



## 中国农业生产与水资源适配性分析

# Matching analysis of food production and water resources in China

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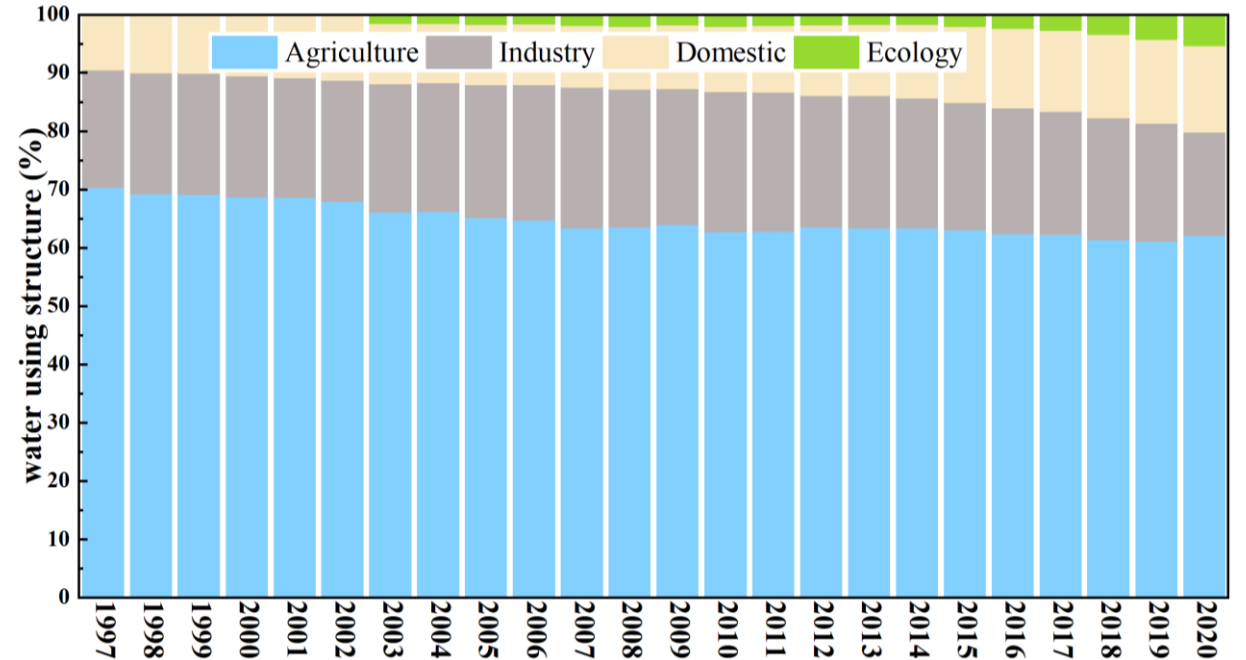
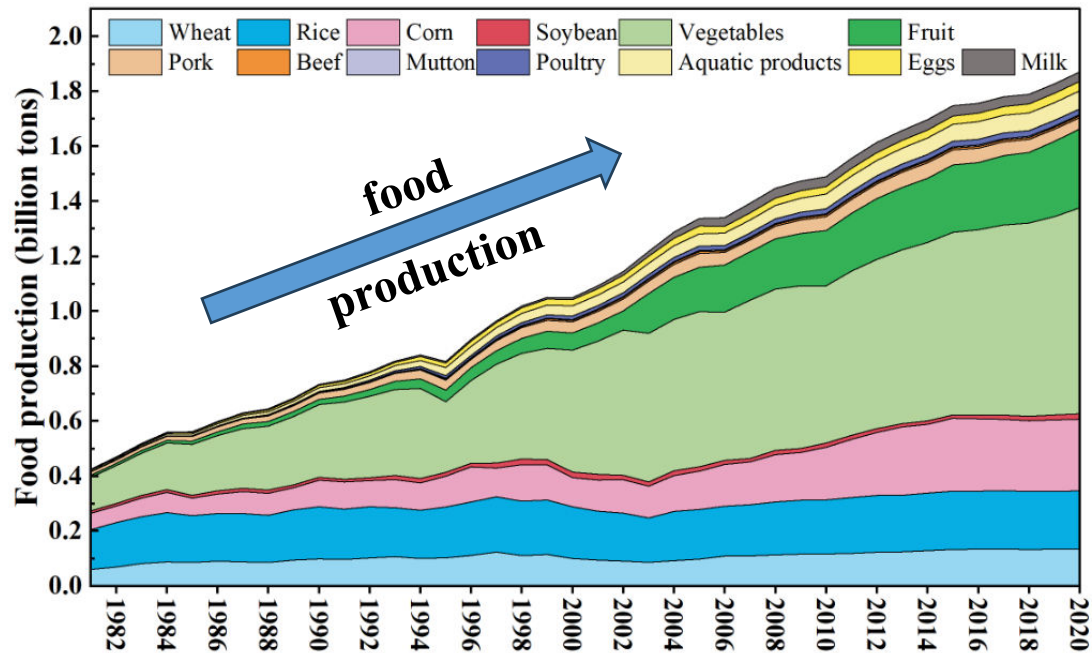
**China Institute of Water Resources and Hydropower Research, IWHR**

