



Multi-dimensional dynamics under water and sediment regulation

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Content

- Background and significance
- Methodological framework
- Results and conclusions

1. Background: (1) research background

- The 2000 Xiaolangdi Reservoir with largest sediment and finest the highest sediment concentration in the world
- For the Yellow River has done the regulation of the Yellow River continuous channel siltation
- Since 2002, three consecutive years of water and sediment regulation prototype tests and ongoing engineering practices have properly regulated the flow and sediment processes

淤积萎缩

过流能力

siltation and atrophy \Rightarrow discharge capacity was reduced to only 1800m³/s

河道强烈淤落



Water safety and the regulation into safety ecological environment for the Yellow River development

1. Background: (2) research status and development

- Most of the studies are limited to changes in the Yellow River of floodwater and lack of comprehensive exploration from a holistic perspective
- Study period typically ranges from one to several years, failing to accurately reflect the dynamics of entire river system over the past 23 years of water and sediment regulation

Flow and sediment transport

Ecological environment

Social economy

- reservoir sediment discharge
- mainstream natural state
- water supply

- irrigation
- power generation

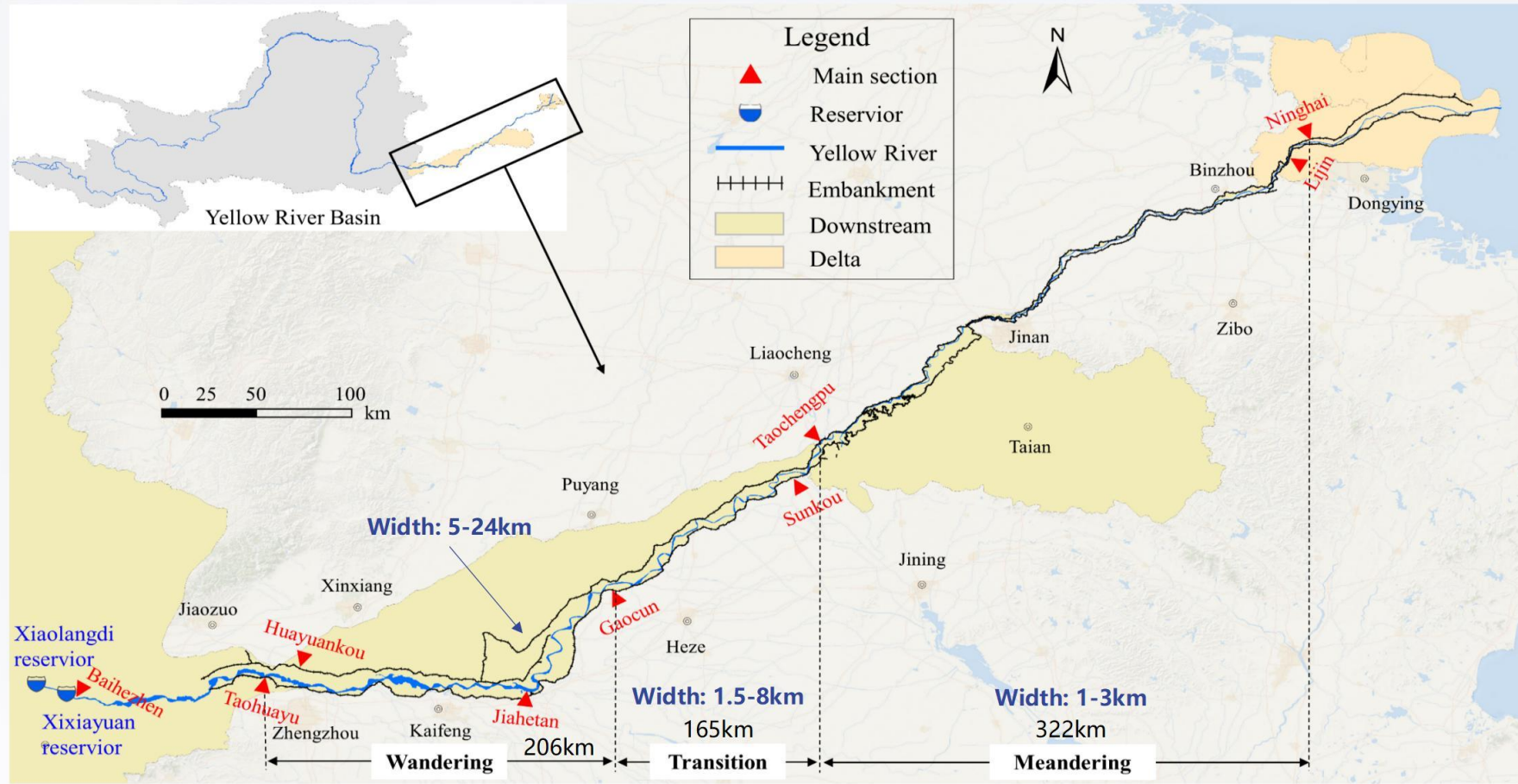
Lower Yellow River is a complex system

- eco-tourism
- breeding industry

Exploring multi-dimensional dynamics of flow and sediment transport, ecological environment and social economy will provide a theoretical basis and reference for future water and sediment regulation, as well as the management of sediment-laden rivers in the world



