Managed aquifer recharge through rivers and lakes in North China Plain

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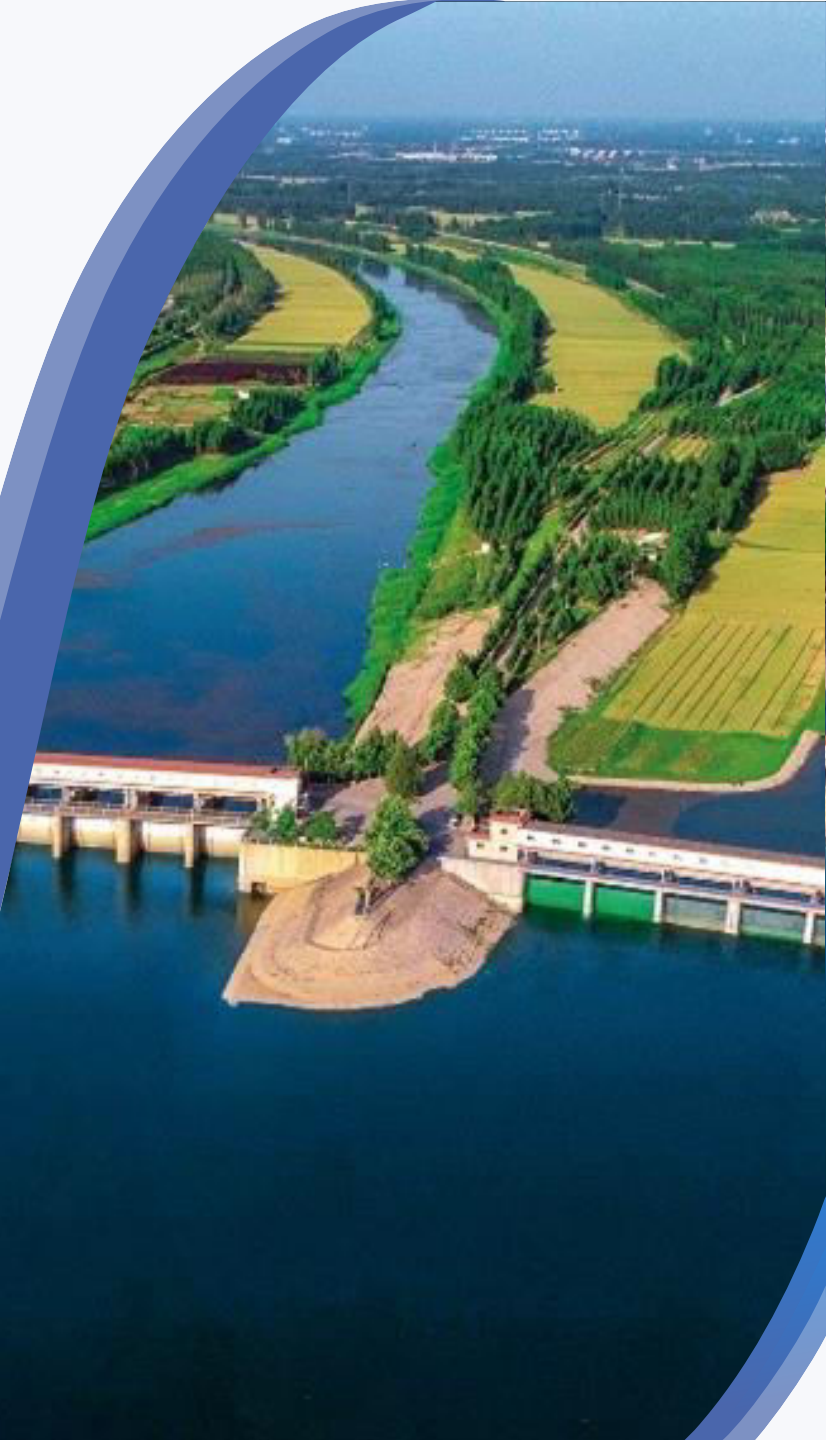