**2023.9.14 · 北京**

# 中国水资源和粮食生产

## Water Resources and Food Production in China

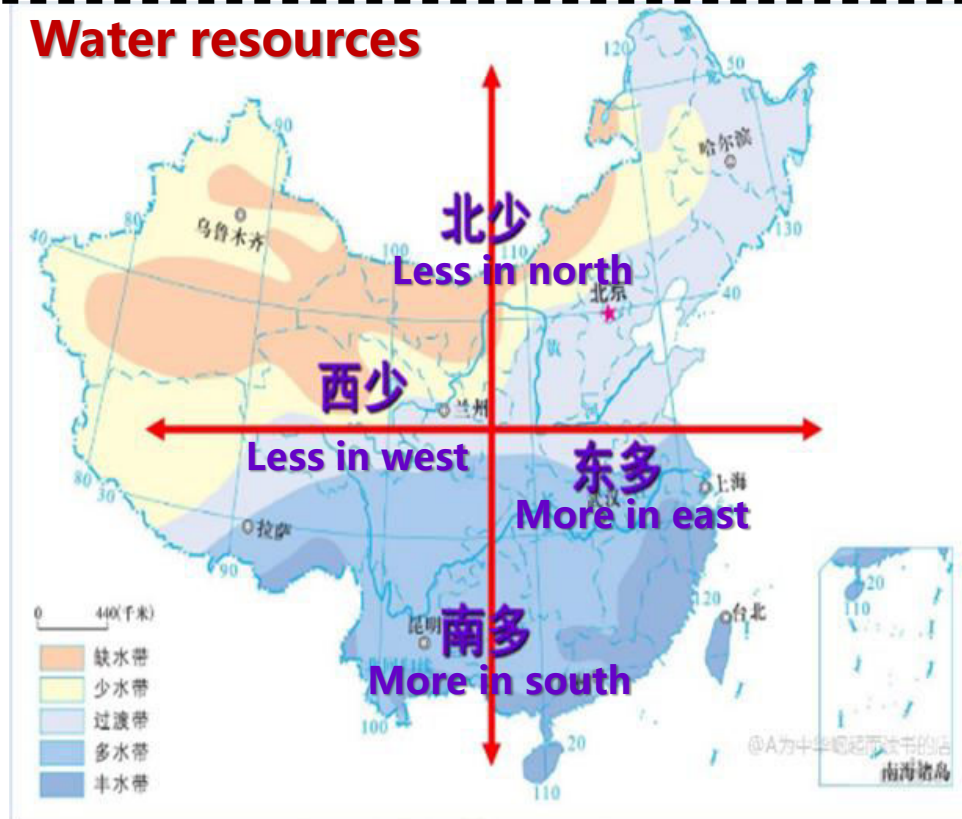
- 农业用水占总用水量的比例最高，约占总用水量的**63%(2020)**;
- 近年来，食物生产呈增长趋势，由1997年的**9.7**增长至2020年的**18.7**亿吨;
- Agricultural water consumption accounts for the highest proportion of China's total water consumption (**62%**). Food production has shown a growth trend.



