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World Water Congress
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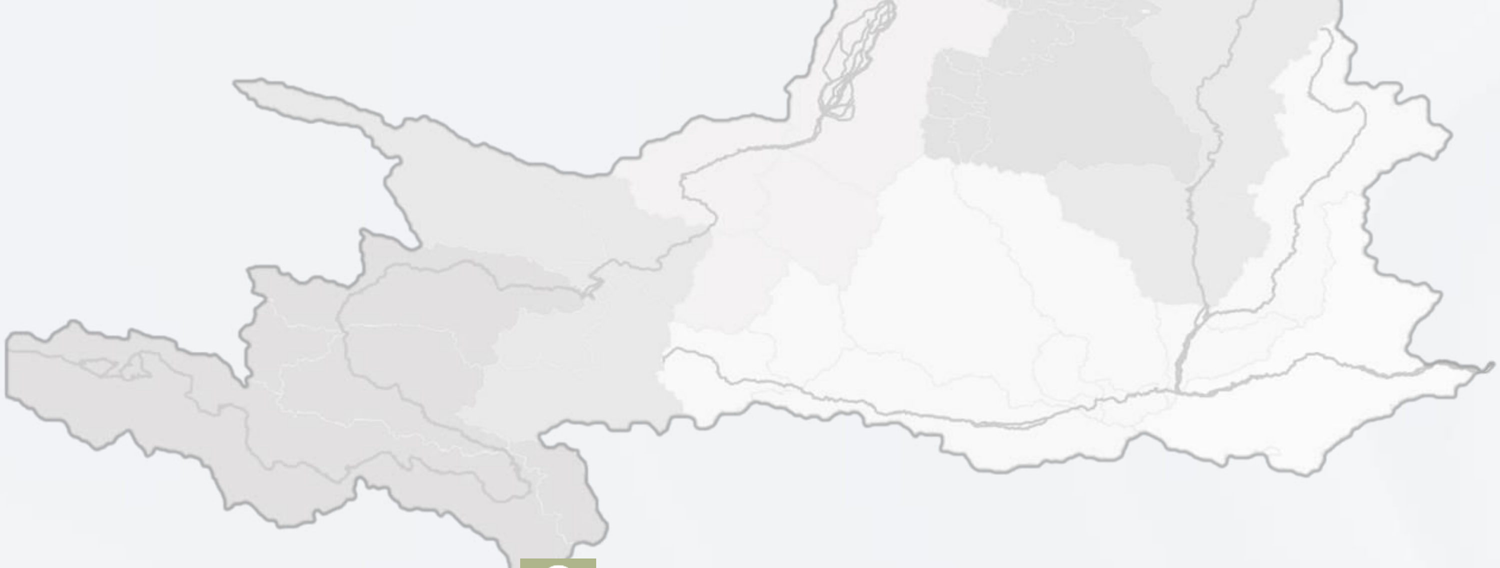
Spatial Analysis of the Water-Energy nexus in the Yellow River Basin



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XVIII
WORLD WATER CONGRESS
Water for All
Harmony between Humans and Nature
第18届
世界水资源大会
水与万物：
人与自然和谐共生

