pollution

1. **Water shortage (drought)**
2. **Floods & storm surge**
3. **Water pollution**

Outlines

1. Shortage of Water
2. Flood & Storm Surge
3. Water Pollution
4. Conclusions

1

水资源短缺

Shortage of Water Resources

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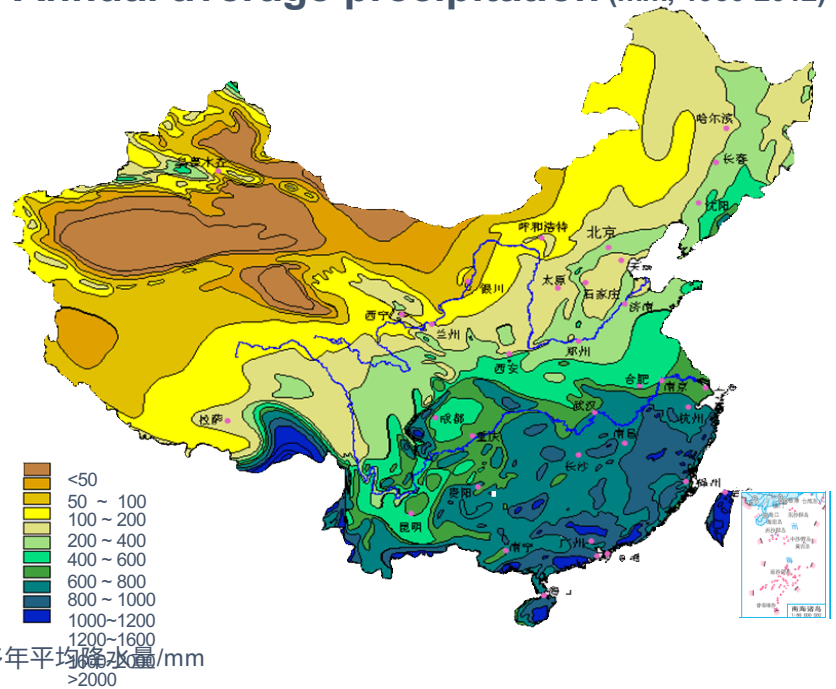
1. Shortage of Water Resources

Annual average precipitation (mm, 1950-2012)



Annual precipitation: **648mm**, **20%** lower than global average

Annual water availability per capita is **2100** m³, which is only **28%** of world's average.

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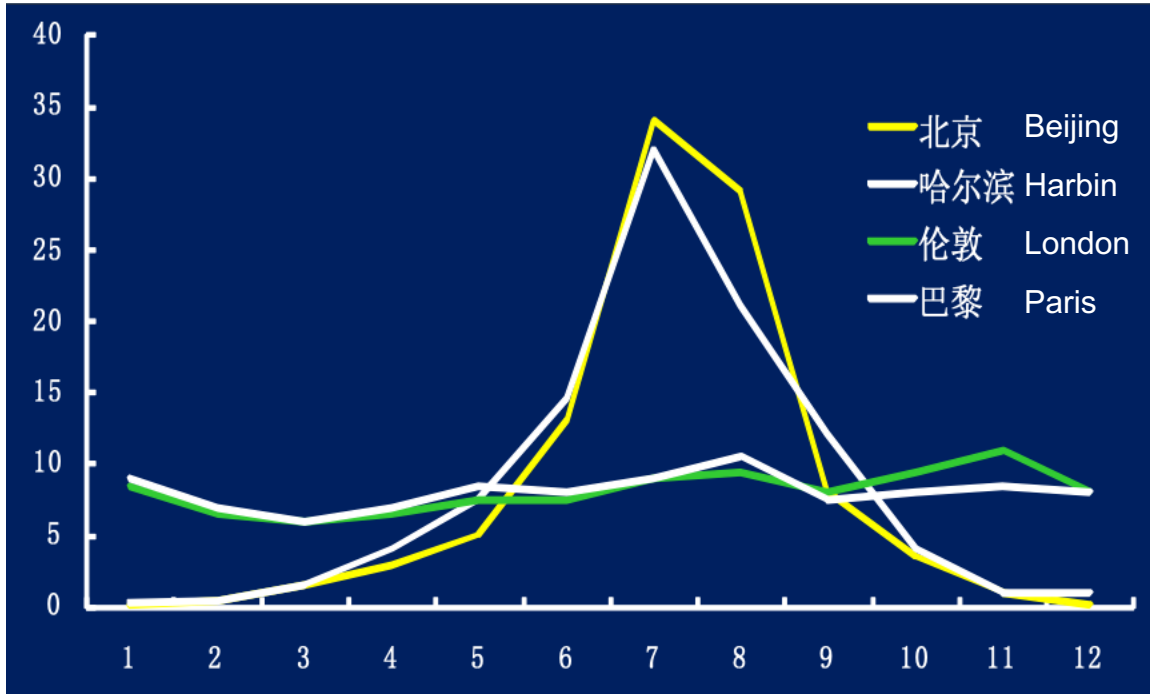
1. Shortage of Water Resources



1. Under a monsoon climate, China's precipitation is unevenly distributed over the year. It receives **60-70% of its precipitation in the rainy season** (July to September).

2. This allows the **dual and frequent occurrences of droughts and floods**

3. The lack of storage infrastructures makes it highly responsive to rainfall, **immediate flood/drought with/without precipitation**

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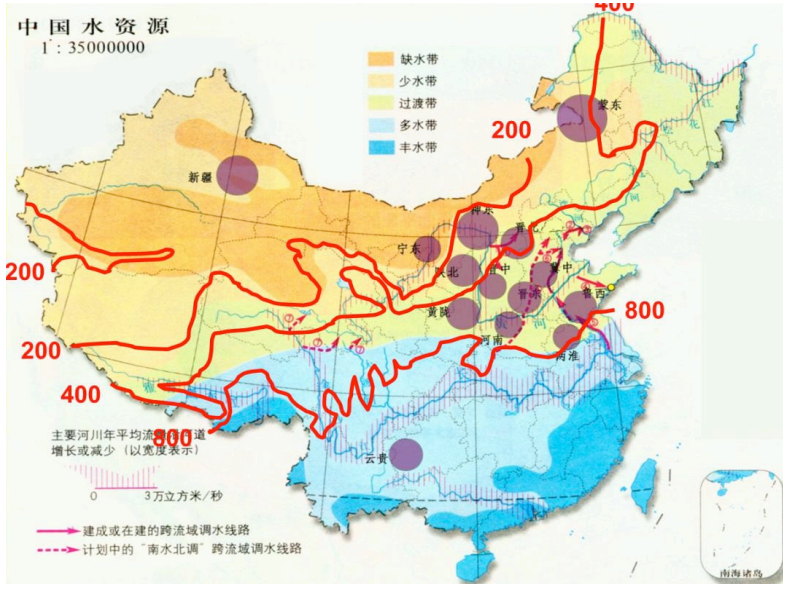
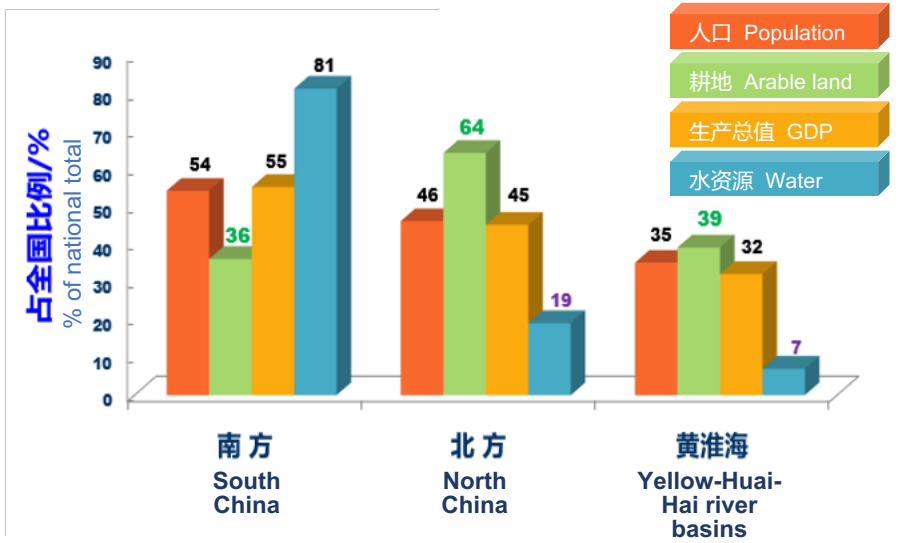
1. Shortage of Water Resources

The monsoon climate makes precipitation in China highly unevenly distributed over its territory, with a general pattern of **flooding in the south and drought in the north**. c.2000-3000mm in the south, c.20-30mm in the north.

There is **an evident mismatch between water and productivity**, which seriously constrains socio-economic development. For example, North China supports 46% of its population with only 19% of its water resources, and it accounts for 45% of national GDP but possess 64% of total arable land.