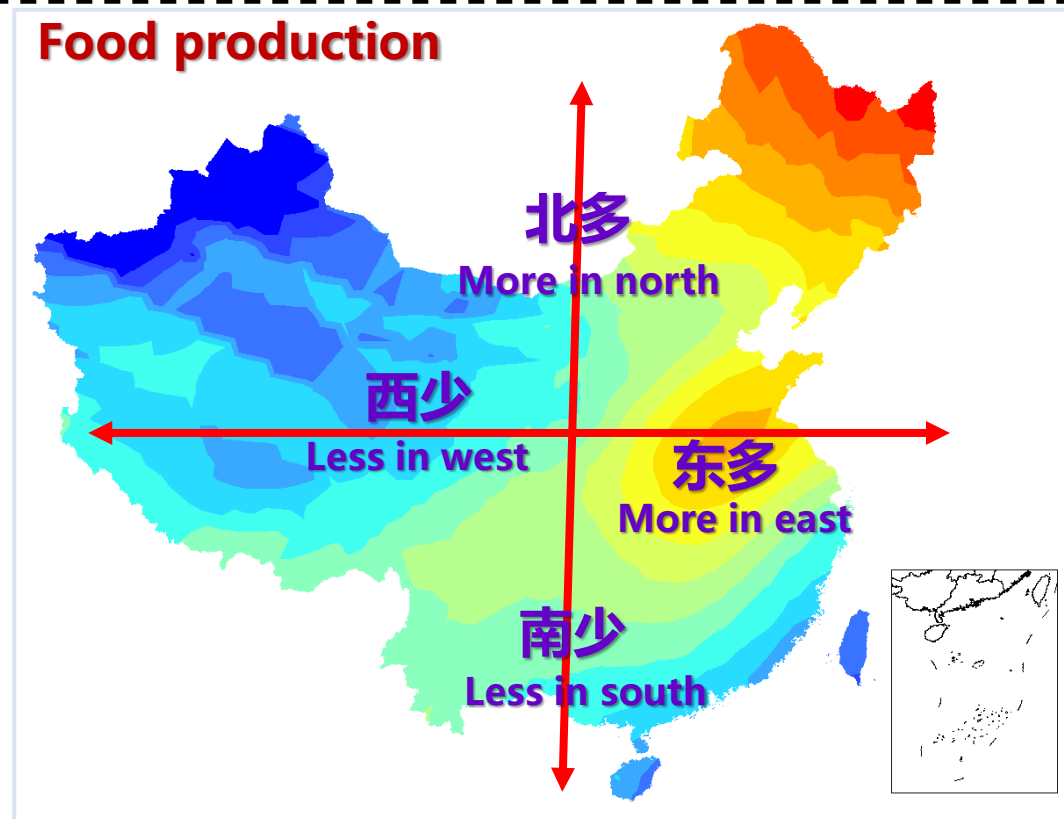
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- **农业与水资源空间上呈逆向分布，北方是农业主产区，约占全国总产量的60%，水资源仅占全国19%。**
- The spatial distribution of food and water resources is inversely distributed, with northern food production accounting for about 60% of the national total, while water resources only account for 19%.



中国水资源分布图 Distribution of Water Resources



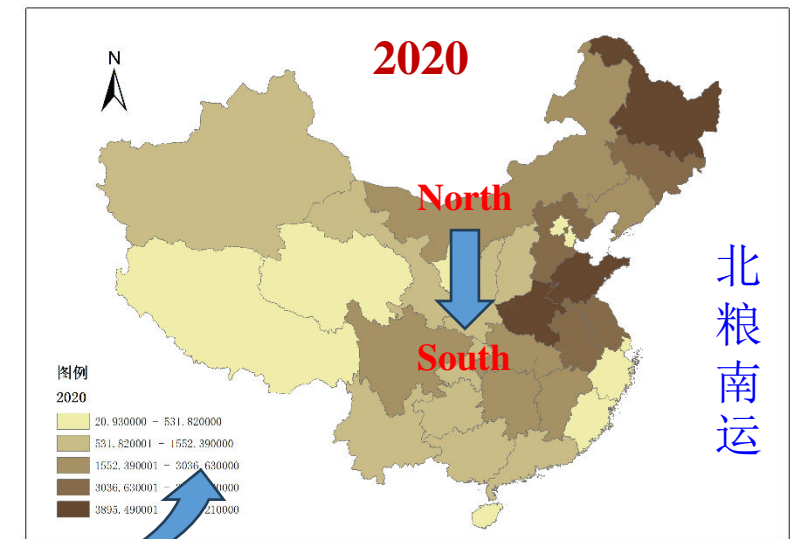
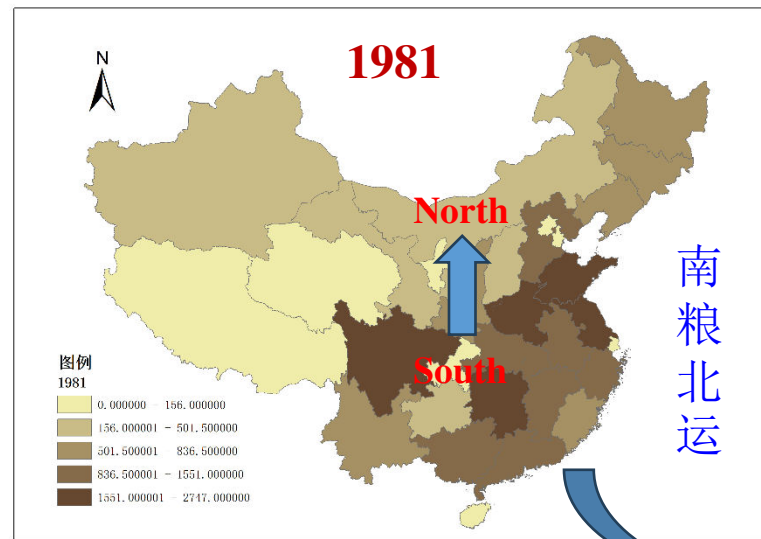
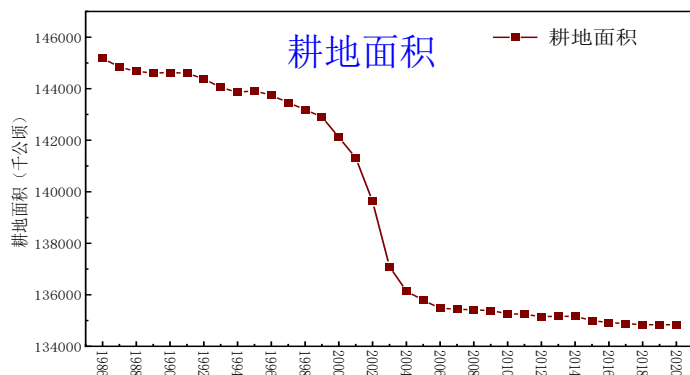
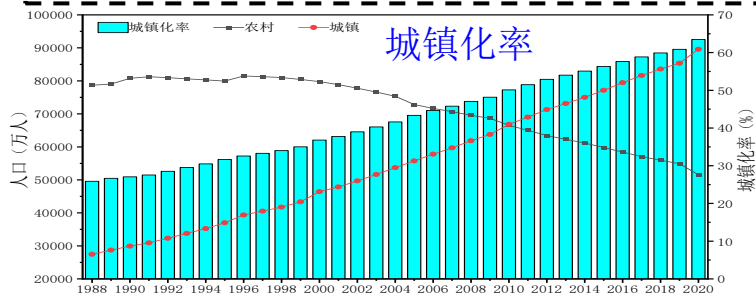
中国农业生产分布图 Distribution of food production

