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Challenges and Adaptive Strategies of Water Resources Change in the Yellow River Basin under the Changing Environment

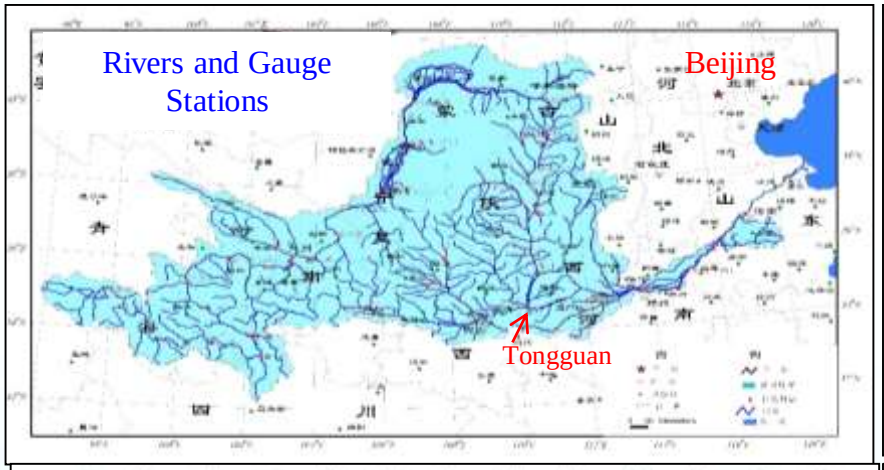
Dr. & Prof. Yangwen Jia

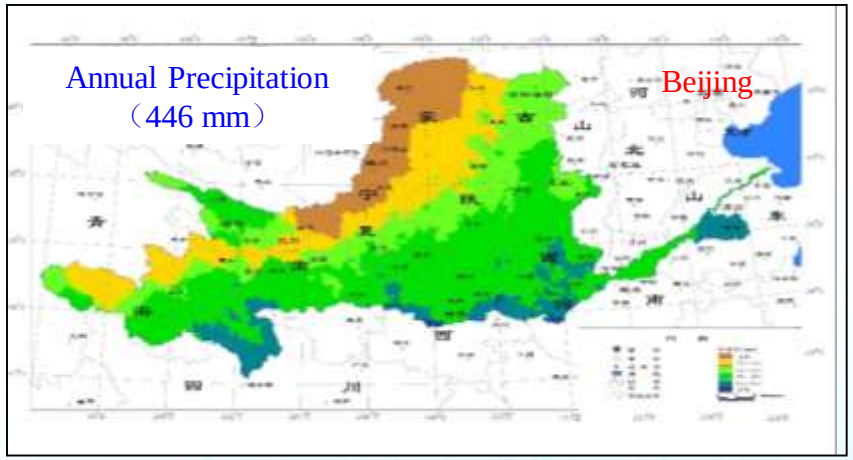
Department of Water Resources,
China Institute of Water Resources & Hydropower Research (IWHR), Beijing 100038, China
Email: jiayw@iwhr.com