Content

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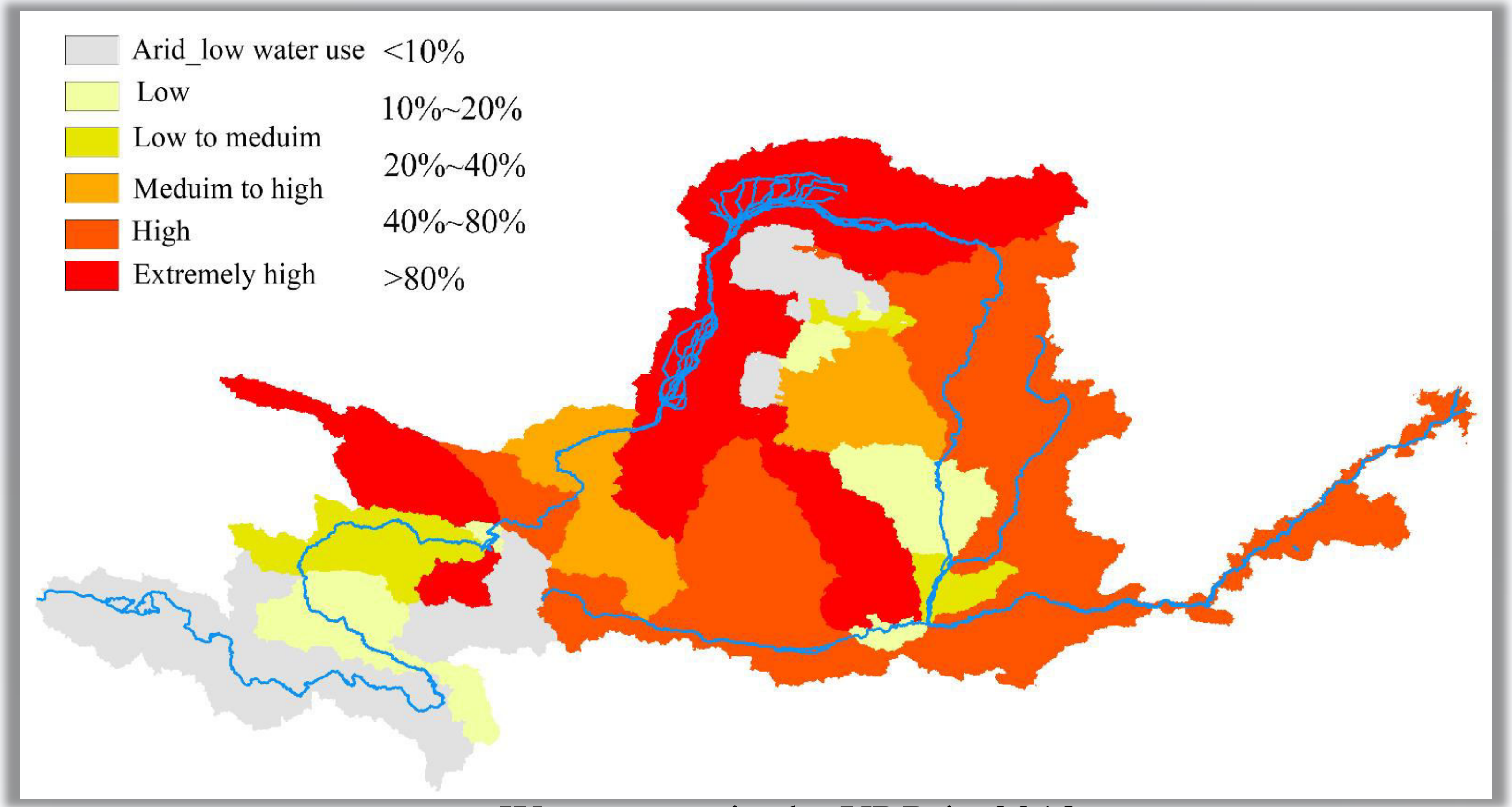
Introduction

- In 2020, coal contributed 27.2% of the world's total primary energy consumption
- water-related environmental stress associated with the coal industry is prominent in China
- Most catchments in the middle and lower reaches of the YRB are under high or extremely high water stress
- Also, there are a lot of coal bases in the YRB, such as Shen Hua