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1. Overview

1.1 Regional profile

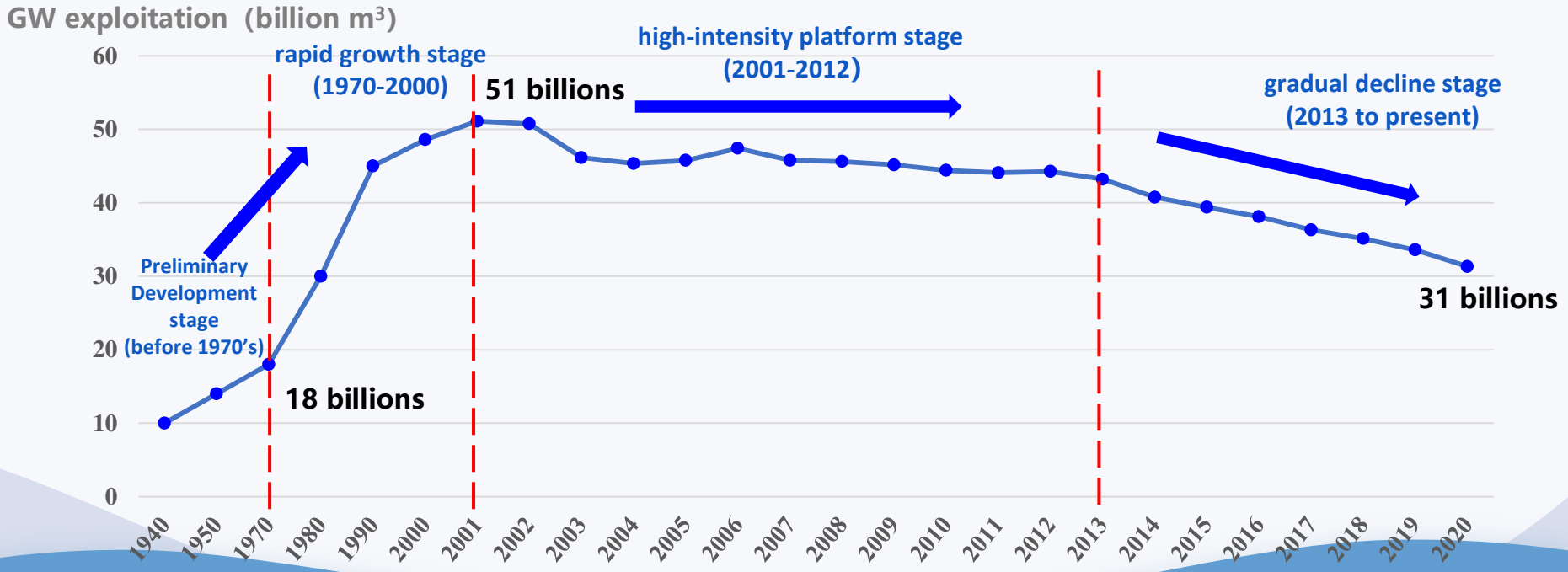
- ≈ 300,000km^2, second largest plain area of China, including Beijing, Tianjin, Hebei, Shanxi, Henan and Shandong.
- Water resources: totally ≈ 103 billion m^3 per year (4% of the national water resources amount), ≈297 m^3 per capita (far below the national average 1960 m^3 per capita), it supports:
  - 24% population
  - 23% GDP
  - 25% irrigation area and food production

Location of North China Plain

1. Overview

1.2 Course of GW utilization

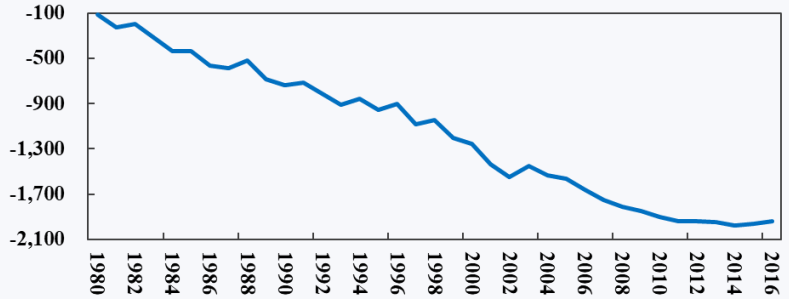
- Since 1940s, the course of groundwater utilization in North China Plain can be divided into four stages: preliminary development stage (before 1970s), rapid growth stage (1970-2000), high-intensity platform stage (2001-2012), and gradual decline stage (2013 to present).