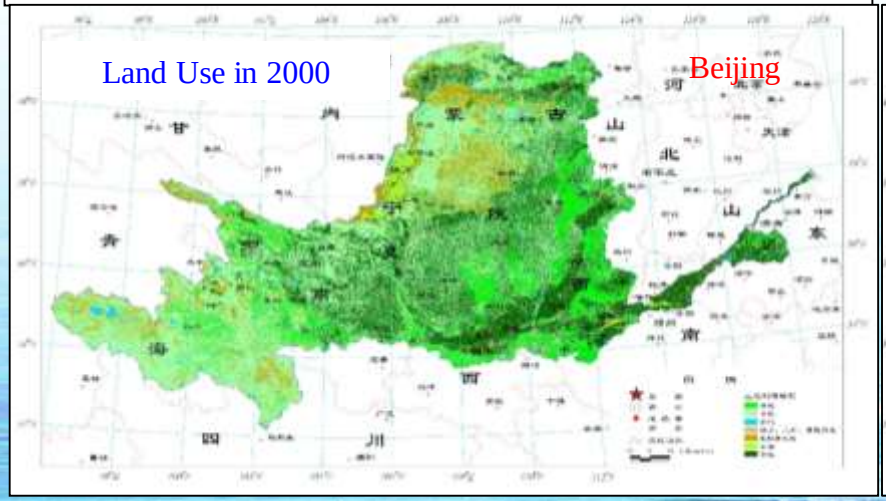
Outline

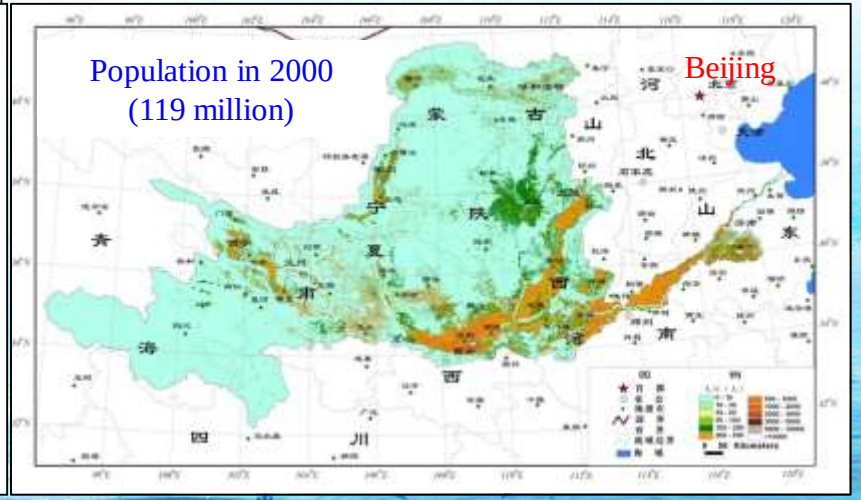
Introduction

- The Yellow River is the second longest river in China. The area of the basin is 795,000 km^2.
- The Yellow River basin has been playing very important roles in the social-economy development of China.
- This study aims to quantify the water resources change and provide management suggestions in the water-stressed Yellow River Basin under the changing environment.









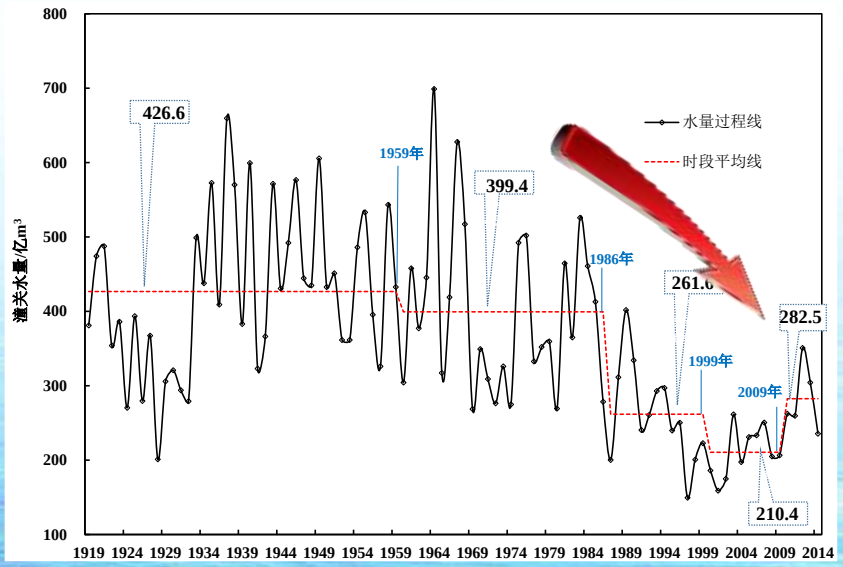
Main Issues：

1. Flow and sediment sharply decreased. The annual average runoff at the Tongguan gauge station (the conjunction point of the Weihe tributary and the main stream) since 2010 has decreased by 34% compared with that from 1919 to 1959, and the sediment has decreased by 94%.