Water stress in the YRB in 2018

Water-coal nexus

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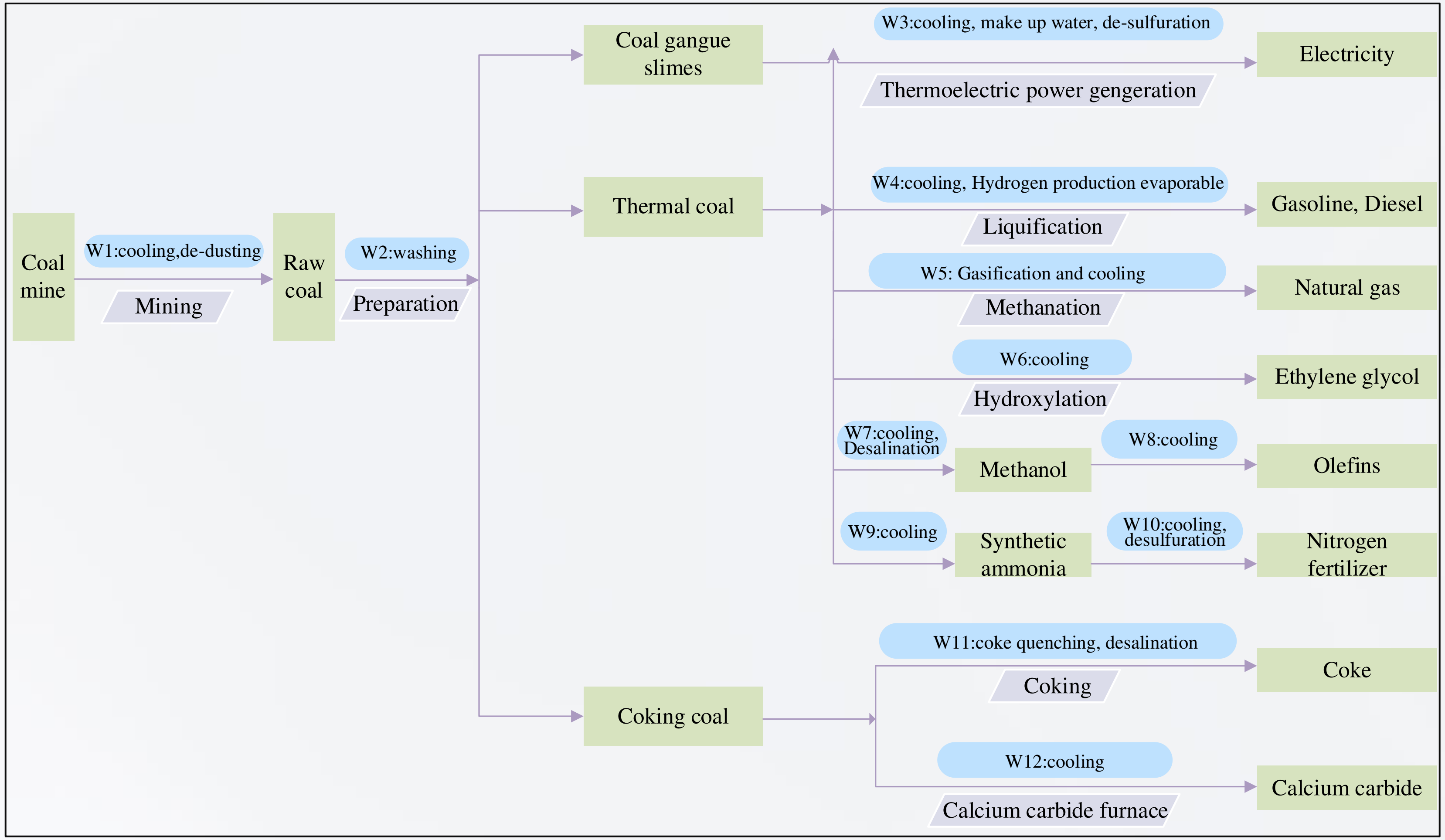
Basic characteristics of water use in the coal industry



The structure of coal industry chain and its water use

- ◆Coal-fired power generation
  煤电
- ◆Coal mining and washing
  煤炭开采和洗选
- ◆Traditional Coal chemical industry
  传统煤化工
- ◆New-type coal chemical industries
  新型煤化工

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Data and methods

What data we need

A facility-level geodatabase, Production capacity, product output and technology type

What we do

- First, collected lists of mines, plants of each production process, and confirm there capacity or output
- Then, searched and identified their geographic location

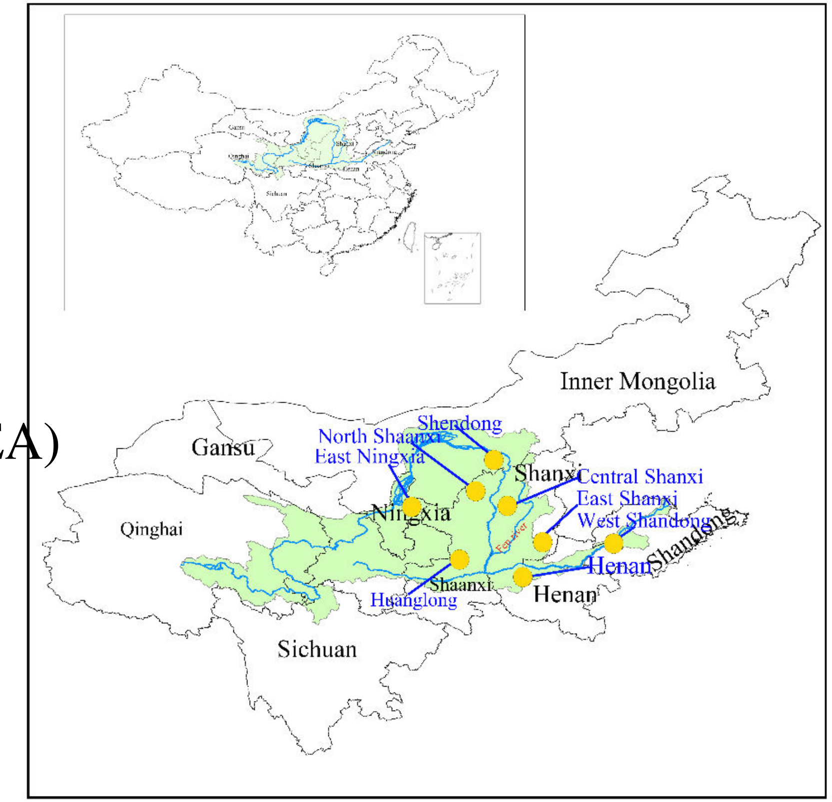
Details

- Coal mines
- Coking plants
- Ammonia and methanol plants
- New-type coal chemical plants
- Coal-fired power plants