Course of GW utilization in North China Plain

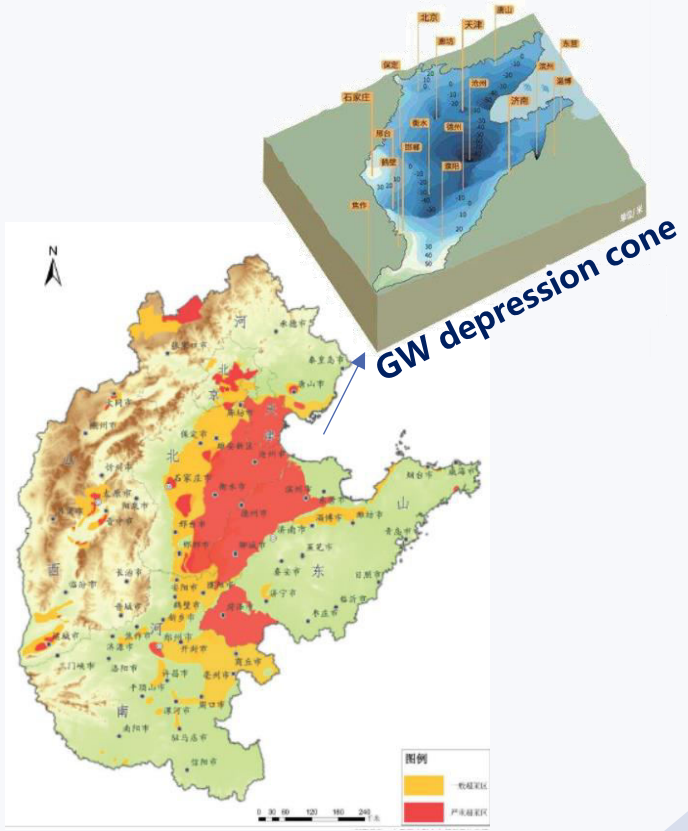
1. Overview

1.3 GW overexploitation



GW deficit in North China Plian

- **Overexploitation and deficit of groundwater**
  - By 2019, the accumulated deficit caused by groundwater overexploitation in North China Plain was180 billion m^3, and the overexploited area was 180,000 km^2.
- **Distribution of groundwater overexploitation**
  - 40% is shallow groundwater overexploited areas, mainly distributed in Piedmont plain area.
  - About 2/3 of the overexploited areas have deep confined water exploitation.
  - Overexploitation of groundwater has formed multiple water level depression funnels, which have maximum depth exceeds 100m.