2. Framework: (1) study area

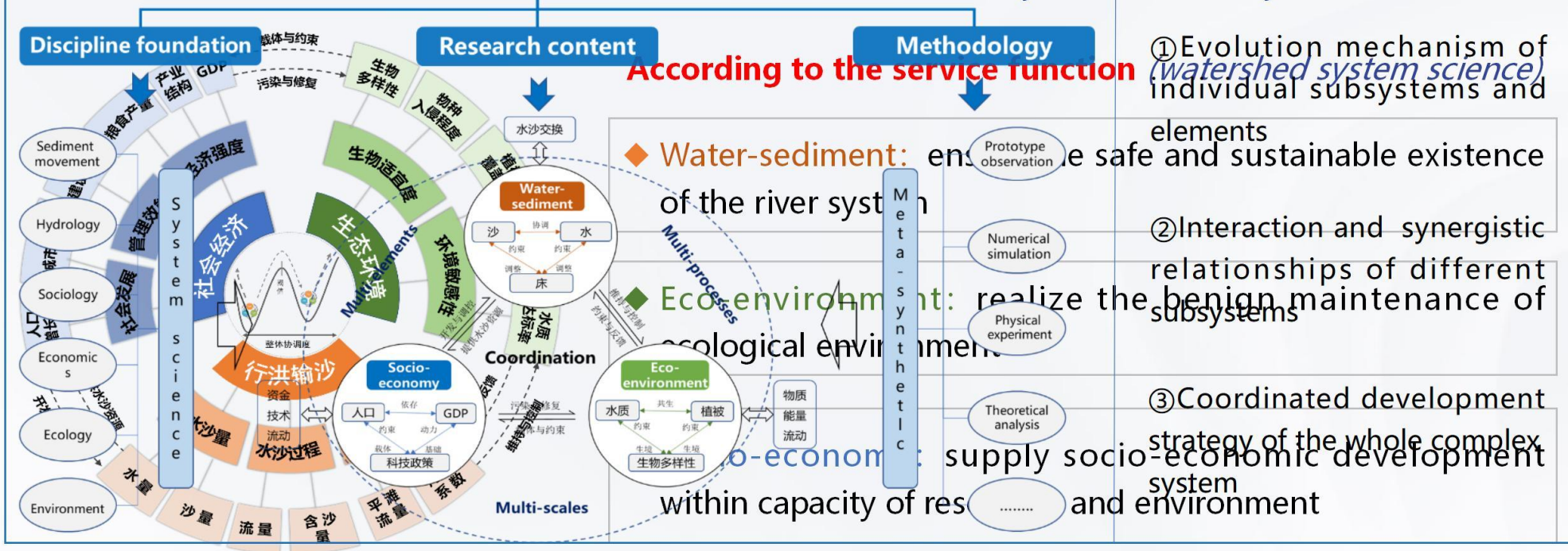


Lower Yellow River and Estuary Delta

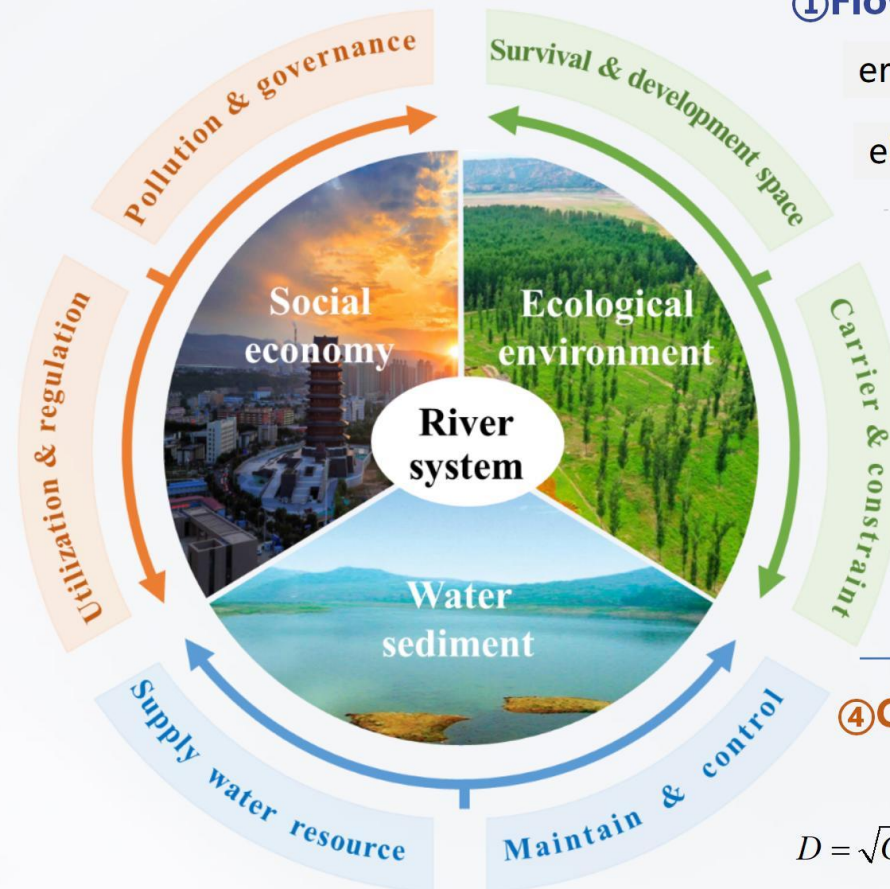
2. Framework: (2) river system

- Basic sustainable development principles to the river by the flow and sediment transport, organization of individual subsystems (and their elements) in economic development

- Highlighting the integrity of the river system, Jiang et al. (2020) divided the river system into water-sediment (行洪输沙), eco-environment (生态环境) and socio-economy (社会经济) subsystems