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- 由于社会经济发展及城镇化进程，南方地区耕地资源逐渐减少。
- “北粮南运” 加剧了北方水资源压力。

Due to socio-economic development and urbanization process, the cultivated land resources in the southern region are gradually decreasing. "Grain transport from the north to the south" has intensified the pressure on water resources in the north.



# 中国水资源和农业生产

## Water Resources and Food Production in China

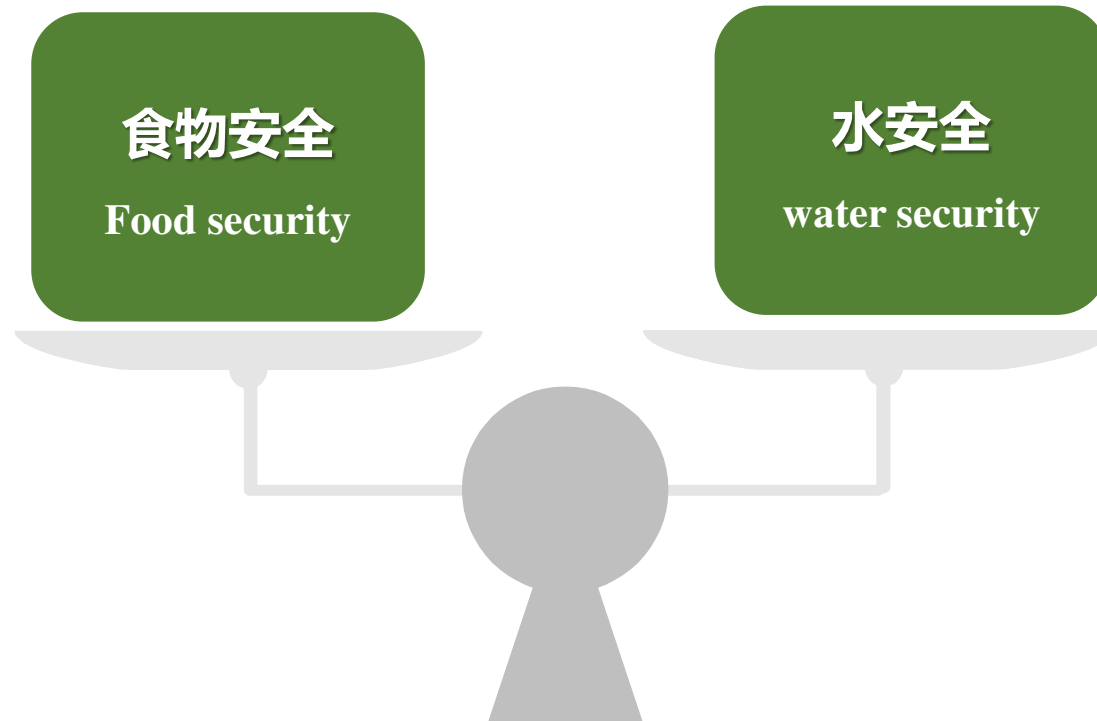
农业生产用水约占中国用水总量的**2/3**;

Agricultural water use accounts for about 2/3 of  
China's total water consumption;

农业生产布局与水资源分布存在空间**错配**.

+

Food production and water resources **mismatch**  
spatially.