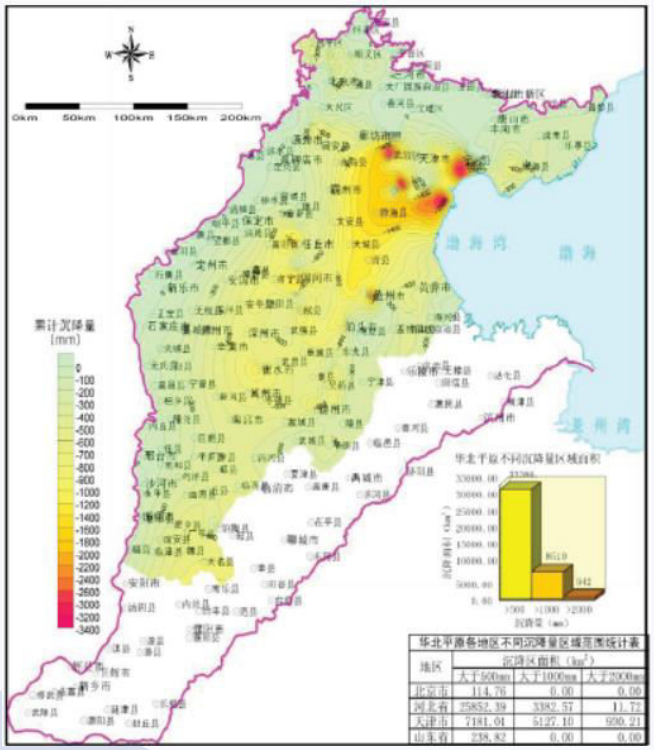


Distribution map of GW overexploitation area in North China Plain

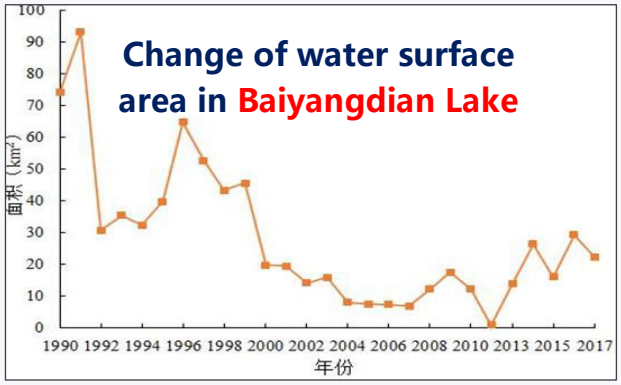
1. Overview

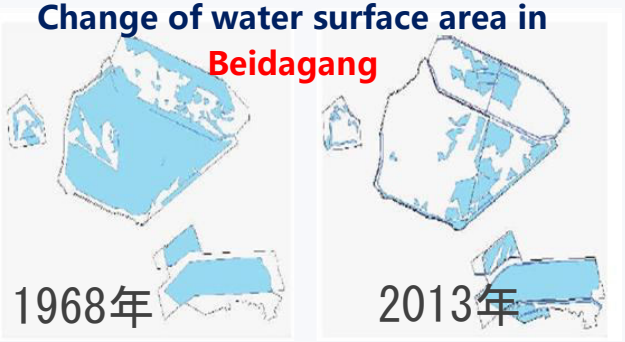
1.3 GW overexploitation

- **Groundwater overexploitation has caused serious ecological and environmental geological problems.**

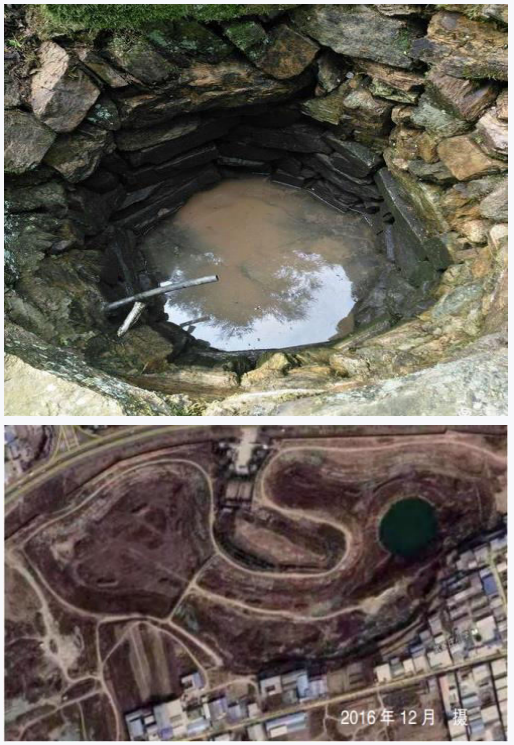


Distribution of land subsidence





Lake wetland shrinking



The spring water cut off

2. Practice on MAR

2.1 *The Pilot Scheme for Groundwater Recharge of Rivers and Lakes in North China Plain* (2018~2019)

- ***Pilot area:*** **Hutuo River(over 170 km), Fuyang River(over 410 km), South Juma River(over 80 km), which are located in severe GW over-exploited area of Hebei province and have easier access to recharge water sources**
- ***Recharge period:*** **September 2018 to September 2019**
- ***Water sources:*** **Middle route of the South-to-North Water Diversion Project and upstream reservoirs**

Schematic diagram of water supply line

2. Practice on MAR

2.1 *The Pilot Scheme for Groundwater Recharge of Rivers and Lakes in North China Plain* (2018~2019)

- ***Implementation situation:*** **During the one-year pilot period, 1.32 billion m^3 of water was supplied to the middle route, upstream reservoirs and reclaimed water. 66% came from the middle route, 28% from the local reservoirs and 6% from the reclaimed water. All the three pilot river sections were connected.**