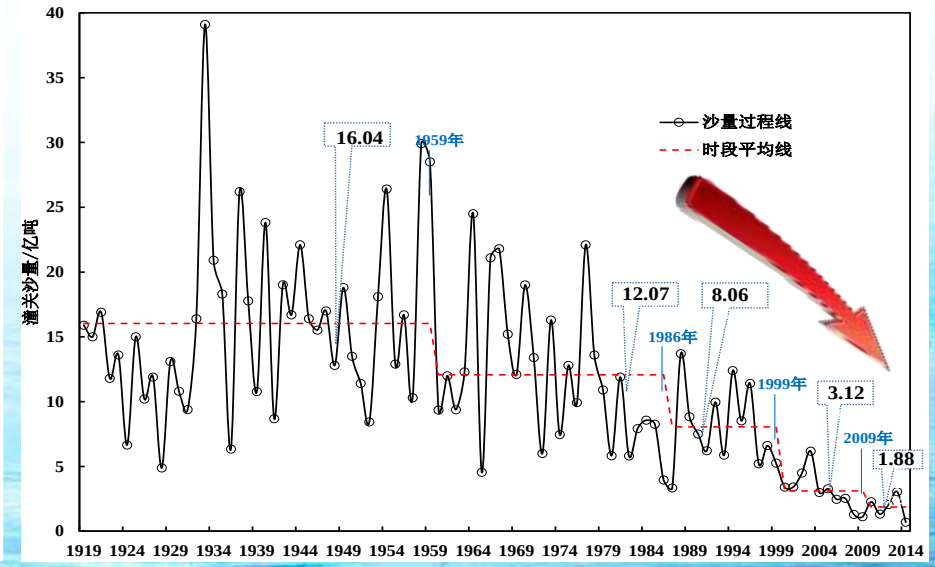
2. The continuously-increased socio-economic water use has caused insufficient environment flow in rivers and groundwater overexploitation.

3. The urbanization progress since 1980s has led to urban inundation and water quality deterioration problems in cities like Xi’ an and Jinan.