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1. Shortage of Water Resources

(1) **Water shortage** (2nd National WR Assessment, 2012):

50 billion m³ in normal years (75%)

c.**400** cities in shortage, c.**110** in severe shortage (661 cities in total)

(2) Water shortage not **only restricts development of economy and society**, but also **occupies environmental flow** and **degrades ecological system** and environment.

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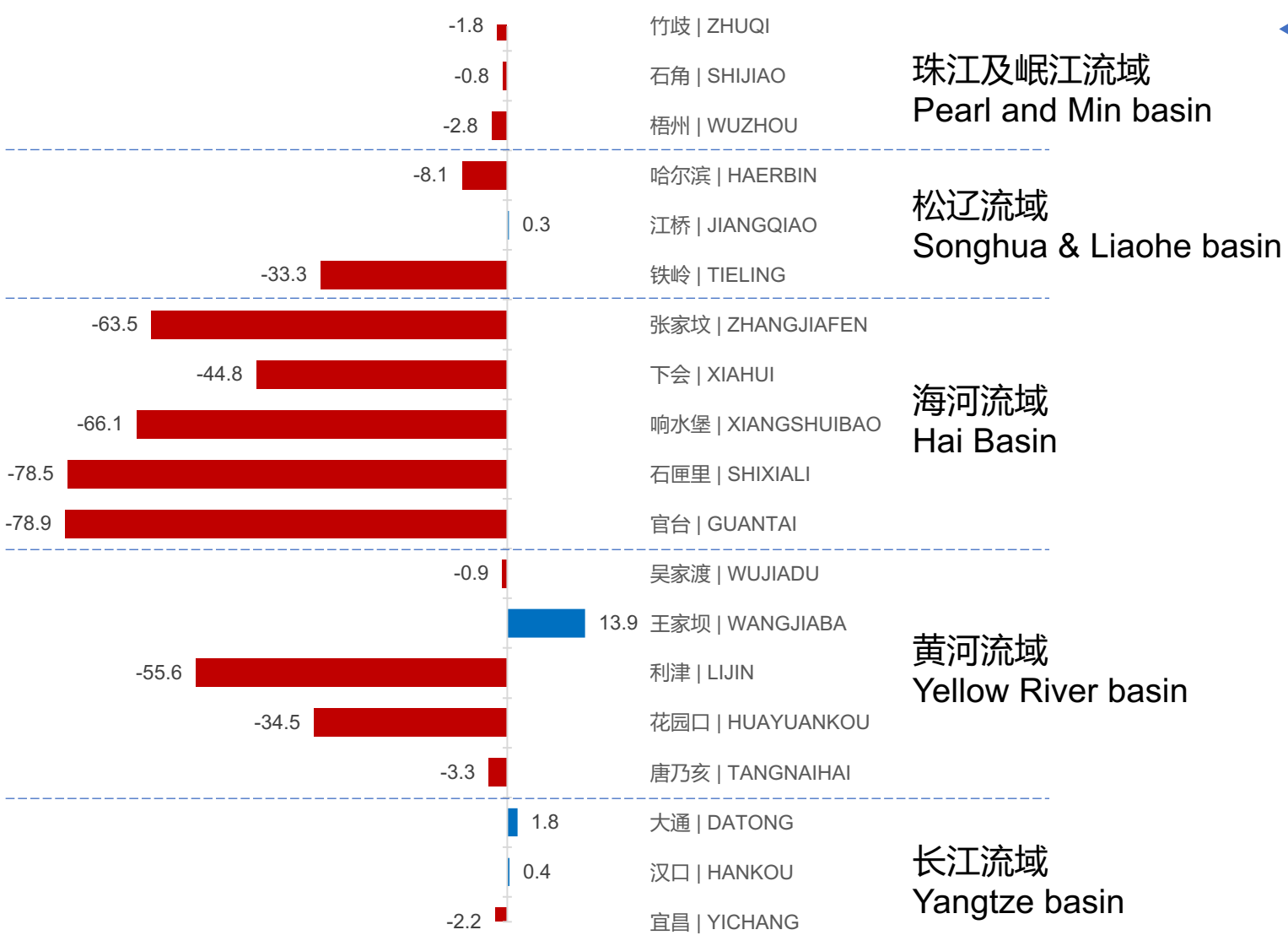
1. Shortage of Water Resources



Runoff change at key gauge stations on China's major rivers (1980-2012 minus 1956-1979)

- **River flow decreasing in general with environment degradation**
- **Evident decrease in basins of Hai, Liao and Lower Yangtze**
- **North China becoming more water scarce**

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1. Shortage of Water Resources

Solution (1): Strengthen demand side management

① Implementation of the most stringent water management system by

State Council since 2012.

Setting up 3 Red Lines for

- Total consumption
- Water use efficiency
- Water quality


中华人民共和国中央人民政府
The Central People's Government of the People's Republic of China
www.GOV.cn

国务院办公厅关于印发实行最严格水资源管理制度考核办法的通知

国办发〔2013〕2号

各省、自治区、直辖市人民政府，国务院各部委、各直属机构：

《实行最严格水资源管理制度考核办法》已经国务院同意，现印发给你们，请认真贯彻执行。

国务院办公厅

2013年1月2日

（此件公开发布）

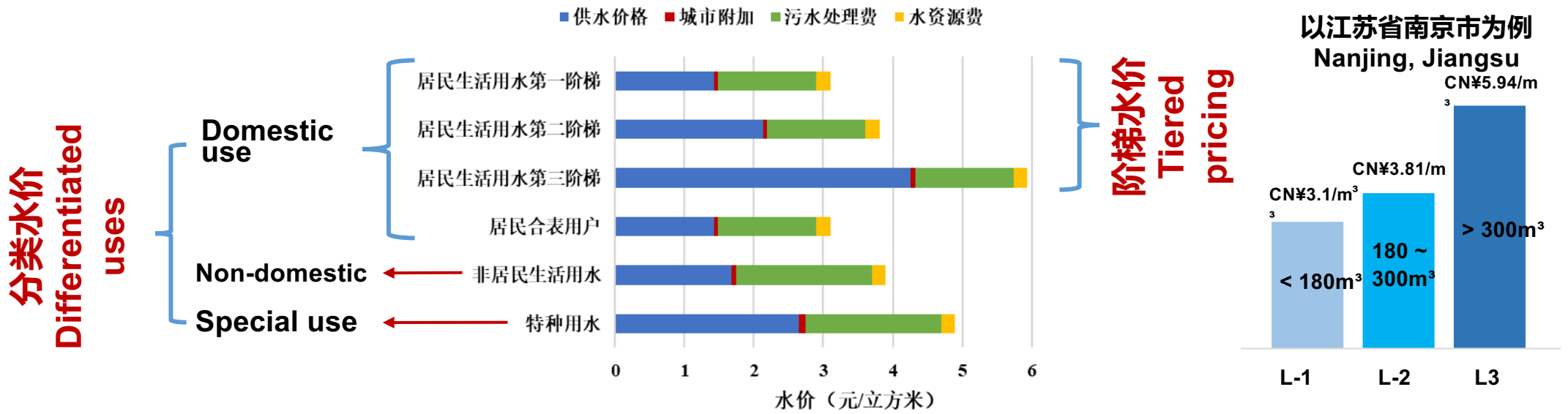
End year	National total consumption (10^8 m^3)	Water consumption per 10,000 CNY industrial added value (10^8 m^3)	Efficiency of irrigation	Water quality compliance of in major water function zones
2020	6700	<65	>0.55	80%
2030	7000	<40	>0.60	95%

1. Shortage of Water Resources

Solutions: (1) . Strengthen demand side management

② Policies for building a water-saving society since 2002

Setting up policies and regulations, for example, differentiated and tiered water pricing plays a very important role in saving water.