Hutuo River

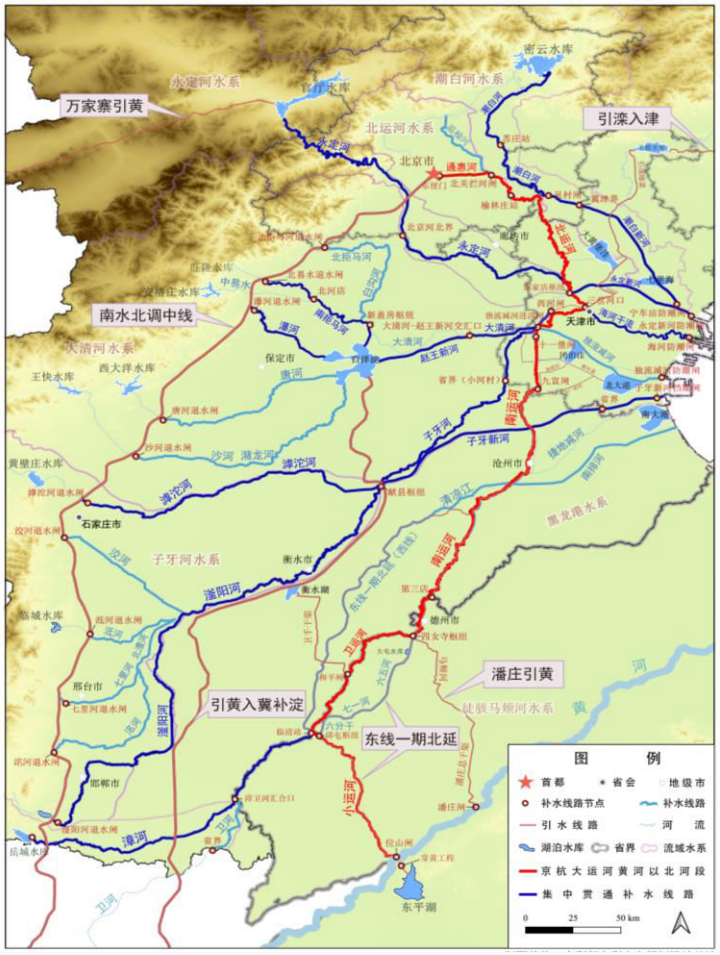
Fuyang River

Nanjuma River

2. Practice on MAR

2.2 *Annual normalized water replenishment* (2019~2021)

- ***Water replenishment area:*** **the scope of water replenishment was expanded to 22 rivers and lakes in Chaobai River, Yongding River, Daqing River, Ziya River, Zhangweinan Canal and so on.**
- ***Recharge period:*** **The whole year of 2019, 2020 and 2021.**
- ***Water sources:*** **Middle route, northward extension of the east route, upstream reservoirs, Yellow River, reclaimed water.**



Schematic diagram of water supply line

2. Practice on MAR

2.2 *Annual normalized water replenishment* (2019~2021)

- ***Implementation situation:*** **The cumulative use of upstream reservoirs, the middle route, the north extension of the east route, yellow river diversion, and reclaimed water has a total of 17 billion m^3. Groundwater recharge by infiltration is nearly 8 billion m^3.**

Water replenishment effect in 2021

2. Practice on MAR

2.3 *Ecological replenishment of centralized rivers and lakes in summer* (2021~2023)

- ***Water replenishment area:*** **Hutuo River and Daqing River in 2018; gradually increase toto 34 rivers and lakes in 7 river systems (Chaobai River, Daqing River Baiyangdian River, Ziya River, Zhangweinan Canal, Luanhe River, Eastern Hebei Coastal River, Ji Canal, Inland River) in 2023.**

Effect of water replenishment in summer of 2021

- ***Recharge period:*** **May to June.**

- ***Water sources:*** **make use of upstream reservoirs——grasp the "window period" that the relevant reservoirs need to vacate the flood control capacity in time before entering the main flood season.**

2. Practice on MAR

2.4 *Beijing-Hangzhou Grand Canal Water replenishment (2022~2023)*

- ***Water replenishment area:*** **707 km north of the Yellow River is the main route, including Tonghui River, North Canal, Xiao Canal, Wei Canal and South Canal.**
- ***Recharge period:*** **March to June.**
- ***Water sources:*** **the eastern route of the South-to-North Water transfer Project, upstream reservoirs, Panzhuang Yellow River diversion, Luan River diversion and reclaimed water.**