Flow at Tongguan



Sediment at Tongguan

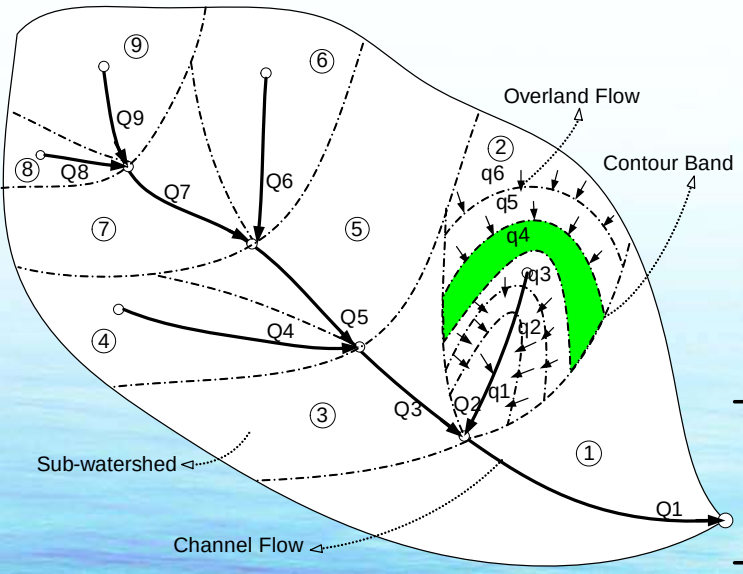


Methodology and Data

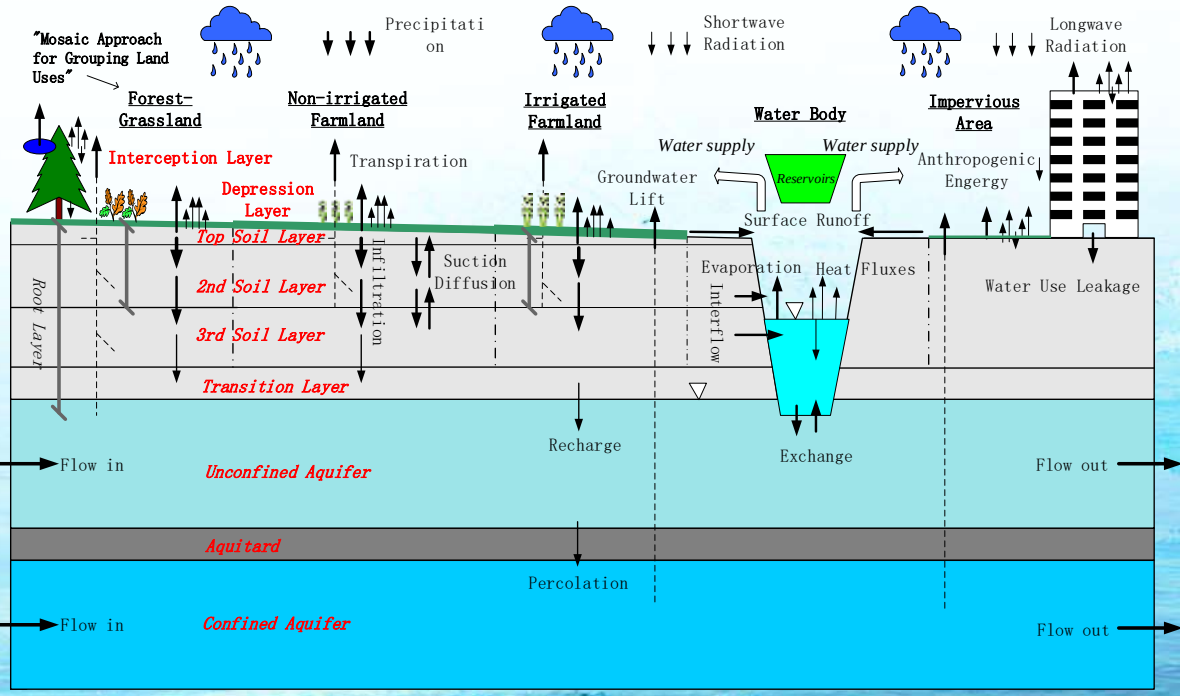
WEP-L Model

- The distributed hydrology model WEP-L with combinations of statistical analysis of hydro-meteorological data and remote-sensing data are adopted to address the above-mentioned issues. Both natural hydrological processes and water utilization processes are depicted in the model, and the observed flow series at main gauge stations are used to validate the model.