- National Energy Administration (NEA)
- The Ministry of Industry and Information Technology (MIIT)
- Compilation of Statistics of Power Industry

a

Location of large coal bases in the YRB



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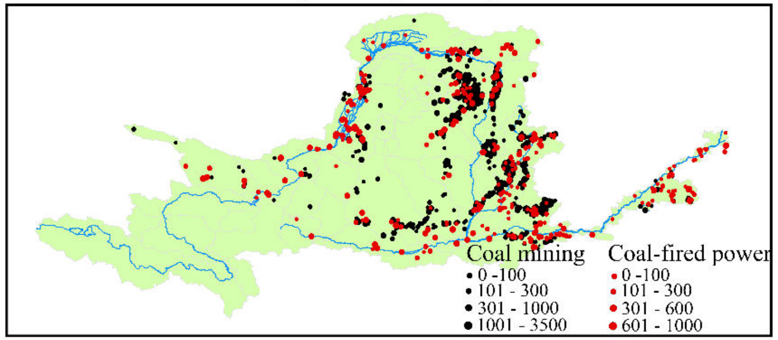
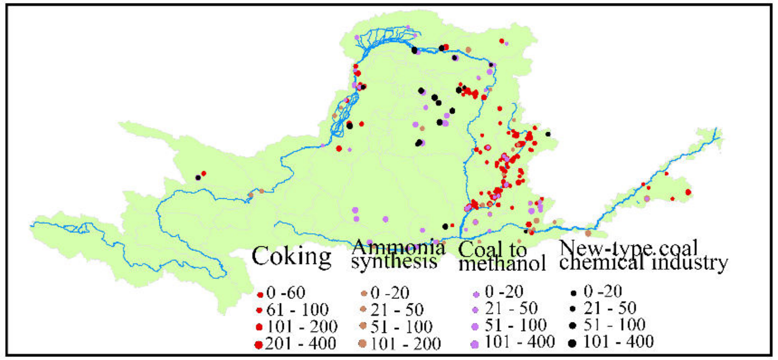
Coal mines and coal-fired power (10^4 T, MW)



c

Coal chemical industry (10^4 T)



Data and methods

Water withdrawal estimation

$$W_j^i = \frac{C_j^i}{C_p^j} \times O_p^j \times S_p^j$$

Where W_j^i is the estimated amount of water withdrawal by facility i of product j in the YRB; C_j^i is the production capacity of facility i of product j in the YRB; C_p^j is the total production capacity of product j province p (e.g., the total coal mining capacity of Shanxi province in 2018, province p is province where the i factory located); O_p^j is the total output of product j in province p in 2018, real output of raw coal, washed coal, coke, synthetic ammonia and methanol by province were reported in industrial statistics (See table 3). S_p^j is the water withdrawal quota of per unit product j in province p regulated by water resources management authorities, they are presented in Table. 1.

Water stress analysis

$$BWS = \frac{TWW}{Ba} = \frac{AWW + IWW + DWW + OWW}{Ba}$$

$$Ba = R + \sum Qout_{up}$$

$$Qout = \max(0, Ba - Uc)$$

Where BWS is the baseline water stress, TWW is the total annual freshwater withdrawal, AWW, IWW, DWW, and OWW represent water withdrawal by agriculture, industry, domestic and others.