2. Framework: (3) evaluation methods



① Flow and sediment transport

erosion and siltation of the channel

bankfull discharge

elevation difference

relative stability index of river regime

② Ecological environment

wetlands ecosystem area

Water system area

saline-alkali land area

habitat quality

③ Social economy

grain production

irrigation water volume

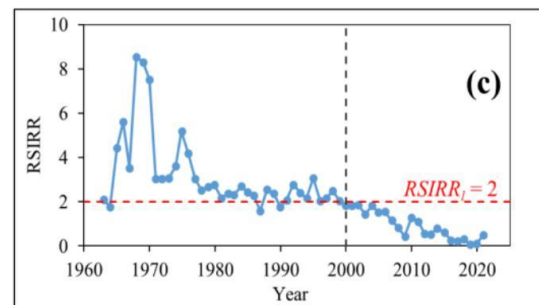
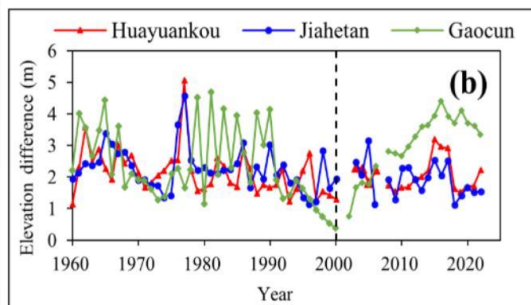
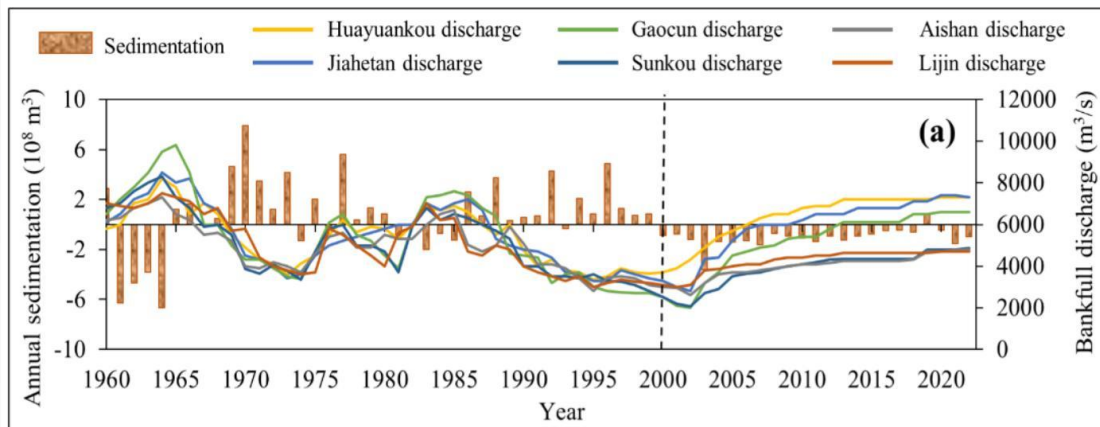
④ Coordinated development level

$$D = \sqrt{CT} \quad C = \frac{m \left(\prod_{i=1}^m f_i \right)^{\frac{1}{m}}}{\sum_{i=1}^m f_i} \quad T = \sum_{i=1}^m \lambda_i f_i$$

[0, 0.2]	Highly uncoordinated
(0.2, 0.4]	Moderately uncoordinated
(0.4, 0.6]	Reluctantly coordinated
(0.6, 0.8]	Moderately coordinated
(0.8, 1]	Highly coordinated

3. Results: (1) flow and sediment transport

- After 2000, the erosion and siltation of channel, bankfull discharge level and difference between flood regulating channel, and of SRIR in the lower Yellow River raising significantly