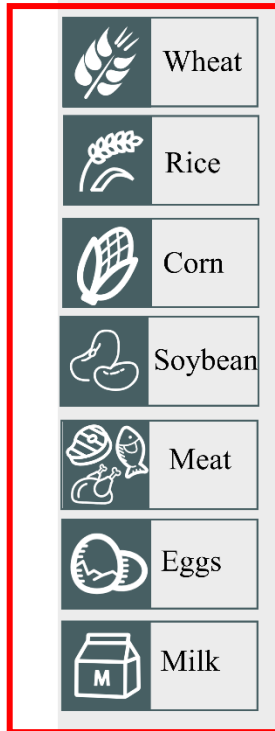
# 中国农业生产与水资源适配性分析

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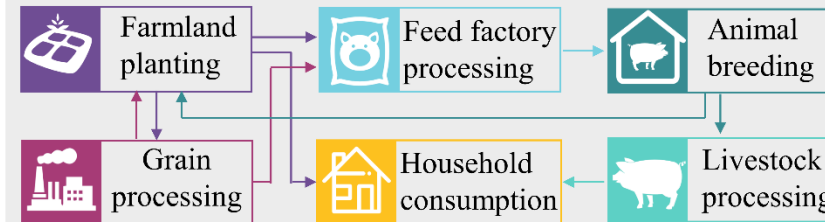
粮食作物  
Grain crops

动物产品  
Animal products

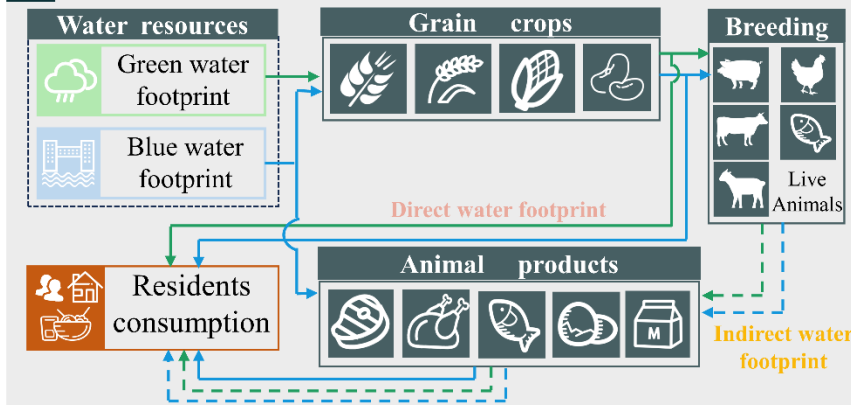
## 1 Food types



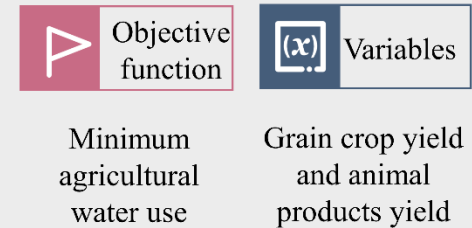
## 2 Food supply and demand structure



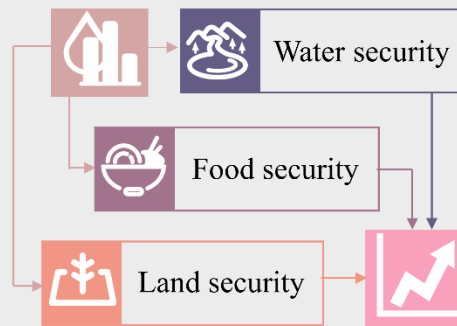
## 3 Life cycle water use of food production