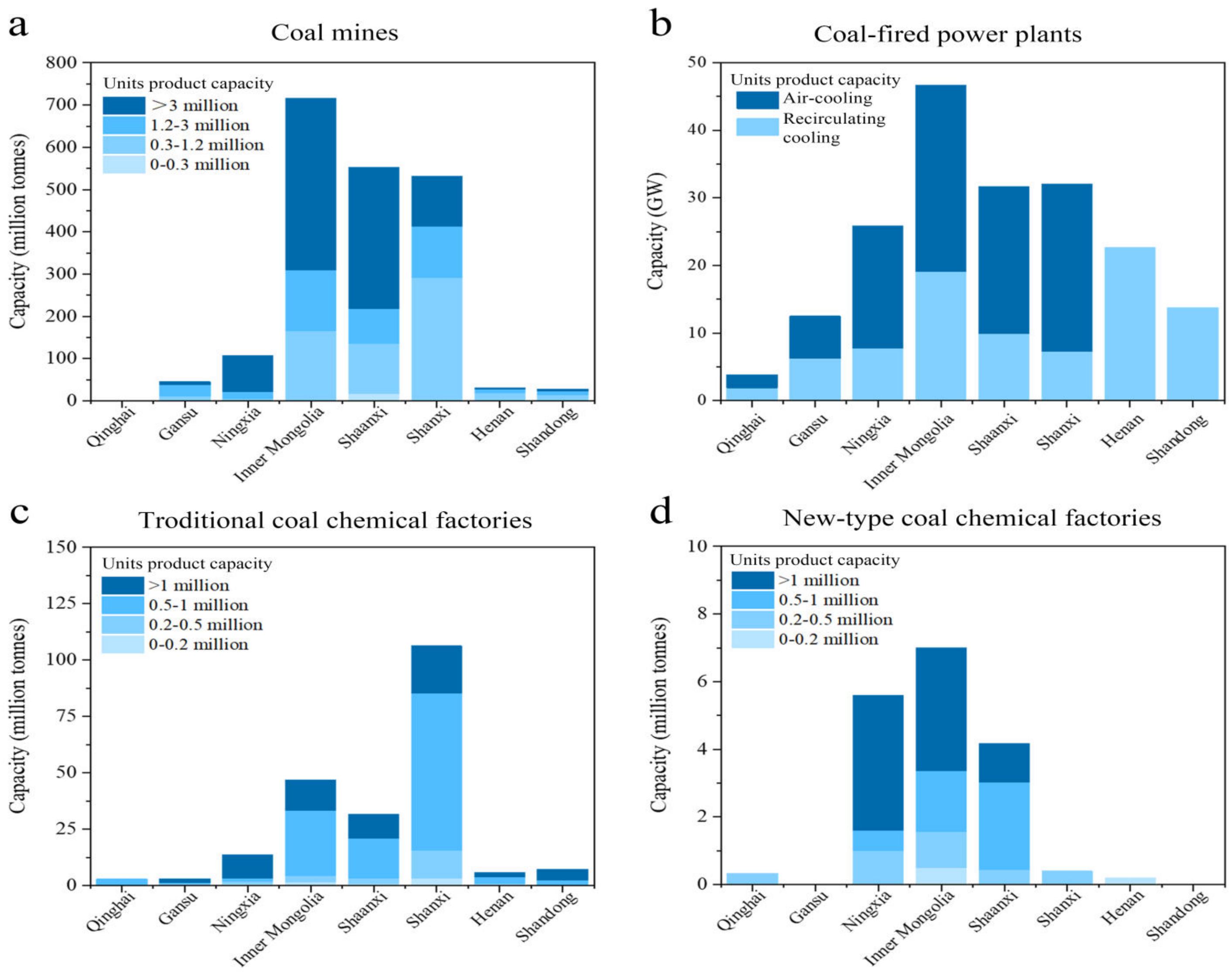
Where R is the self-produced long-term average annual surface water runoff in a certain catchment, $Qout_{up}$ represents the inflow of surface water from upstream catchments.

Results: Spatial distribution of production facilities

- coal mines are mainly in Shanxi, Shaanxi and Inner Mongolia

- There are eight large-scale coal bases with annual production capacity over 100 million tonnes being developed in the YRB