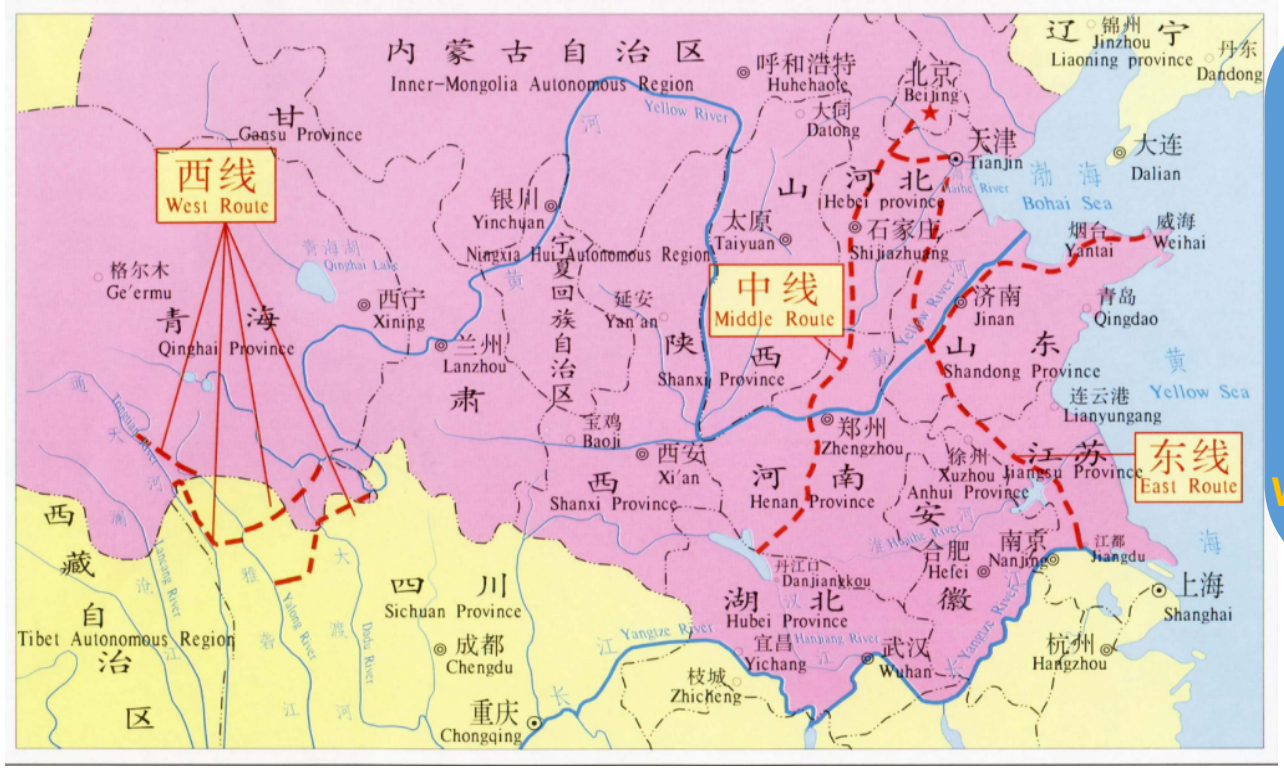


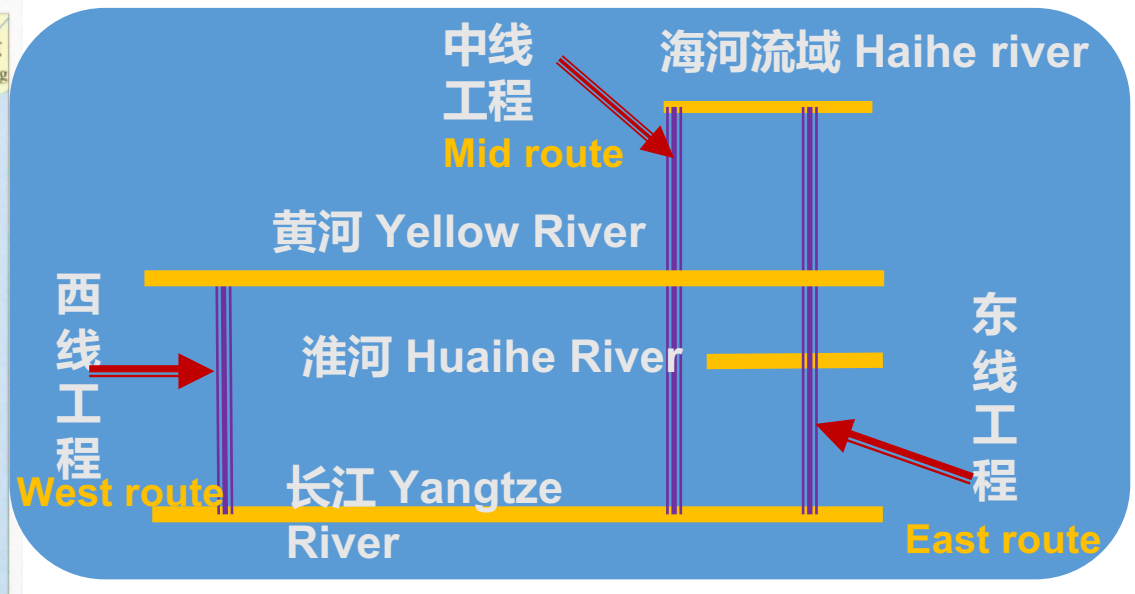
1. Shortage of Water Resources

Solution (2): Inter-basin water transfer

Transferring water from the Yangtze (1,000 billion m^3/a) basin to the north

→ Re-allocating water according to socio-economical development





A national water grid of 4 rivers &
3 vertical inter-basin water transfer routes

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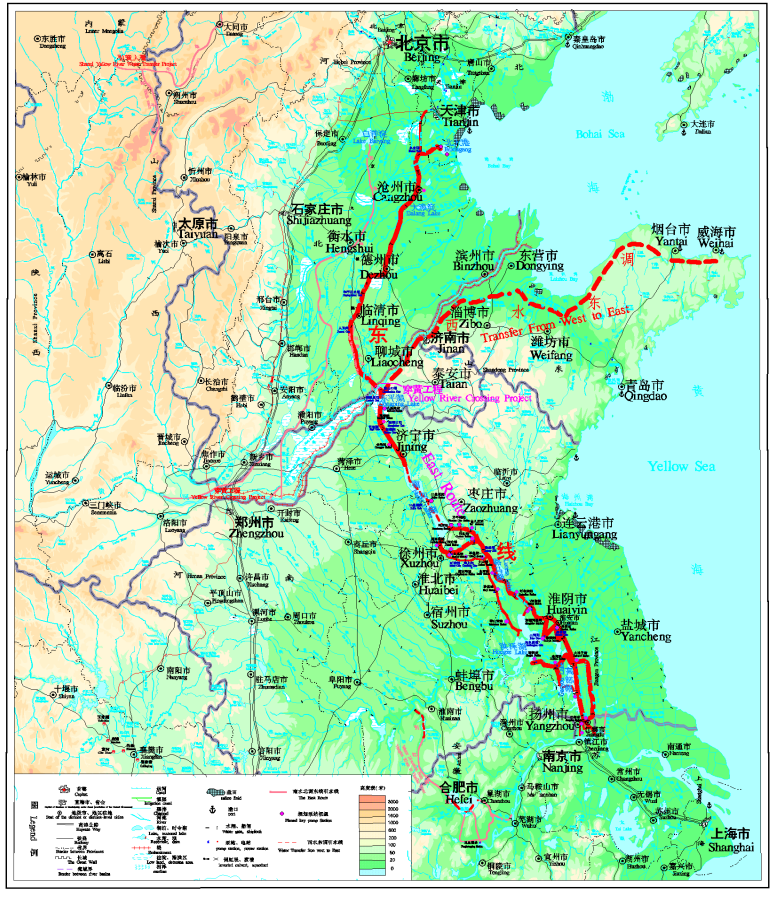
1. Shortage of Water Resources

Transferring water from the Yangtze basin to the north

南水北调东线位置图
The East Route scheme of the South-to-North Water Transfer Project



East Route

- **Source:** Jiangdu，Jiangsu
- **Terminus:** Sandong/Tianjin
- **Length** of delivery: 1150km
- First-phase (by 2014) pumping **capacity**: 600-700 m^3/s
- Since completion in Nov. 2013，c.4.6 billion m^3 water to Shandong

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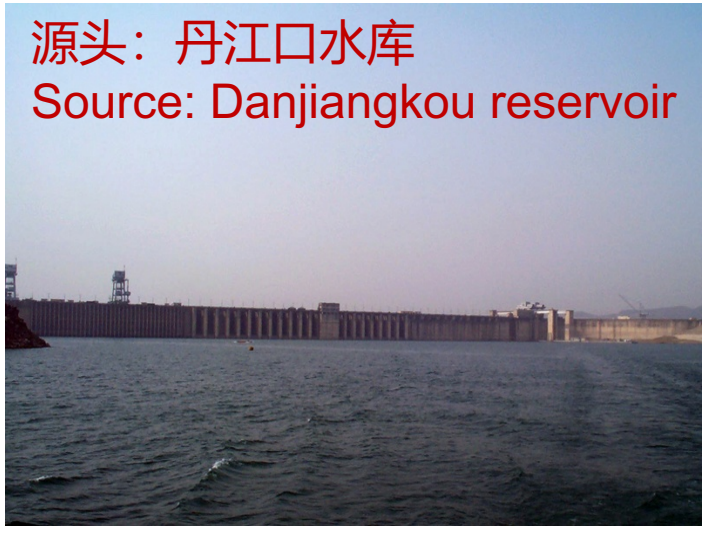
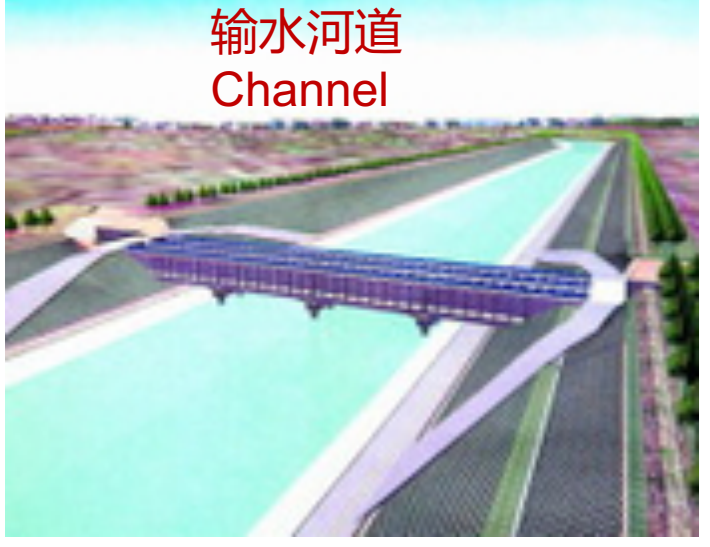
1. Shortage of Water Resources