## 4 Optimization of food production structure



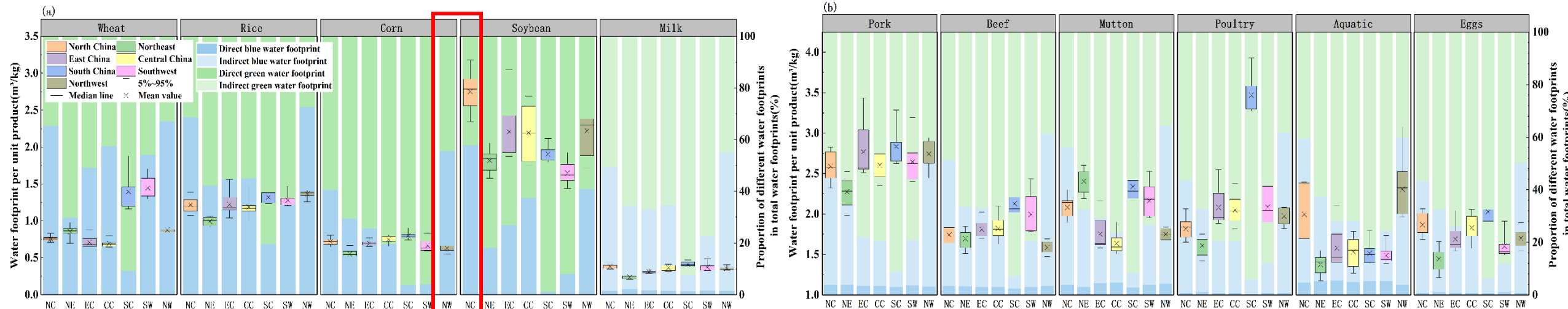
## 5 Optimize benefits



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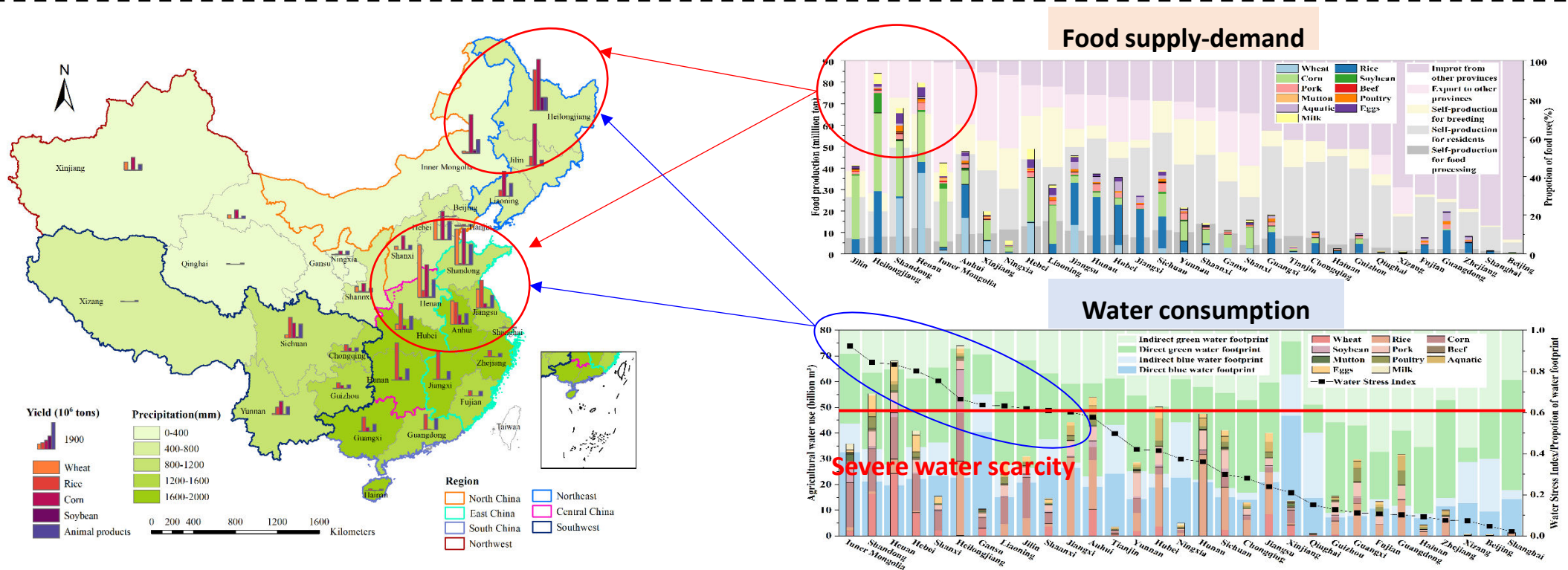
- 农业水效率呈区域性特点，北方多数作物蓝水足迹大于南方。
- 华北地区大豆蓝水足迹 $1.4\text{m}^3/\text{kg}$ ，西北地区玉米蓝水足迹 $0.35\text{m}^3/\text{kg}$ ，是全国均值的2.6和1.9倍。
- The blue water footprint of food produced in many provinces in the north is larger than in the south.
- The blue water footprint of soybeans in North China and corn in Northwest China is  $1.4\text{m}^3/\text{kg}$  and  $0.35\text{m}^3/\text{kg}$ , which are 2.6 and 1.9 times the national average, respectively.



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- ▶ 北方15个省中，10个省（区、市）农业水压力指数均大于0.6。
  - ▶ 黑龙江、河南、山东食物产量和农业用水均位居全国前三，均处于严峻水压力状态。
  - ▶ About 2/3 provinces in the northern region have an agricultural water pressure index greater than 0.6.
- Heilongjiang, Henan, and Shandong provinces are under severe water pressure.