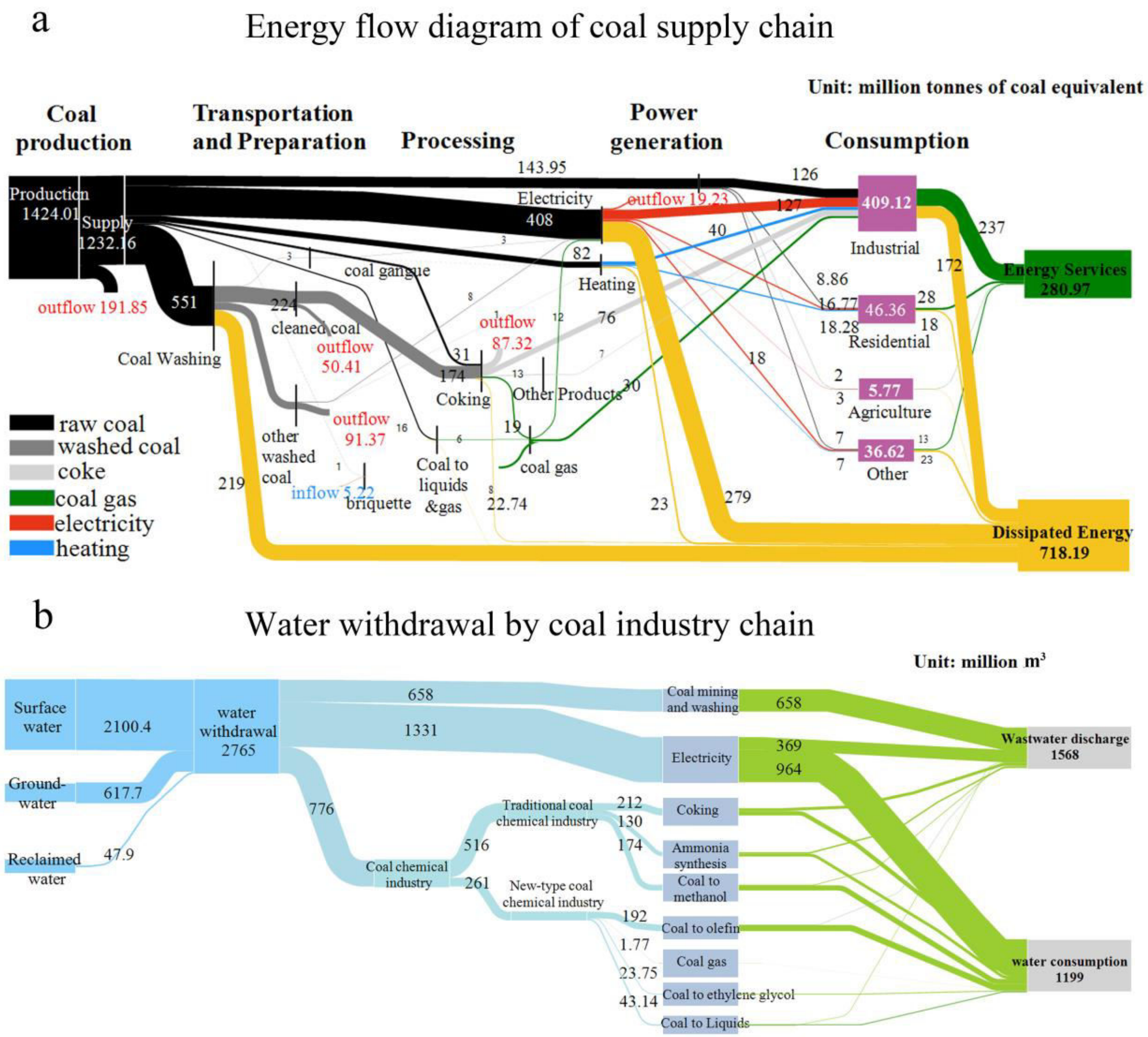
  - These coal bases are mainly located in the middle reaches of the YRB