transferring water from the Yangtze basin to the north

Middle Route

- **Source:** Danjiangkou Reservoir
- **Terminus:** Beijing, Henan, Hebei & Tianjin
- **Length** of delivery: 1246km
- First-phase (by 2014) pumping **capacity**: 350m³/s
- In operation since Dec. , 2014, 32.6 billion m³ water transferred





1. Shortage of Water Resources

Solution (3) : Exploring new water sources

- Constructing of **basin-scale flood control and regulation projects**, and improving use of flood water by real-time forecasting and operation
- Increasing **usage of recycled water**
- Exploring **sea water desalination** & usage

2

洪涝灾害和风暴潮

Flood & Storm Surge

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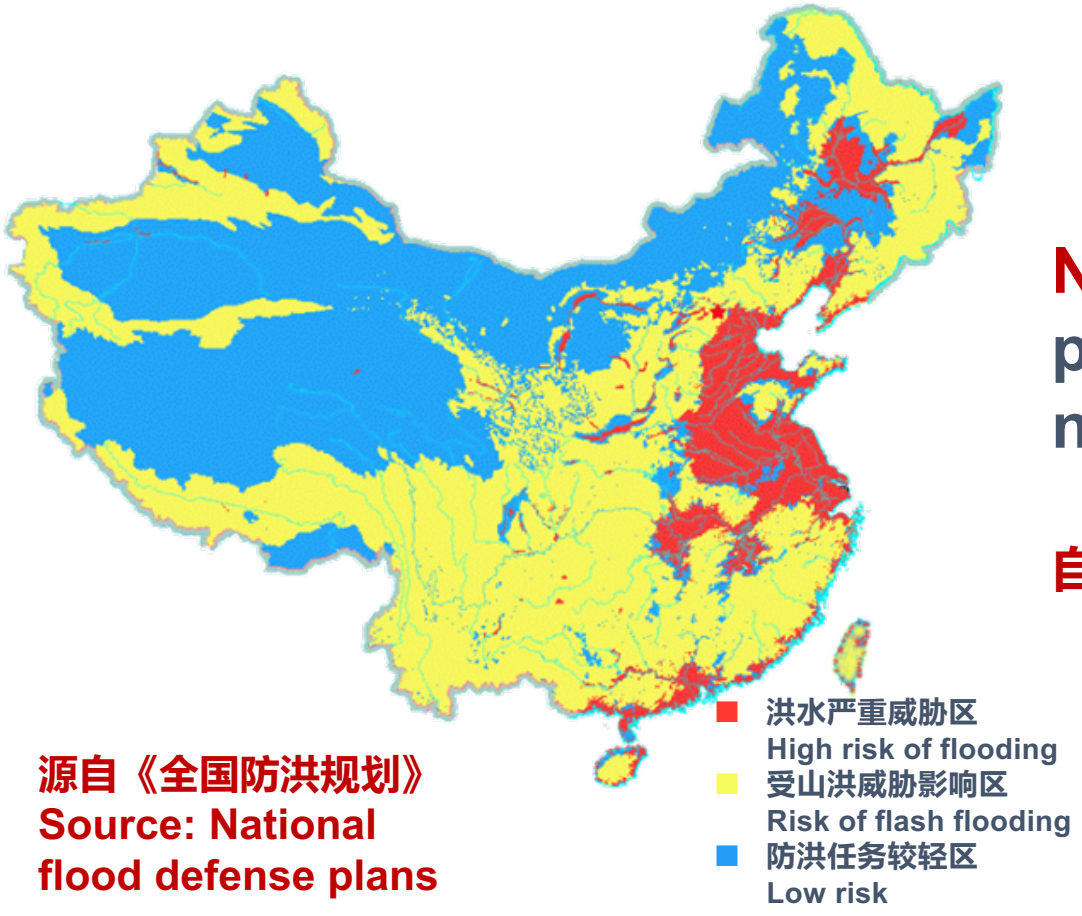
2. Flood & Storm surge

- **2/3 of the territory** under flood risk
- **2/3 of all cities** suffering from urban pluvial flooding



源自《全国防洪规划》
Source: National flood defense plans

Natural features: flooding as a prominent and constant natural disaster.

自然禀赋：洪涝始终是中国突出的自然灾害。

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2. Flood & Storm surge

2020 is a year of **abundant precipitation** and therefore **severe flooding**.

The Yangtze: basin scale flooding with 5 flooding events. Highest-ever records at Dongting Lake, Poyang Lake and Chao Lake. The Three Gorges Project played a crucial role in retaining flood and therefore produced significant benefit.

Huai river: Basin scale flooding; 8 retention areas were used for flood storage.

Taihu Lake: Basin scale flooding

2. Flood & Storm surge

Increased flooding in China is found to be correlated to climate change and anthropogenic activities

2007	济南	Jinan
2010	广州、重庆	Guangzhou, Chongqing
2012	北京	Beijing
2013	宁波、余姚、上海	Ningbo, Yuyao, Shanghai
2015	上海、常州、镇江、南京	Shanghai, Changzhou , Zhengjiang, Nanjing
2016	武汉、南京、郑州	Wuhan, Nanjing, Zhengzhou
2017	广州、长沙、重庆、南京	Guangzhou, Changsa, Congqing, Nanjing
2018	北京、南京、武汉	Beijing
2019	广州、深圳	Guangzhou, Shenzhen
2020	广州	Guangzhou