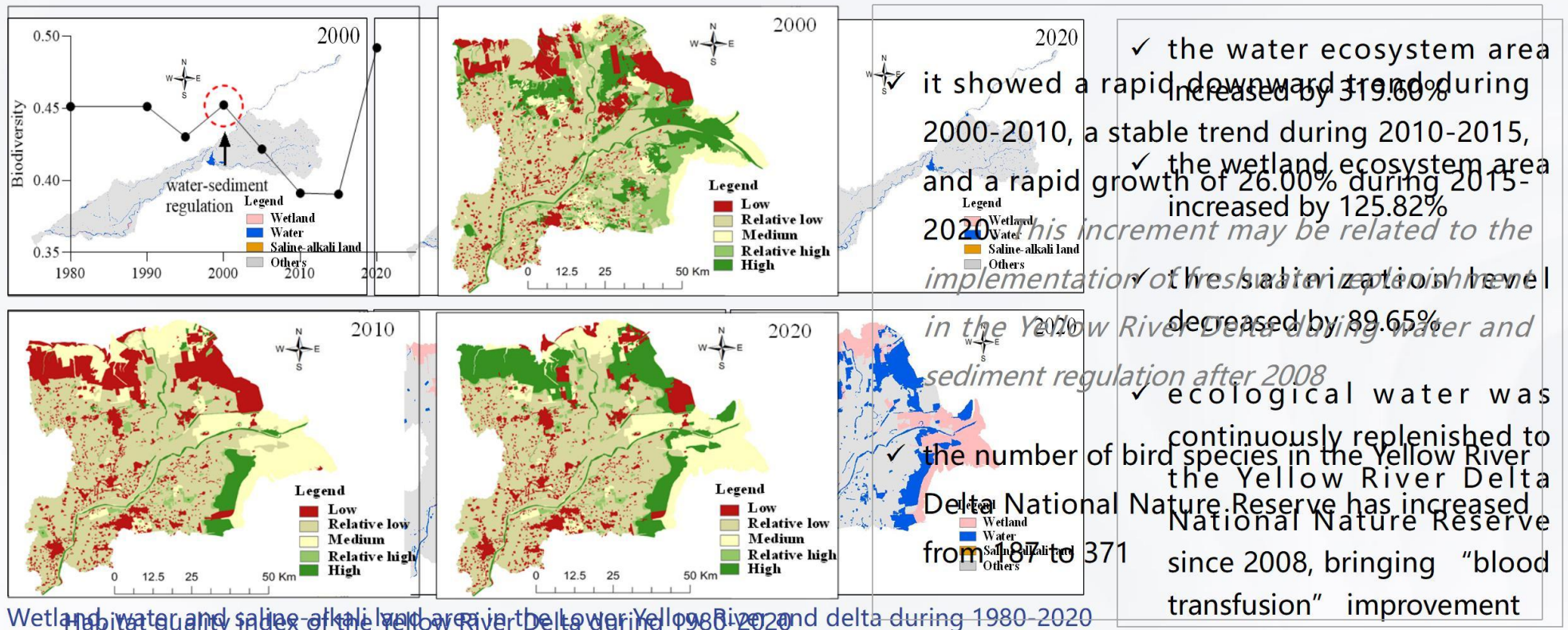
(a) Erosion and siltation amount; (b) Elevation difference; (c) RSIRR

Xiaolangdi station

- the Lower Yellow River experienced a continuous erosion of 2.402 billion m^3
- the bankfull discharge of Huayuankou, Jiahetan and Gaocun recovered to more than $6,500 m^3/s$, and that of Sunkou, Aishan and Lijin recovered to more than $4,700 m^3/s$
- the development of the secondary perched river in the reach from Jiahetan to Gaochun Xiaolangdi was obviously improved
- Xiaolangdi station was 1.11 million tons
- the river regime was effectively controlled
- retaining ratio was 61.8%.

3. Results: (2) ecological environment

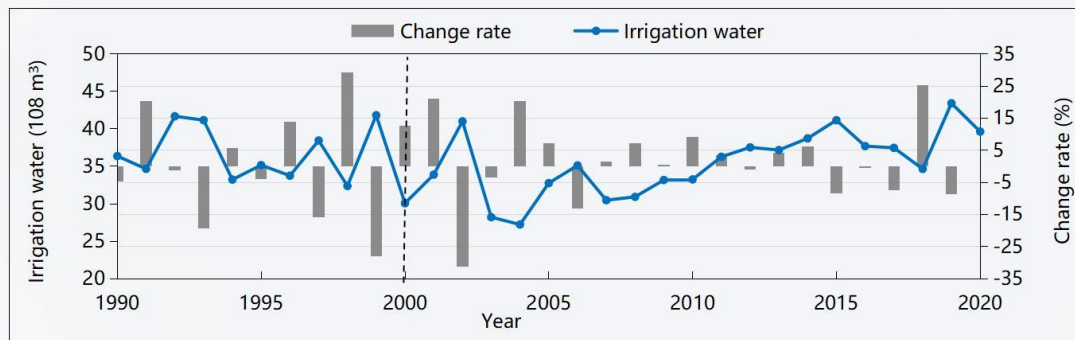
- The habitat quality of the Yellow River Delta has declined gradually since the 1980s, with saline-alkali lands increased sharply during 2000-2010