the size or cooling technology structure of production facilities by province

Results: Energy and water flow of the coal-water nexus

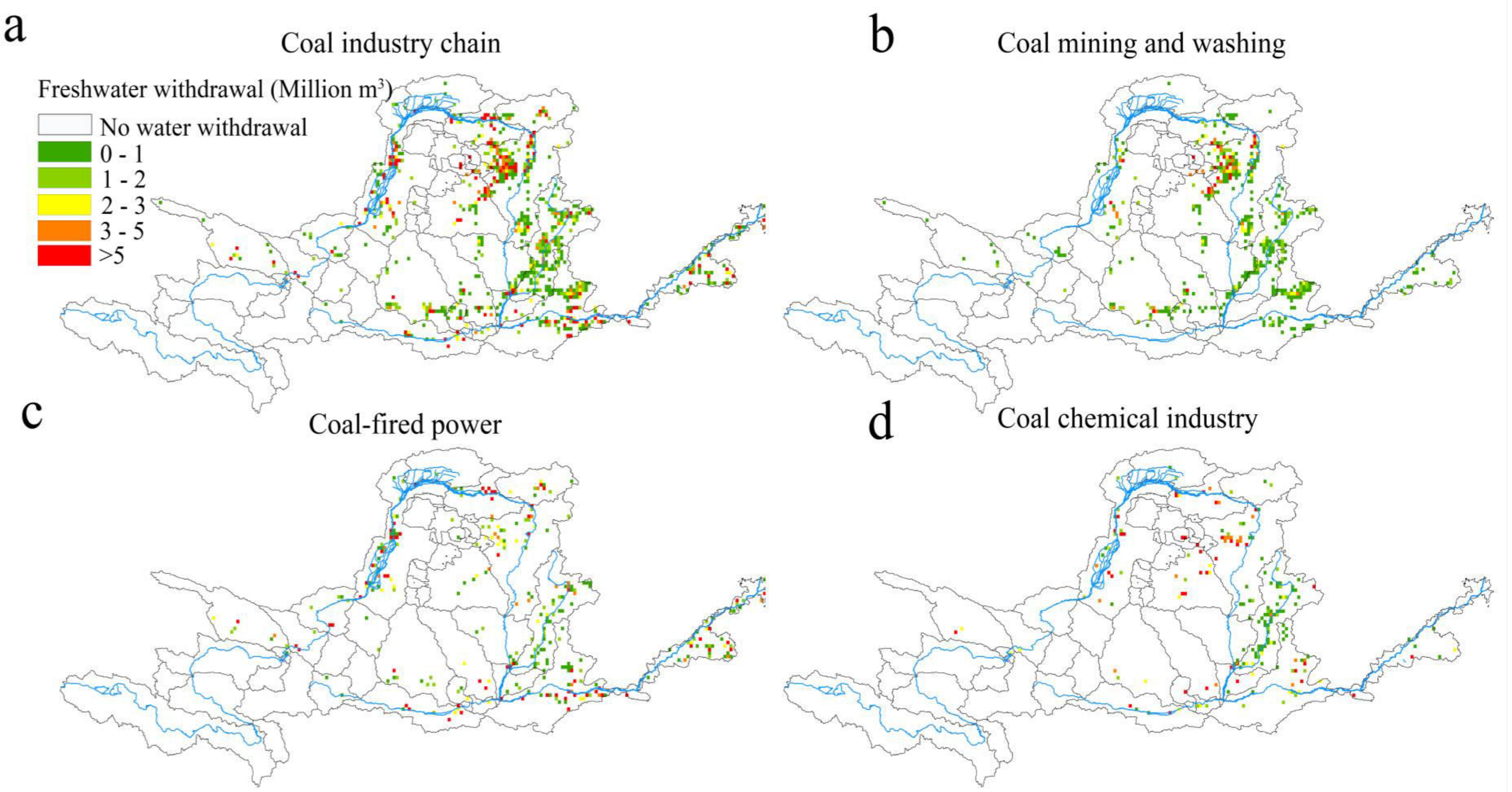
- The total amount of raw coal extraction in the YRB was 1.424 billion tonnes
- 87% of the coal production (1.232 billion tce) was further processed within the YRB
- The total water withdrawal was 2.756 billion m^3, 76% came from surface water.
- **Coal-fired power generation is the largest water user** in the YRB, responsible for about 48%
- Coal mining and washing and Traditional coal-to-chemical industry used 658 million m^3 and 516 million m^3 water

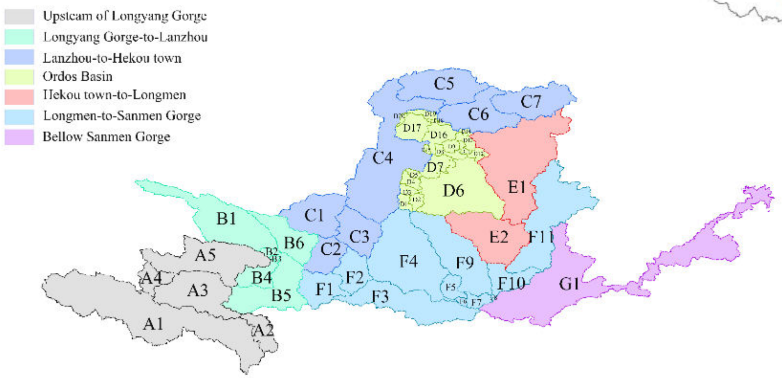


energy flow diagram of coal supply chain in the YRB in 2018, water withdrawal by coal industry chain

Results: Spatial distribution of water withdrawal

G1, E1, C4 Water withdrawal in all these three catchments exceeded 400 million m^3 and added up to 1558.6 million m^3, or 56.6 % of the total withdrawal