2. Flood & Storm surge

2013.10.8, Yuyao after Typhoon Fitow

2016.6.17, Shanghai

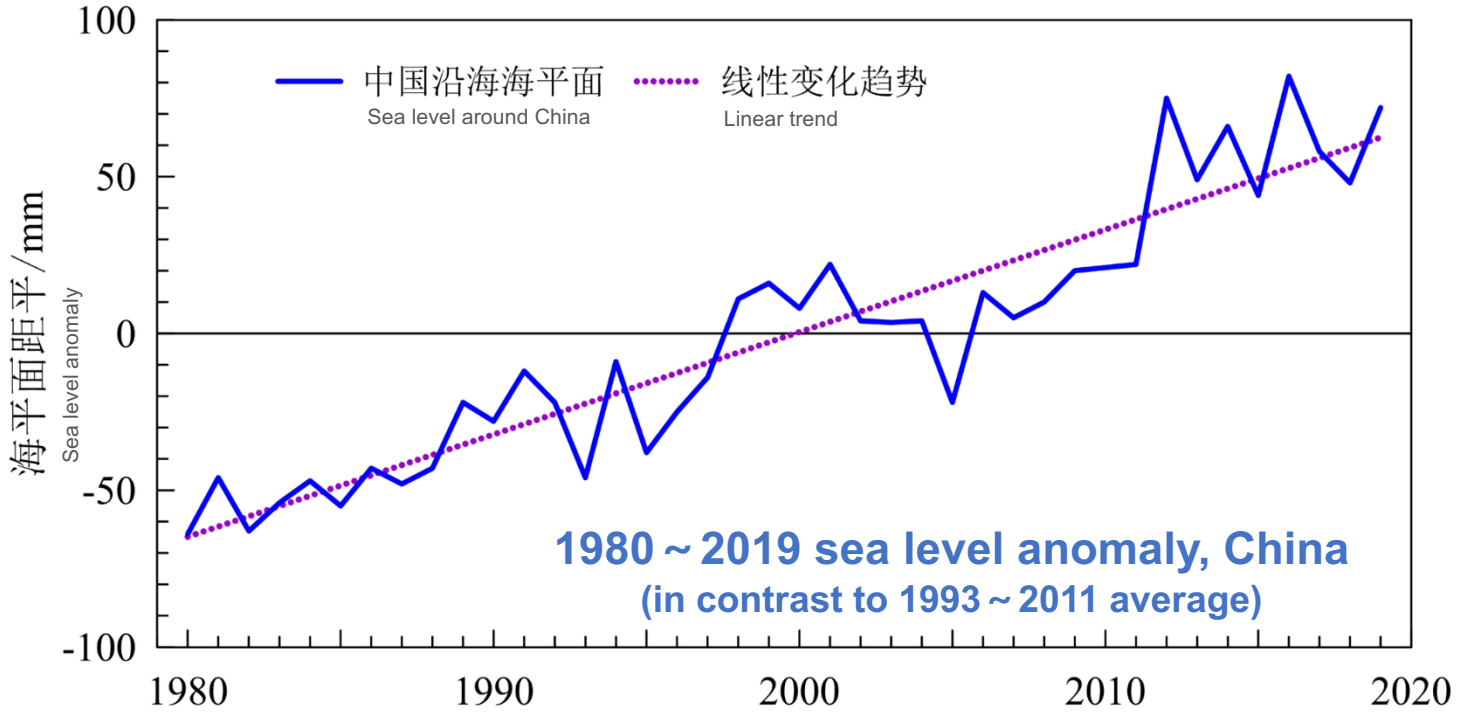
2016.7.19, Xiamen after Typhoon Cimaron

2019.4.12，Shenzhen

2020.5.22, Guangzhou, Water depth: 1.65m

2020.5.22, Guangzhou after a storm

2. Flood & Storm surge



- Lowered standards of sea defence
- Impacted estuarine ecosystems
- Increased risks of fresh water supply

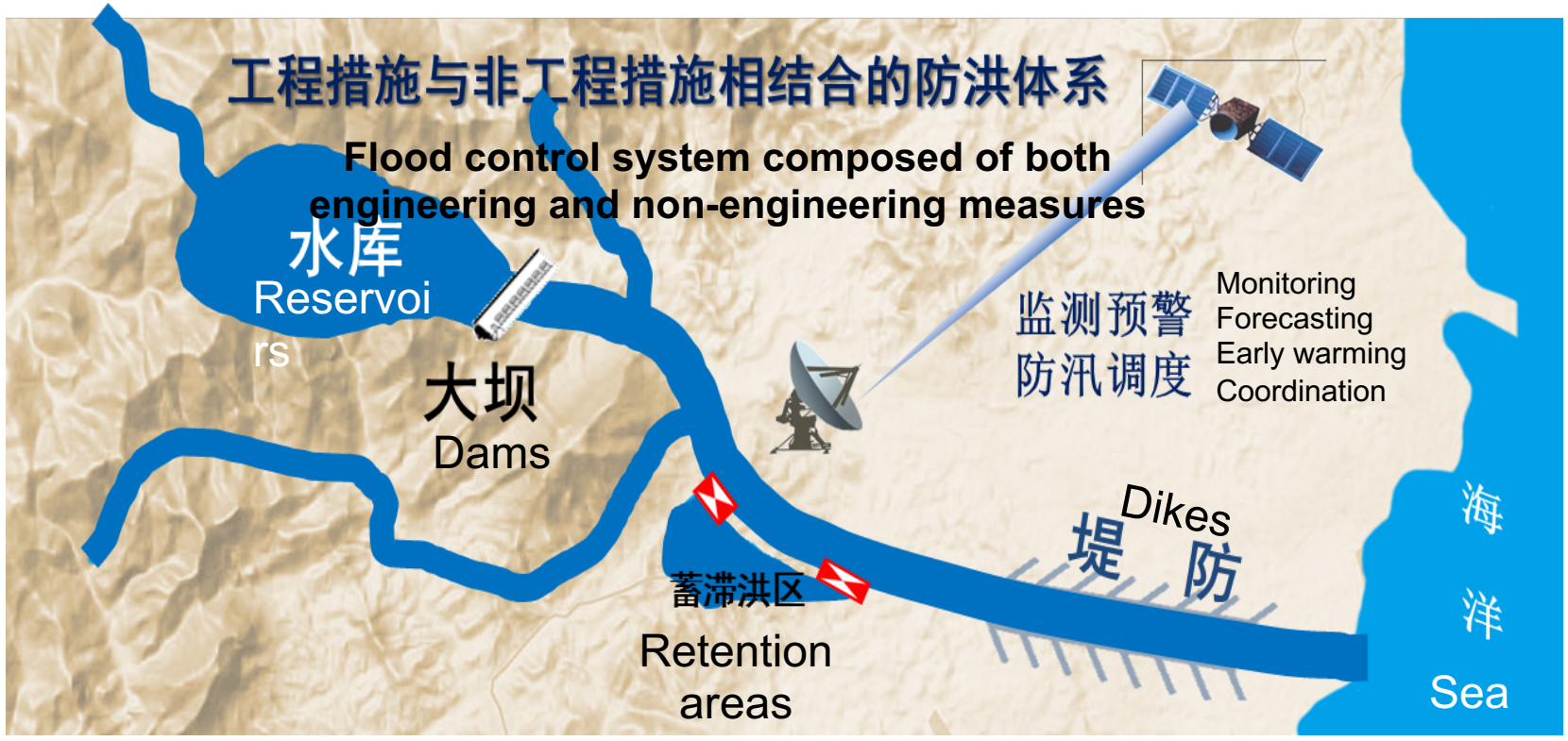
China Sea Level Bulletin (2019) :

Sea level rise is gaining pace on a global scale with an average of 3.2 mm/a between 1993 and 2019.

Sea level around China, although fluctuating, is on a rising trend with an annual average of 3.4 mm, which is higher than meantime global average.

2. Flood & Storm surge

Solution (1): Integrated flood control and disaster relief system combining dikes, reservoirs and retention areas

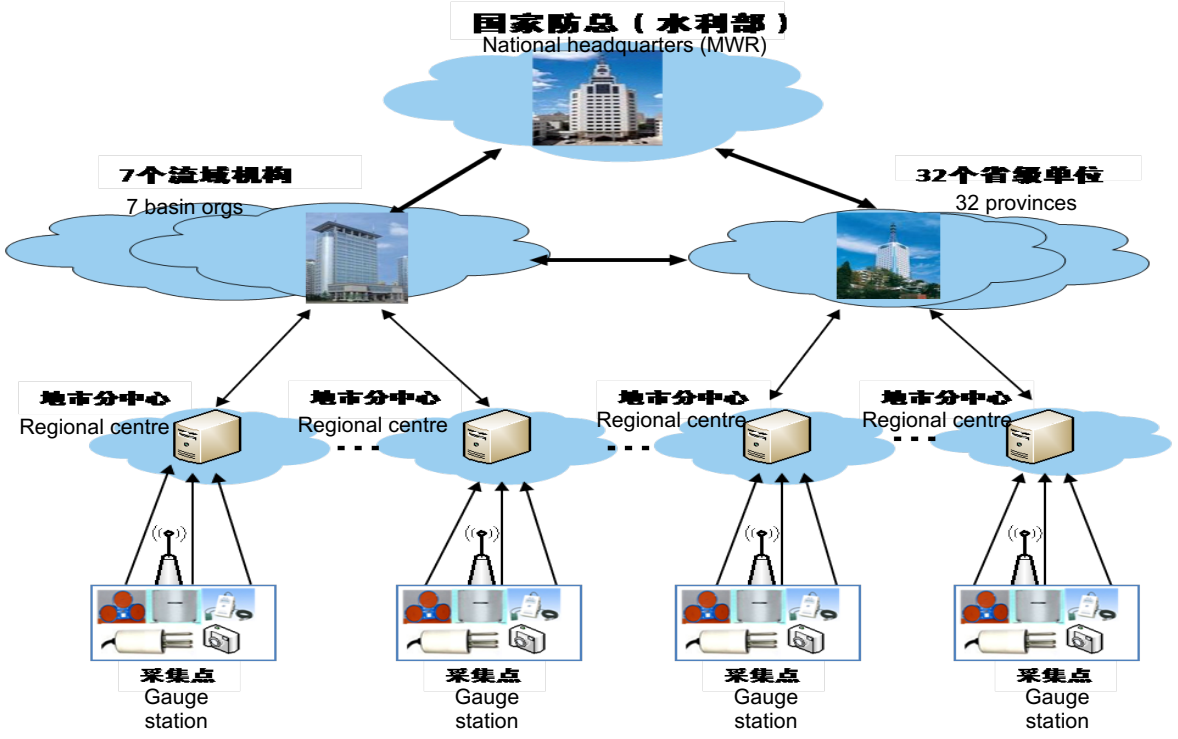


The engineering components:

Reservoirs: 98,000
River Dikes: 340,000 km
Sea wall: 145,000km
Retention area: 98

2. Flood & Storm surge

Solution (2): National commanding system for flood control (NCSFC)



NCSFC composure:

- Data collection
- Communication network
- Realtime forecasting
- Decision support
- Commanding and relief