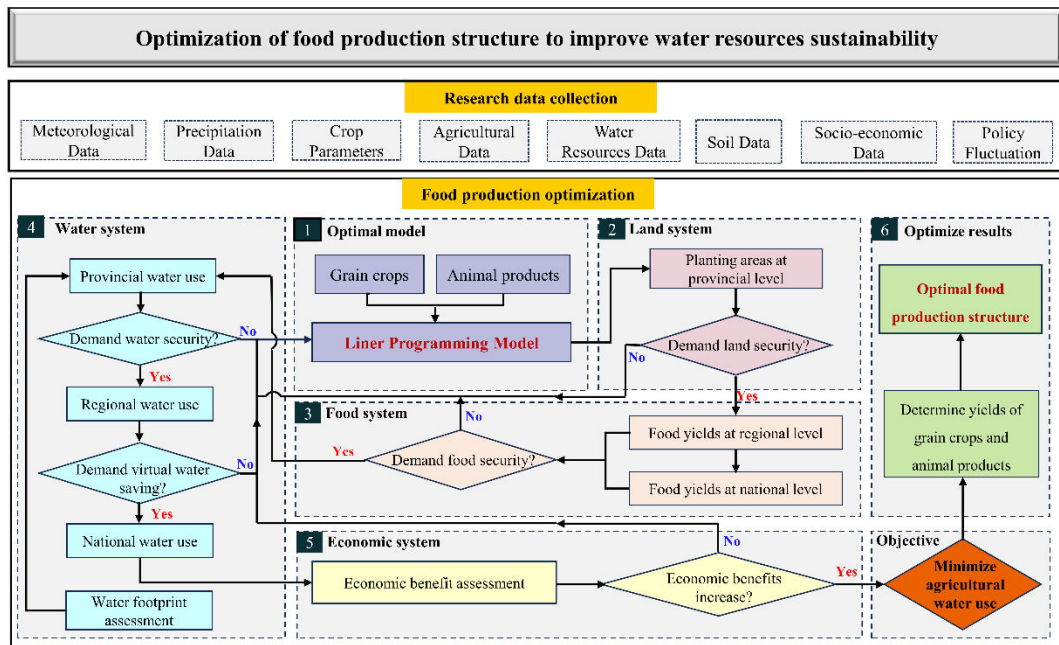


# 中国农业生产与水资源适配性分析

## Matching analysis of food production and water resources in China

以节约水资源与缓解缺水地区的水资源压力为首要目标，构建食物生产结构优化模型，从全国水平节约稀缺蓝水资源，期望得到缓解缺水地区的水资源压力的农业种植结构。

With the goal of saving national water resources and alleviating water resource pressure in water deficient areas, a food production structure optimization model is constructed to save scarce blue water resources at the national level.



目标：食物生产蓝水最小

Food production with minimum blue water

约束条件 Constraints :

$$AWU_j \leq AWC_j$$

(1) 水资源总量约束 Total water resource constraints

$$A_{min,ij} \leq A_{ij} \leq A_{max,ij}$$

$$Y_{min,sj} \leq Y_{sj} \leq Y_{max,sj}$$

(2) 种植传统约束 Traditional planting constraints

$$\sum_s \sum_j Y_{sj} \times \beta_{sj} \leq \sum_i \sum_j Y_{ij}$$

$$\sum_j Y_{ij} = Y_{ref,i}$$

(3) 食物安全约束 Food security constraints

$$\sum_j Y_{sj} = Y_{ref,s}$$

$$\sum_i A_{ij} \leq A_{j,ref}$$

(4) 耕地约束 Land resources constraints

$$\sum_j \left( \sum_i Y_{ij} \times E_{ij} + \sum_s Y_{sj} \times E_{sj} \right) \geq E_{ref}$$