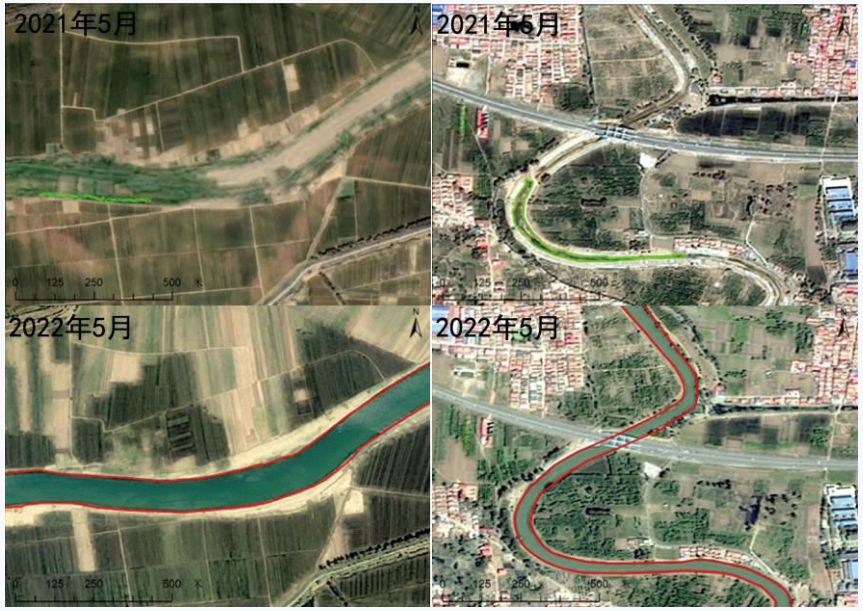
Schematic diagram of water replenishment of the Grand Canal

2. Practice on MAR

2.4 *Beijing-Hangzhou Grand Canal Water replenishment (2022~2023)*

- ***Implementation situation:*** **The Beijing-Hangzhou Grand Canal was completed for the first time in nearly a century with a replenishment of 840 million m^3 of water in 2022, and 1.32 billion m^3 in 2023.**

All lines of the BH Grand Canal were connected in 2022



a. Wei Canal **b. North Canal**

The water surface area changed after water replenishment compared with the same period of the previous year

3. Governance effectiveness

3.1 Water space of rivers and lakes increased

- The total amount of ecological water replenishment in rivers and lakes reached 24.9 billion m^3.The Chaobai River, Yongding River, Daqing River, Hutuo River and other rivers flowed into the sea after have been cut off for more than 40 years.

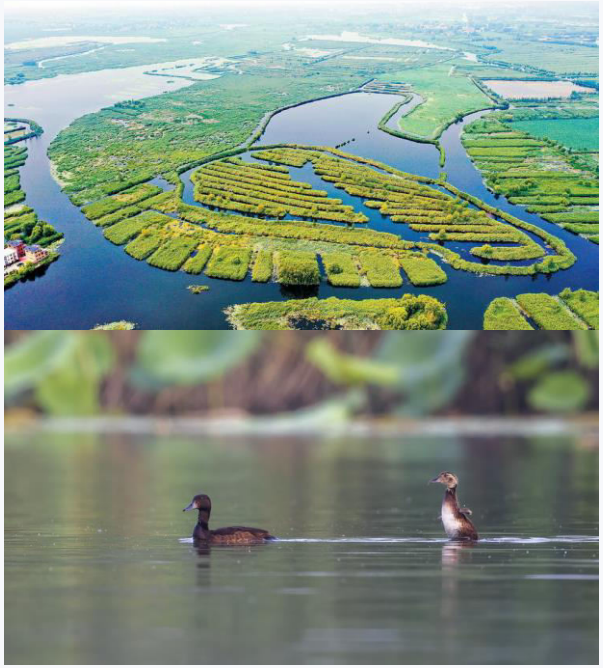
- By the end of 2022, the length of Beijing-Tianjin-Hebei water-replenishing rivers and lakes has increased to 2283 km, forming a surface area of 750 km^2, which is 2.5 times and 2.1times of that before ecological water replenishment, respectively.