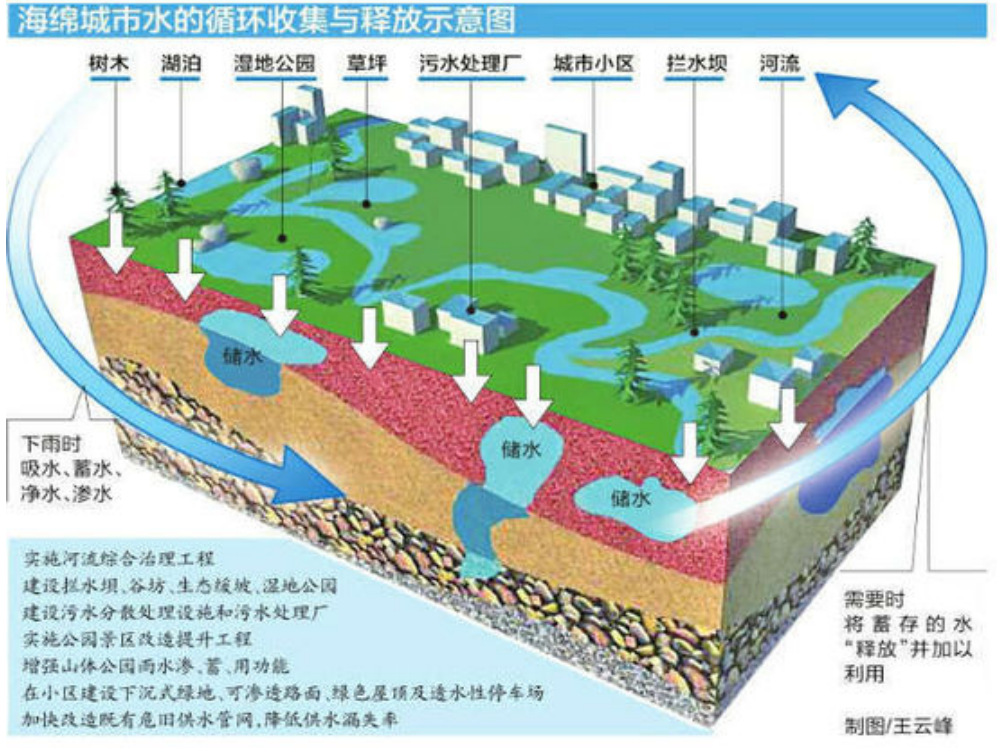
2. Flood & Storm surge

Solution (3): The Sponge City

A concept proposed by Xi Jinping in December 2013:

A “Sponge City” that prioritizing local retention of rainwater and relies more on natural drainage, storage and infiltration.

Six key processes of a “Sponge City”: infiltration, retention, storage, purification, reuse and discharge



2. Flood & Storm surge

Solution (3): The Sponge City

Priorities

- Integrated management of urban water bodies and shorelines
- Flood control and drainage system
- Resource allocation and efficiency
- Protection of water resources and rehabilitation of aquatic ecology
- Prevention of soil erosion
- Water management capacity building

2. Flood & Storm surge

Solution (3): The Sponge City

In cities which suffers great loss from urban flooding, if surface drainage and storage are too expensive to build, large scale underground storage and treatment facilities are necessary, such as deep storage tunnels.

法国马赛中心广场地下蓄水场所
Underground flood storage tank in downtown Marseilles

广州东濠涌深隧工程
Guangzhou,China

- 调蓄容积：
  Storage:
  $165.2 \times 10^4\ m^3$
- 对初期雨水处理，消减70%污染
  Reducing 70% of pollutants after initial processing
- 缓解城区内涝
  Easing water logging

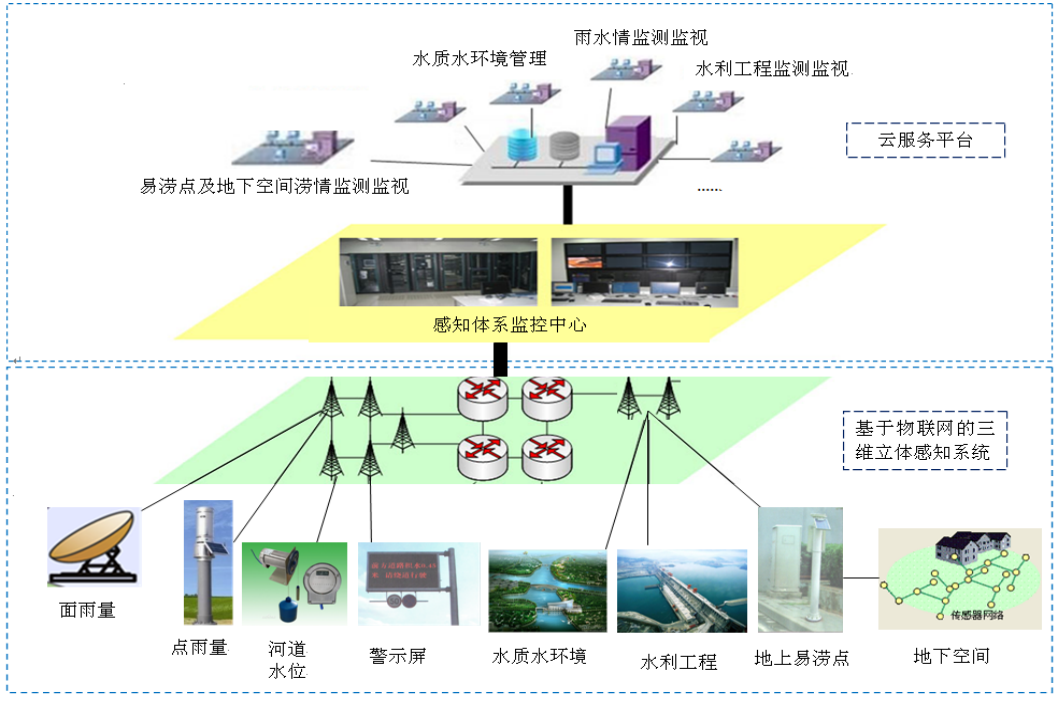
On-going projects are in Shanghai, Beijing and Shenzhen, etc.

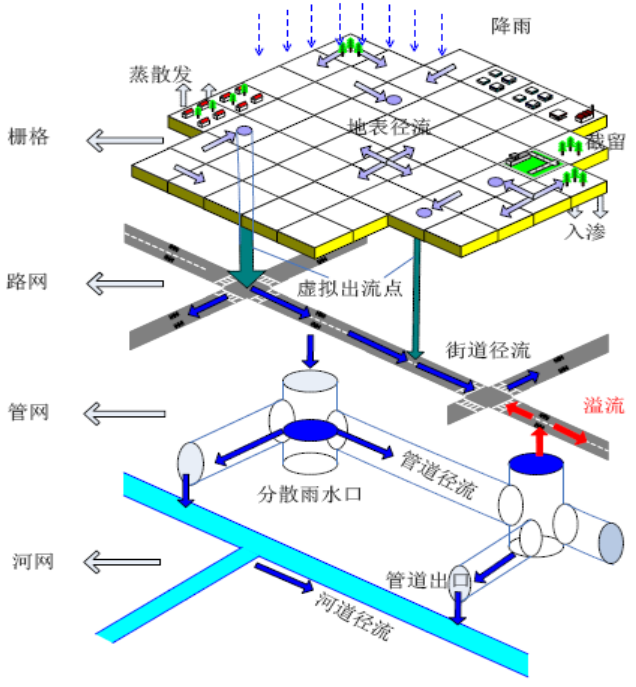
2. Flood & Storm surge

Solution (3): The Sponge City

Non-engineering measures are also important components to urban flood control, including multi-dimensional monitoring, timely and accurate forecasting, dynamic and real-time risk assessment and decision support systems.

信息立体监测
Multi-dimensional monitoring





多层模型耦合
Coupling of multiple models

2. Flood & Storm surge

Solution (3): The Sponge City

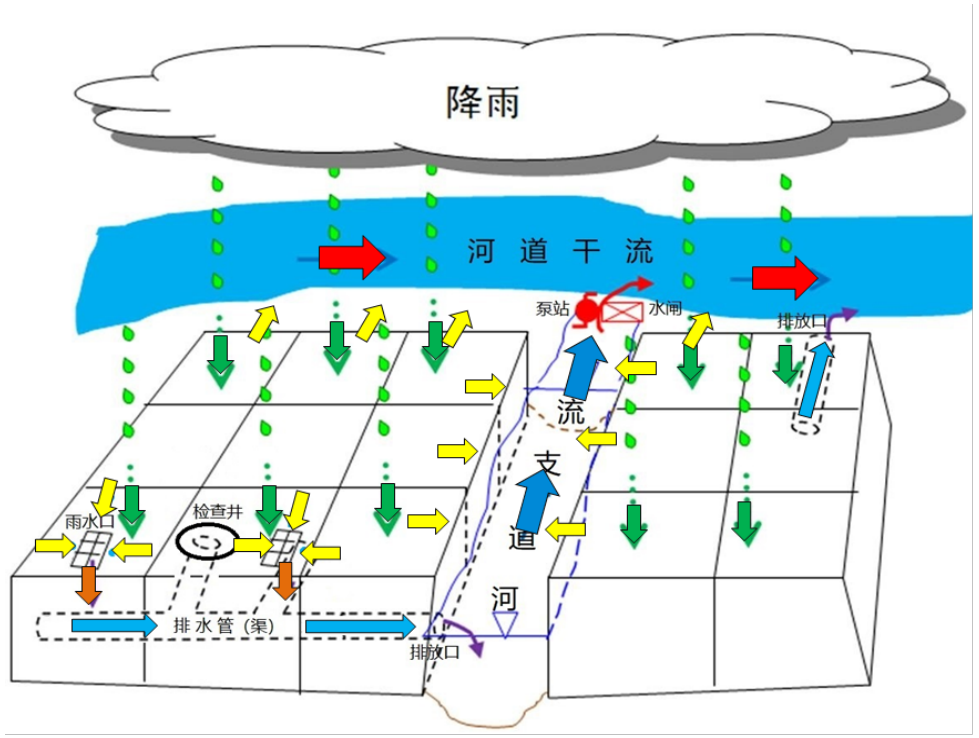
X-band dual-polarization precipitation radars and atmospheric vapor monitoring