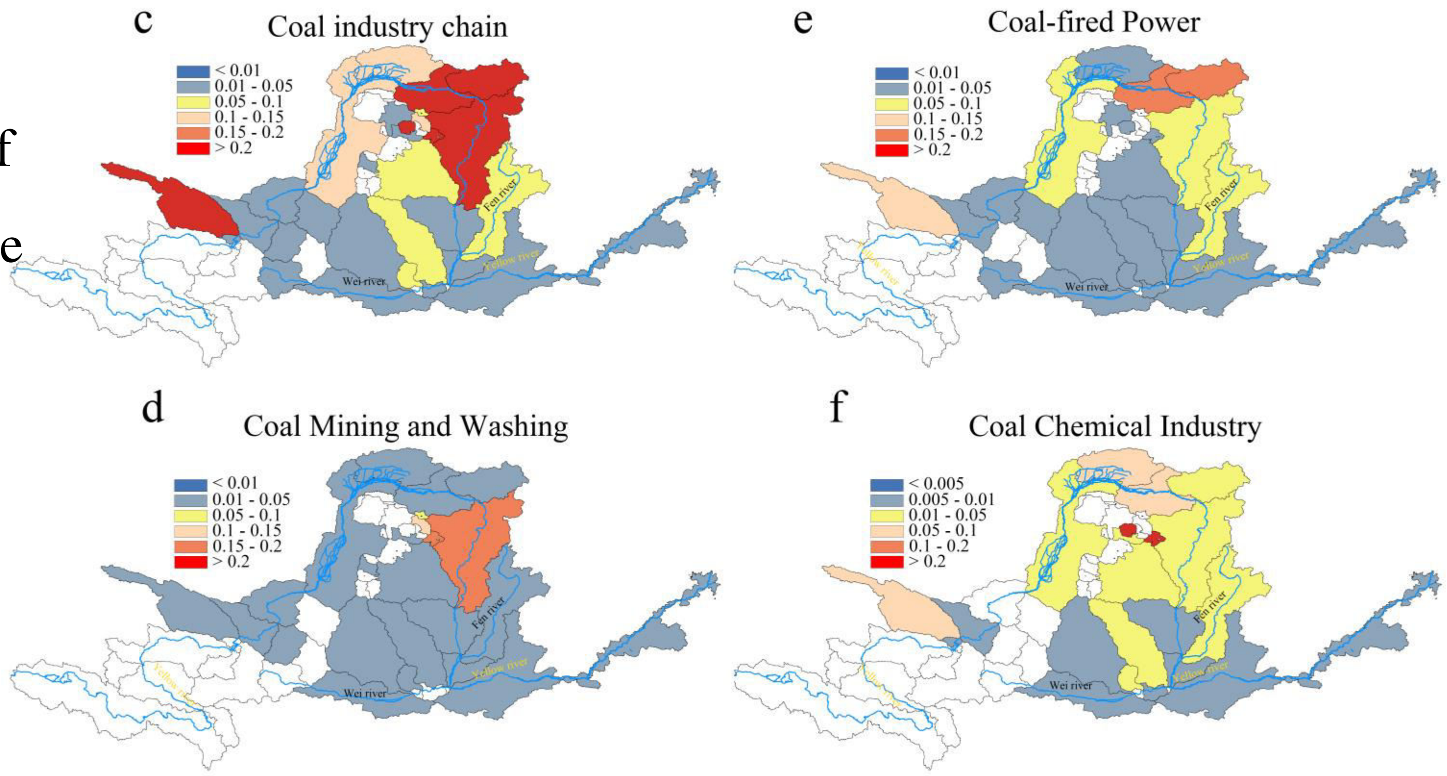


Spatial distribution of water withdrawal by coal industry with 0.1° × 0.1° resolution in the YRB in 2018

Results: Water stress induced by coal industry chain

Coal-relevant water stress in the east part of the 'Hetao' area and the intersections of Shanxi, Shaanxi and Inner Mongolia) were the highest, with WTA ratios exceeding 20%

We also show water stress caused by different kinds of coal products



the baseline water stress induced by water withdrawal by the coal industry chain in YRB

Discussion

- Acquire water-related data is hard

➢ With only top-down analysis, the spatial structure of such pressure is unclear and the regional differences of dominant contributors to water withdrawal/water stress cannot be elaborated

➢ Development of a high resolution geodatabase, however, bottom-up accounting, the real water use inevitably has some deviations from our estimation

- Water scare

➢ 95% of the coal-fired power generation and 60% of the new-type coal chemical industry in the YRB are located in areas under high or extremely high water stress

➢ Increase water use efficiency

➢ Re-allocation of water resources. Water allocation scheme should keep up with the dynamics of coal industry development