Horizontal structure

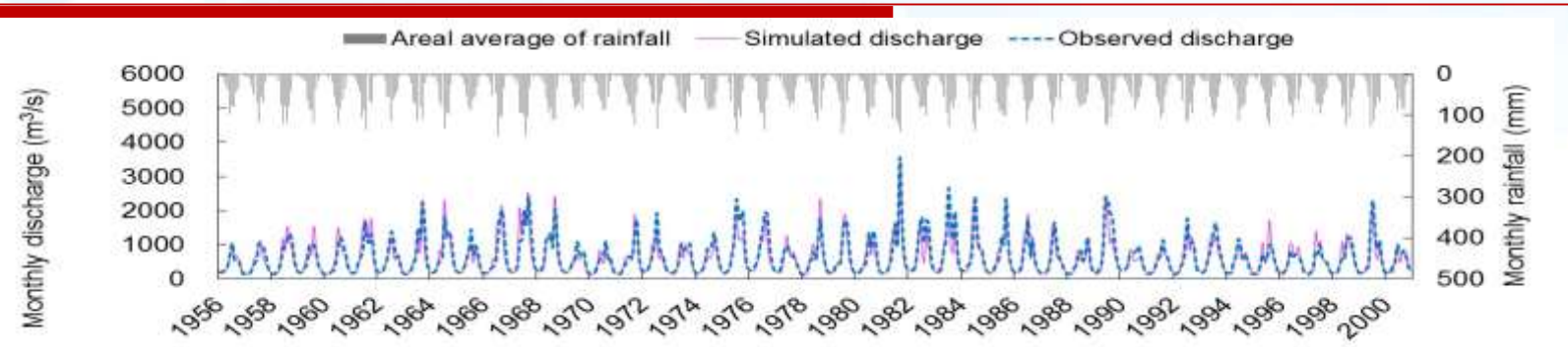


Vertical structure

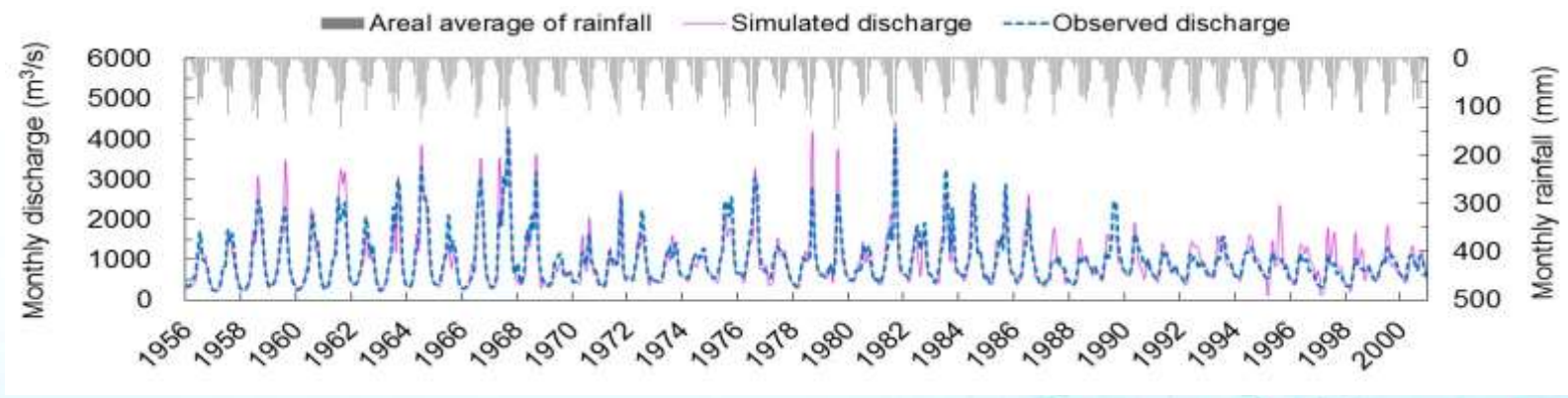


Verification of simulated monthly discharges at: (a) Tangnaihai station, (b) Lanzhou station, and (c) Huayuankou station of the main river

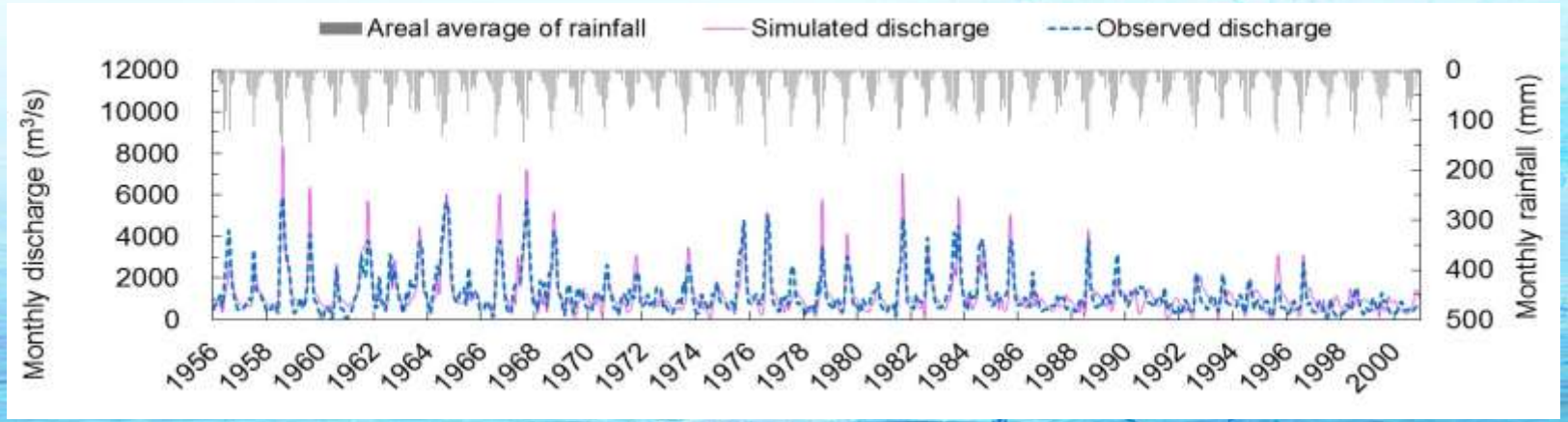
(a)