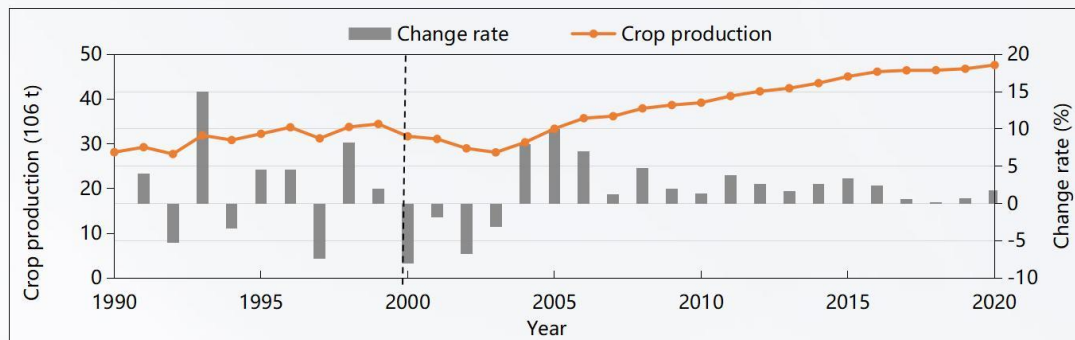
Wetland, water and saline-alkali land areas in the lower Yellow River and delta during 1980-2020

3.Results: (3) social economy

- Xiaolangdi Reservoir redistributed monthly runoff, bringing an improvement in the guarantee rate of water diversion, which further promoted the higher grain yields



Irrigation water volume during 1990-2020

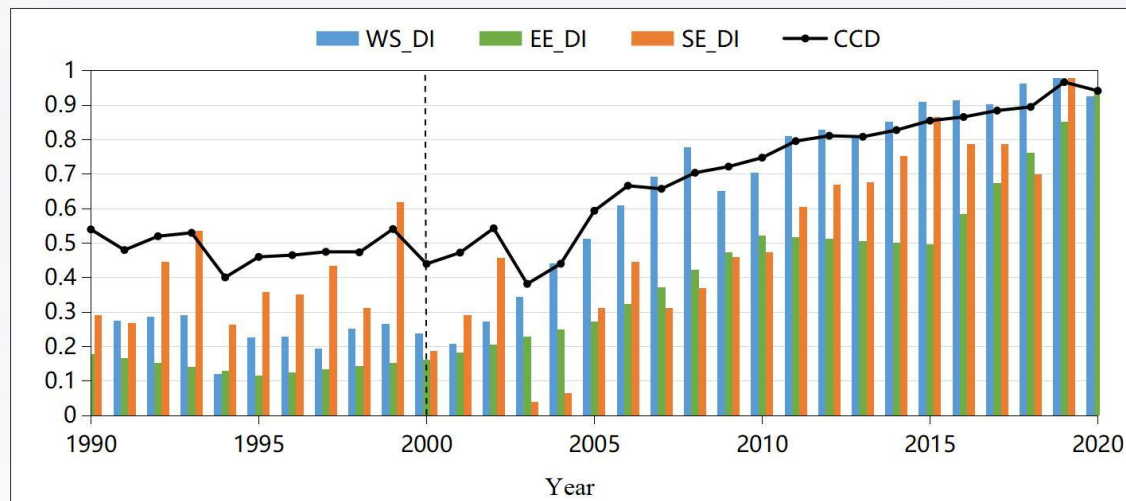


Crop production during 1990-2020

- ✓ The irrigation water volume showed a fluctuating decline trend from 3.63 billion m³ in 1990 to 2.72 billion m³ with a reduction of 25%
- ✓ But after 2004, it increased from 2.72 billion m³ to 3.96 billion m³ with an increase of 31%
- ✓ The crop production also achieved growth for 16 consecutive years with an increase of 71%

3.Results: (4) coordinated development level

- the coordinated development level has been continuously improved from the reluctantly coordinated level (before water and sediment regulation) to the highly coordinated level



Development index and coupling coordination degree during 1990-2020

- ✓ The development index of the three subsystems presented an upward trend
- ✓ Flow and sand transport and social economy showed a decreasing trend before 2000 and a rapidly increasing trend after 2000, while that of the ecological environment kept slow growth during the whole period

- ✓ The coupling coordination level showed a continuous growth from reluctant coordination in 1990-2005 to moderate coordination level in 2006-2011, and thence to high coordination in 2012-2020

Overall, there were obvious improvements in the three subsystems under water and sediment regulation

Thanks for your attention!

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