- Radar observation
- Rain droplet size spectrum
- Per minute precipitation

2. Flood & Storm surge

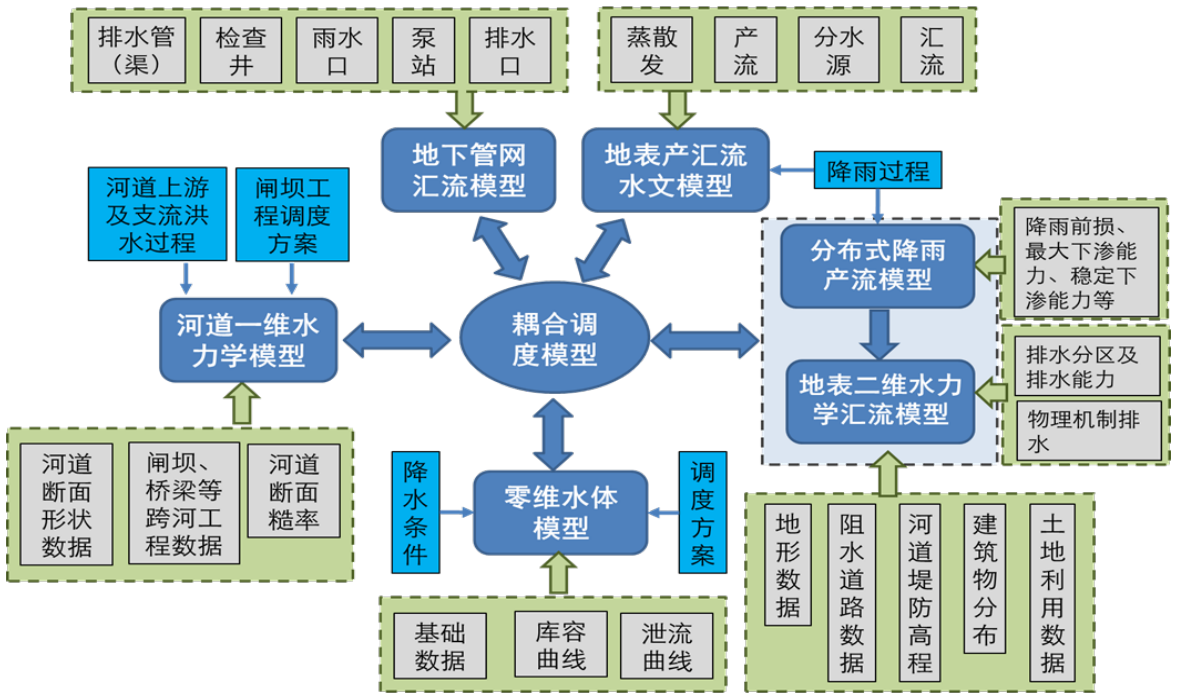
Solution (3): The Sponge City

Coupled modeling of the full process of urban flooding



城市雨水产汇流物理过程

Rainfall-runoff process



城市洪涝模拟模型结构图

Full process modelling of urban flooding

3

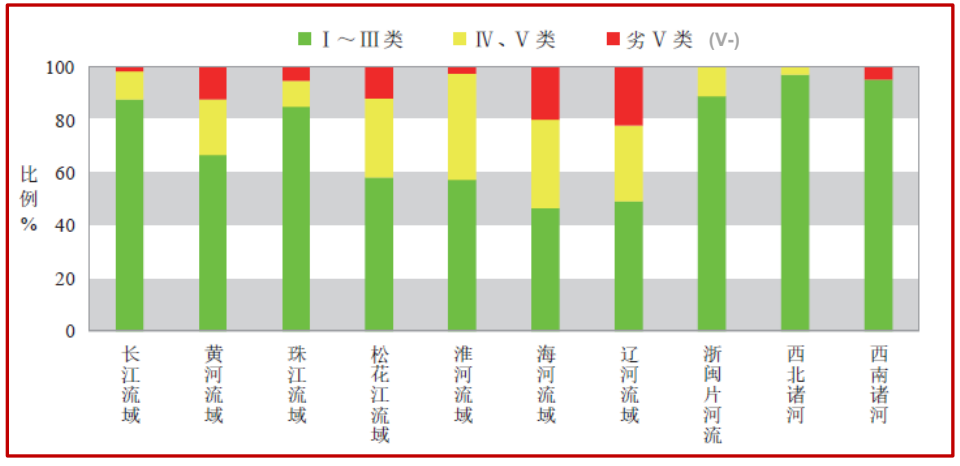
水体污染

Water Pollution

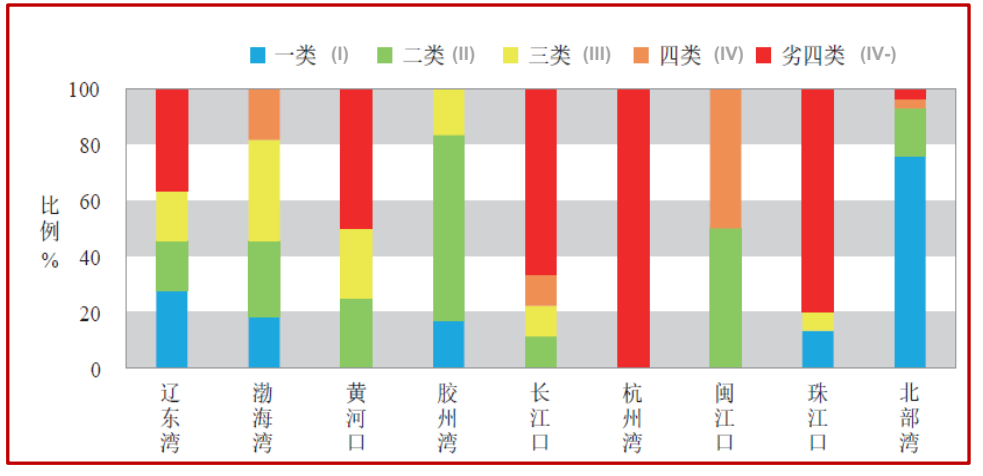
Water Pollution

Water pollution is a prominent and enduring problem

Water quality 2018 by basin



Water quality 2018 at major estuaries



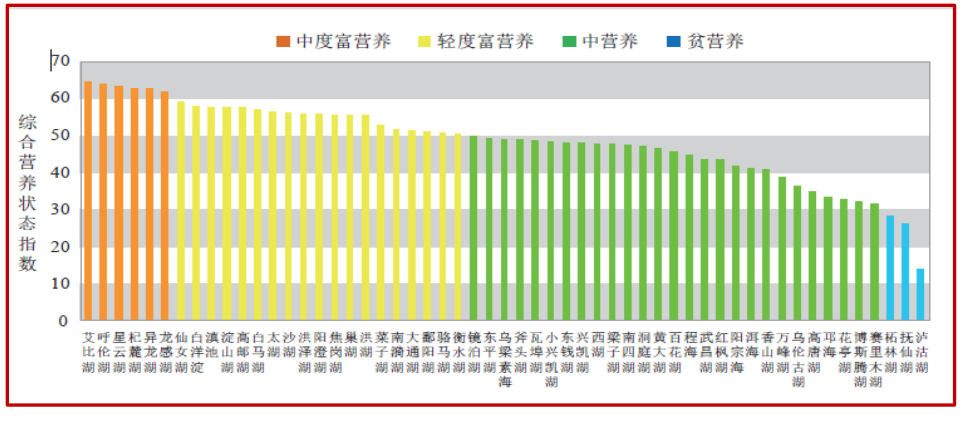
Water quality classes of China

Good

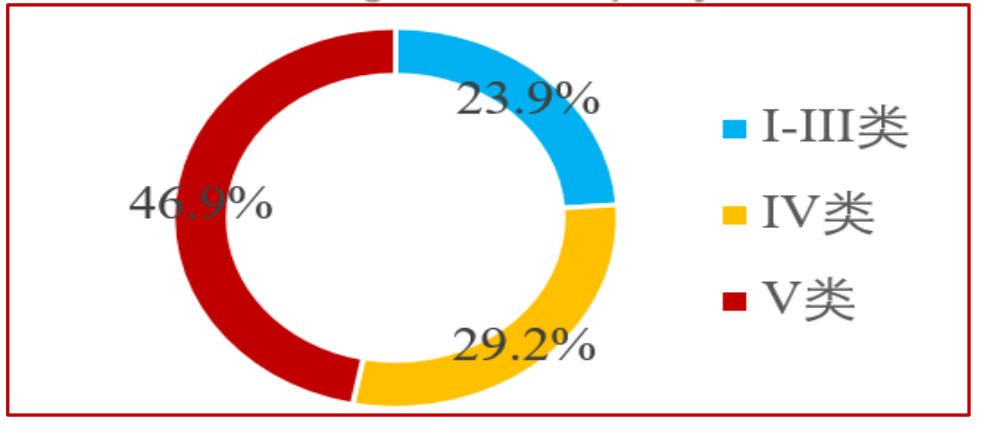
Class I
Class II
Class III
Class IV
Class V
Class V-

Heavily polluted

Eutrophication of major lakes 2018



Shallow ground water quality 2018



Water Pollution

Solution (1): Source control to reduce loading

- Reducing the use of fertilizers and pesticides, centralizing aquaculture and wastewater treatment, to reduce non-point source pollution
- Regulating compliance of industrial effluence

Water Pollution

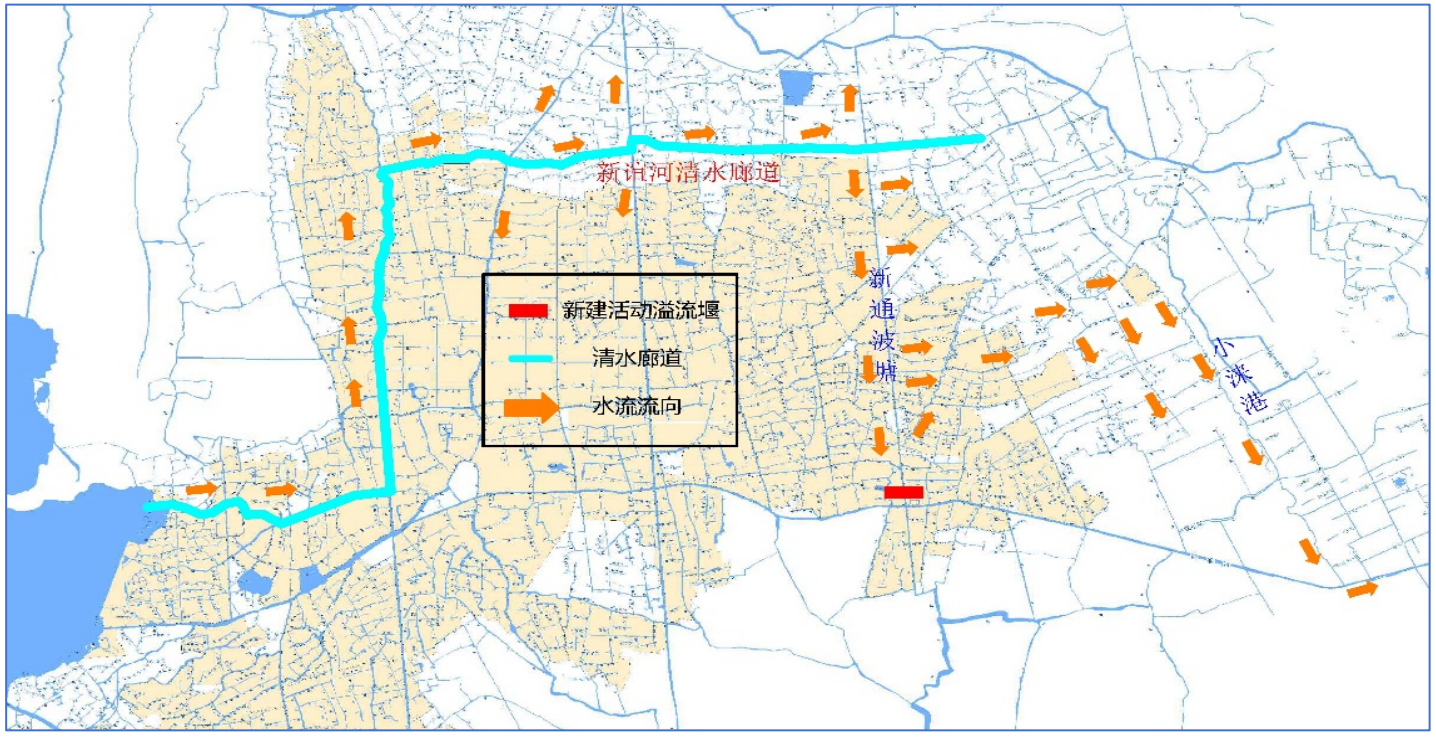
Solution (2): wastewater treatment and effluence compliance

- Centralizing wastewater treatment and improving treatment efficiency
- Raising standards for wastewater treatment

Water Pollution

Solution (3): Improving hydrodynamic conditions to improve loading capacity

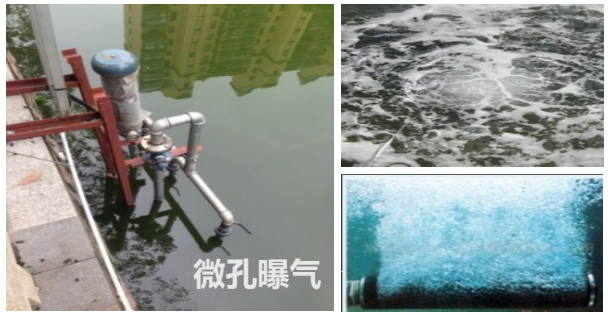
- Proper replenish of clean water