Comparison before and after replenishment of Yongding River

3. Governance effectiveness

3.2 The ecological functions of rivers and lakes were gradually restored

- By the end of 2022, the proportion of regional water-replenishing rivers and lakes in class Ⅰ-Ⅲ monitoring stations reached 76.8%. The water quality of Baiyangdian Lake has been upgraded to Class III, the best level in nearly a decade.
- The water ecology of the replenishment rivers and lakes continued to improve, the density of plankton significantly decreased, the degree of eutrophication improved, and the number of wild birds in Baiyangdian increased to 242 species, an increase of 36 species compared with that before water replenishment.



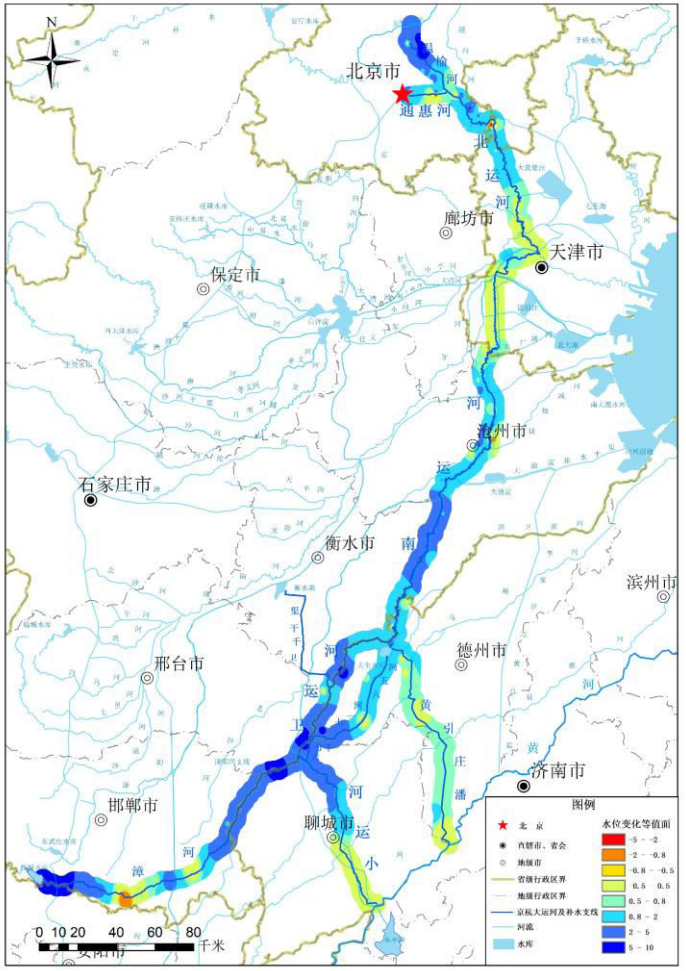
The Baiyangdian lake after ecological water replenishment

3. Governance effectiveness

3.3 The groundwater table has rebounded

- **Compared with the same period of the previous year, the groundwater level around the replenishment channel showed an overall upward trend.**

The average inland water level within 0~2 km of the Beijing-Hangzhou Grand Canal rose by 1.44 m; the range of 0~5 km, the water level of the inland water rose by 1.33 m on average.



Comparison of groundwater level around the Grand Canal with the same period of the previous year