(b)

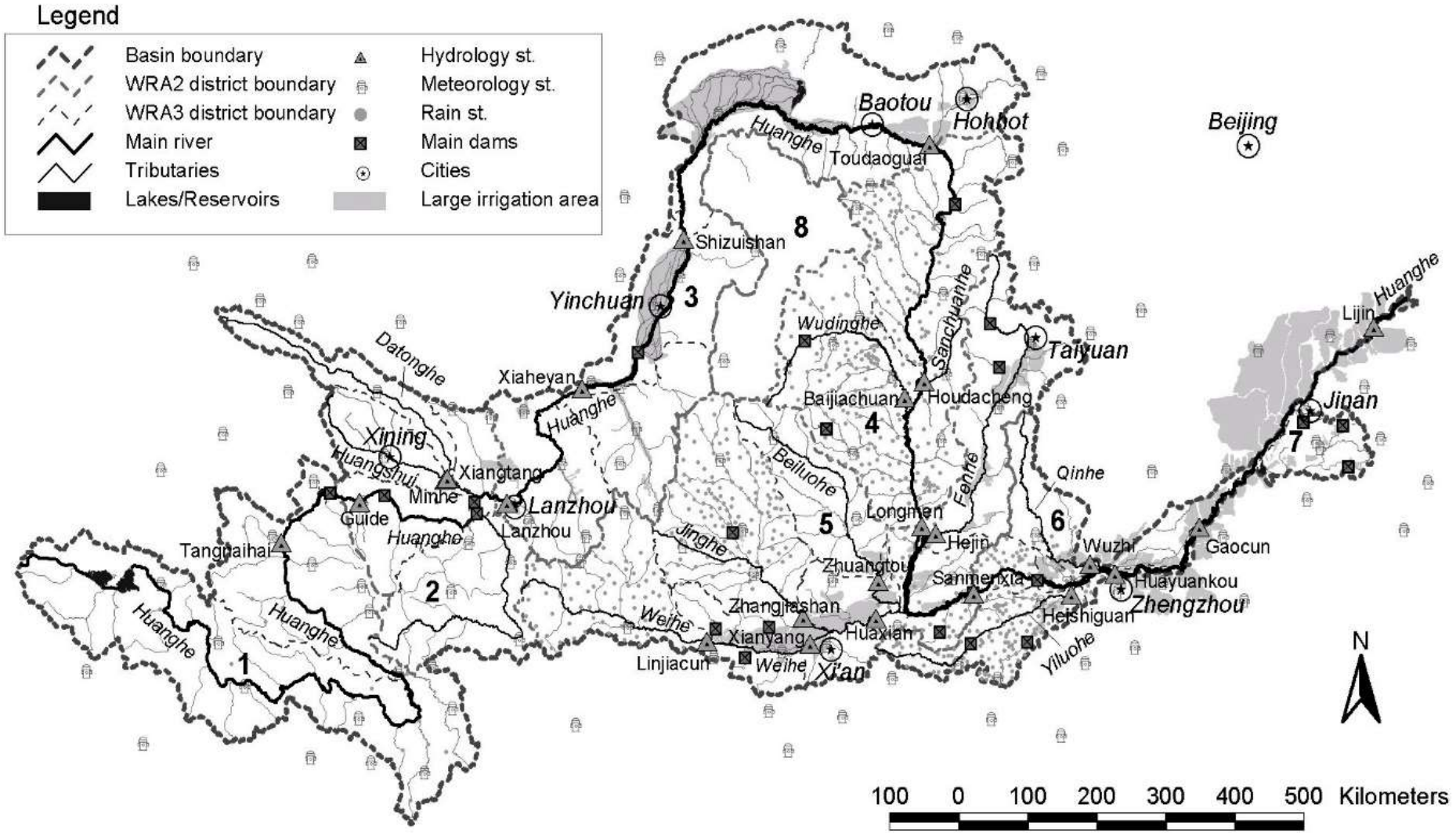


(c)