- Optimizing layouts for better connectivity

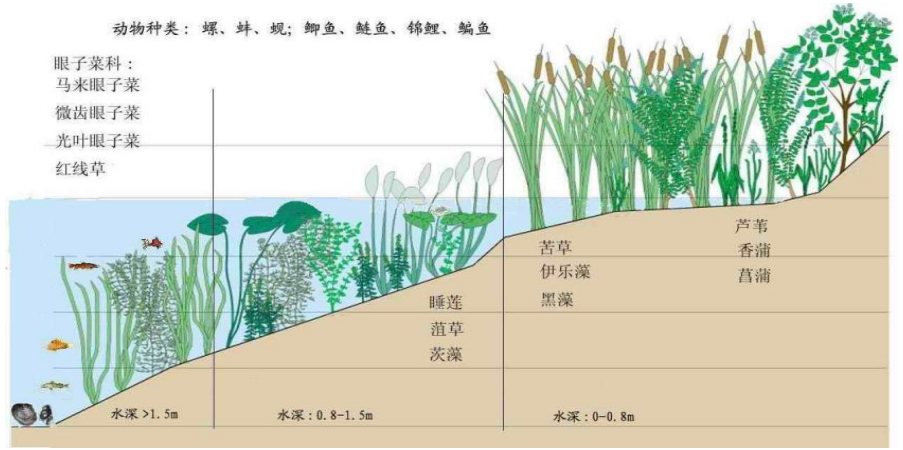


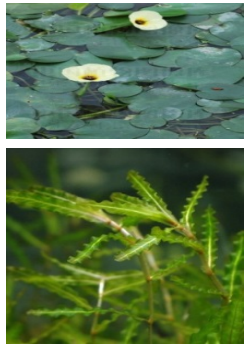
Water Pollution

Solution (4): Technology package for ecological rehabilitation for better natural treatment

- Wetlands
- Macrophytes: for absorption of N and P
- Oxygenating water bodies







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Water Pollution

Solution (5): Institutional reforms -- the River/Lake Chief System

- *Directive on Full Implementation of River Chief System*, State Council, Dec. 2016
- Top officials of governments at all levels act as river/lake chiefs, responsible for management & protection.
- Each river or lake falls into explicit responsible of a government official.

4 结束语

Conclusions

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Conclusions

1) Unique **geomorphological** and **hydro-meteorological** conditions of China makes it highly susceptible to **water scarcity**, **flooding**, **water pollution** and **ecological degradation**, with its water security being challenged.

2) Global changes such as **the warming climate** and **anthropogenic interference** further endangers its water security and result in higher risks.

3) Water security relies on **both engineering and non-engineering measures**, of which the former enhances robustness of the system, and the latter develops capacities for better resilience.

Thank you for your attention!

Comments and questions are appreciated.

E-mail: jyzhang@NHRI.CN