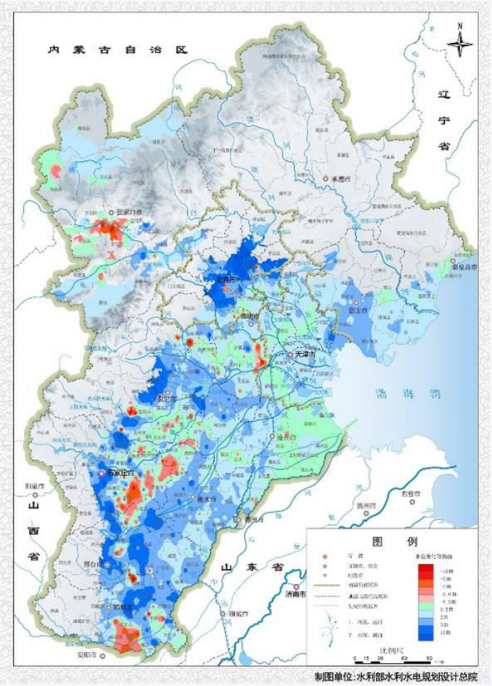
3. Governance effectiveness

3.3 The groundwater table has rebounded

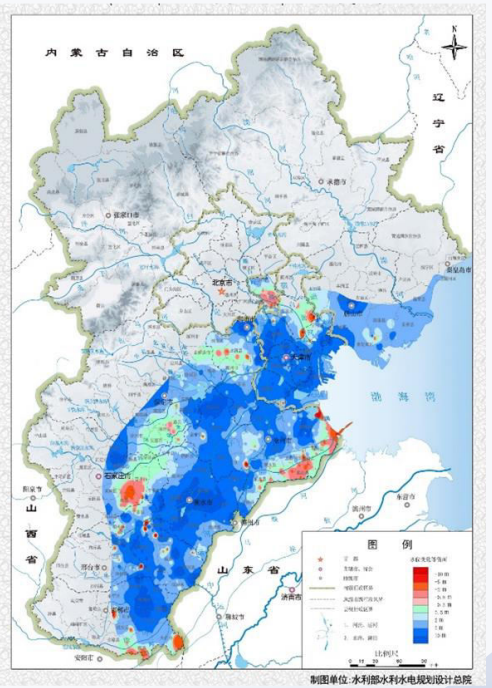
- **With the combination of groundwater pressure mining and ecological water replenishment, the groundwater level in the region has obviously rebounded.**

Compared with the end of 2018, the water level of shallow groundwater and deep confined water rose by **2.3 m** and **6.7 m** respectively in the same period in 2022.

Shallow Groundwater



Deep Confined Groundwater



Change of Groundwater Table (2022 vs. 2018)

3. Governance effectiveness

3.4 Spring water surges again

- **Some spring areas gradually recover. The rise of groundwater level has prompted springs that have been dry for many years to resume flowing. Bai Spring in Xingtai, Hebei Province have resumed flowing after 30 years.**

Bai Spring resumes its flow

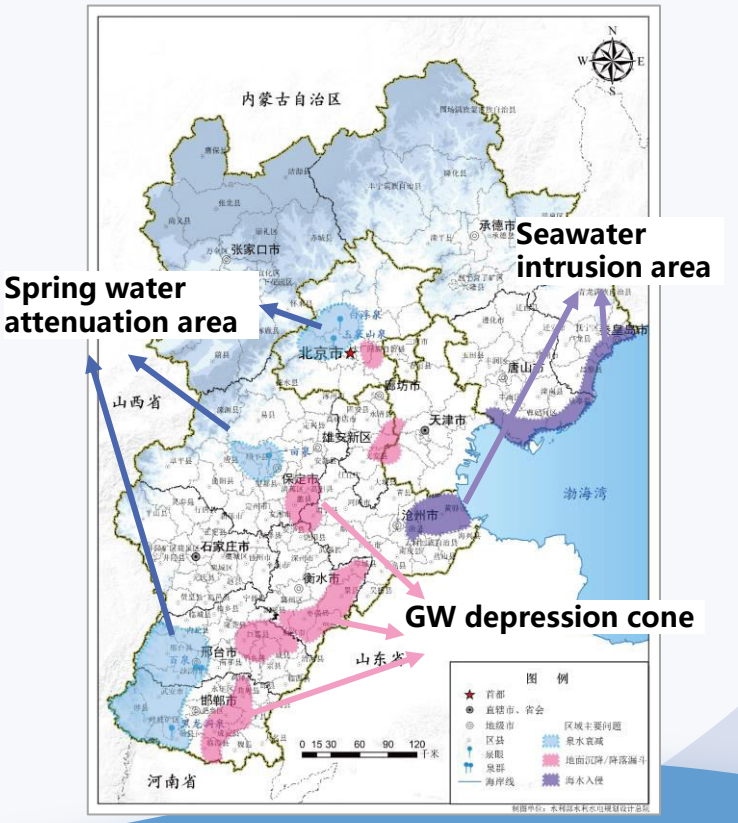
4. Next Plan

- ***Challenge:*** **The problems caused by overexploitation of deep confined water have not been fundamentally solved, and geological disasters and ecological damage problems such as land subsidence, spring flow attenuation, seawater intrusion and so on still exist.**

- ***Next Plan:***

  - **Implement ecological water replenishment of rivers and lakes and lateral recharge of deep confined water in the Piedmont area;**

  - **Explore the implementation of deep aquifer recharge in the central funnel area and areas with serious ecological and geological environment damage.**



THANKS