Water Resources Assessment (WRA) Districts :

Numbers (1-8) in the figure are codes of 8 WRA2 districts. WRA2 represents the 2nd level national water resources assessment sub-basin in China, WRA3 means the 3rd level one (a further subdivision of WRA2), and WRA1 means the 1st level one. The Yellow River basin is one of total 10 WRA1 districts in China



Results and Discussion

The combined impact of climate, land use and water use changes on water resources: correspondent to various periods of meteorological data under condition of historical land cover and water use（unit: billion m^3 yr^{-1}）

Meteorological periods	Precipitation	Surface water resources	Groundwater resources		Total special water resources
			Total	Non-overlapped with surface water	
1956－1959	378.88	60.86	37.28	6.94	67.80
1960－1969	374.38	65.02	38.30	8.97	73.99
1970－1979	354.34	56.98	39.65	11.20	68.17
1980－1989	353.75	61.40	39.58	10.99	72.39
1990－2000	335.76	52.49	39.37	12.28	64.77
1956－1979	366.78	60.94	38.69	9.62	70.56
1980－2000	344.43	56.71	39.47	11.68	68.39
1956－2000	356.30	58.94	39.06	10.67	69.62

The surface water resources from 1980 to 2000 decreased by 6.9% than that from 1956 to 1979, the non-overlapped groundwater resources increased by 21.4% than that from 1956 to 1979, and the total special water resources from 1980 to 2000 decreased by 3.1% than that from 1956 to 1979.

The impact of land cover and water use conditions on water resources: the surface water resources decreased by 4.1 billion m^3 yr^{-1}, the non-overlapped groundwater increased by 2.1 billion m^3 yr^{-1}, and the precipitation directly utilized by ecosystem increased by 11.4 billion m^3 yr^{-1}

Assessed water resources of WRA districts under condition of historical land cover and water use （unit: billion m^3 yr^{-1}）

WRA2 district name	Surface water	Total groundwater	Non-overlapped groundwater	Special water resources	Precipitation directly utilized by ecosystem
Whole basin	58.94	39.06	10.67	69.62	196.62
Upstream Longyangxia	22.33	6.77	0.18	22.51	20.73
Longyangxia - Lanzhou	12.35	3.77	0.23	12.59	21.89
Lanzhou - Hekouzhen	1.99	5.83	3.37	5.35	23.31
Hekouzhen - Longmen	4.11	3.70	0.53	4.64	27.54
Longmen - Sanmenxia	11.48	11.62	2.93	14.42	69.99
Sanmenxia - Huayuankou	4.23	3.54	0.78	5.01	17.62
Downstream of Huayuankou	2.14	1.98	1.16	3.30	10.84

Assessed water resources of WRA districts under condition of Year-2000 land cover and water use（unit: billion m^3 yr^{-1}）

WRA2 district name	Surface water	Total groundwater	Non-overlapped groundwater	Special water resources	Precipitation directly utilized by ecosystem
Whole basin	54.87	40.42	12.77	67.64	208.01
Upstream Longyangxia	21.01	6.53	0.19	21.21	23.28
Longyangxia - Lanzhou	11.28	3.70	0.34	11.61	23.23
Lanzhou - Hekouzhen	1.85	5.86	3.52	5.37	23.92
Hekouzhen - Longmen	4.23	4.00	0.69	4.92	28.82
Longmen - Sanmenxia	10.45	12.51	3.90	14.35	72.36
Sanmenxia - Huayuankou	3.92	3.51	1.10	5.03	20.98
Downstream of Huayuankou	1.80	2.36	1.40	3.20	10.95

Conclusions

- **Based the above-results, the special water resources (blue water) especially the surface water resources in the basin were decreased under the impacts of climate change, land cover change and water use increase, which threatens the water resources security in the basin.**
- **Adaptive strategies for ensuring the water resources security are suggested from the aspects as follows:**

(1) Comprehensive water-saving

(2) Control of groundwater overexploitation

(3) Ecological sponge city construction

(4) Optimal allocation and regulation of water resources

(5) legislation-institution arrangements: it includes updating water rights allocation, water pricing, and environmental flow guarantee policy etc.


Thank You !