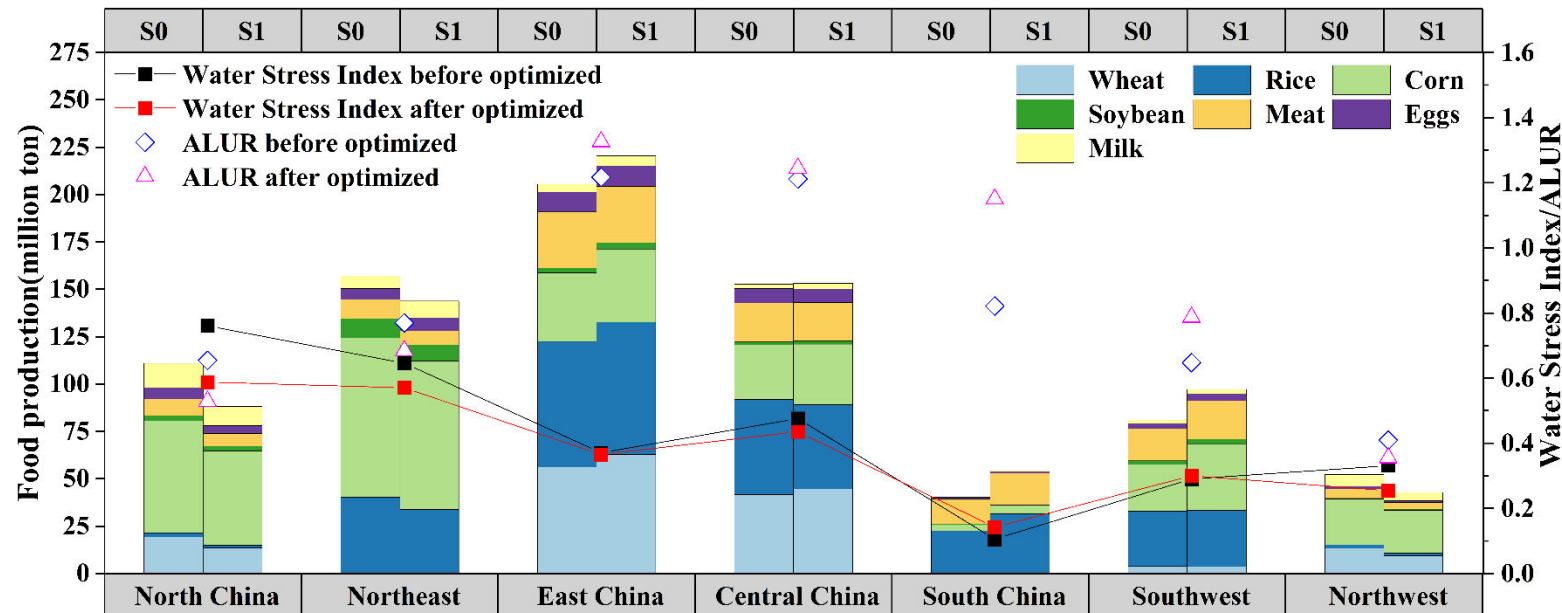
(5) 经济效益约束 Economic benefits constraints

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尽管南方地区水资源丰富，但由于社会经济发展及城镇化进程，耕地资源有限。

模型优化结果显示，**华南有一定水稻增产潜力 (20~30%)**，**西南可增加玉米 (20~30%) 与大豆 (30~40%) 生产**。The optimization results of the model show that although the arable land resources in the south are limited, there is still a certain potential for increasing rice production (20-30%) in South China, while corn (20-30%) and soybean (30-40%) production can be increased in Southwest China.



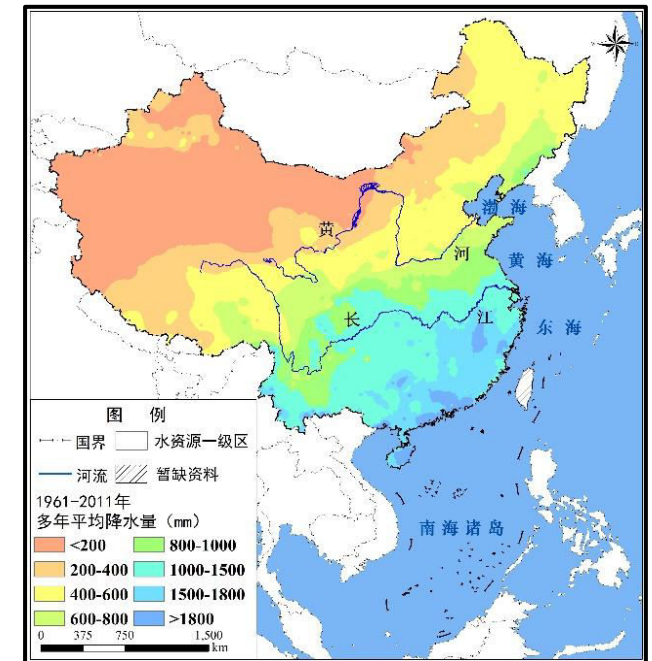
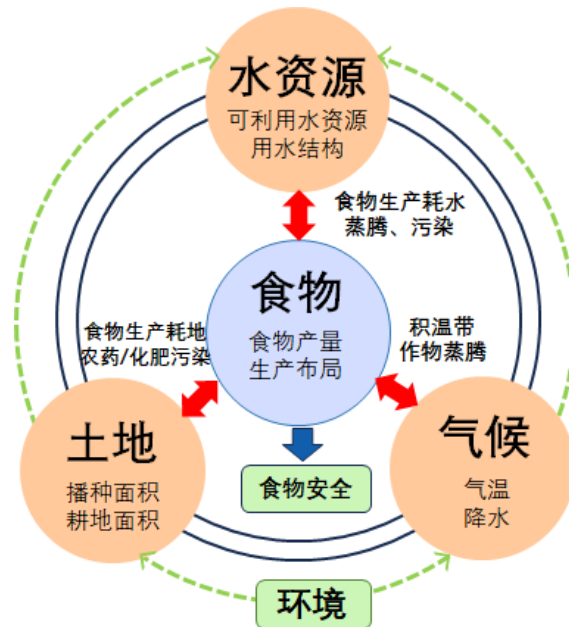
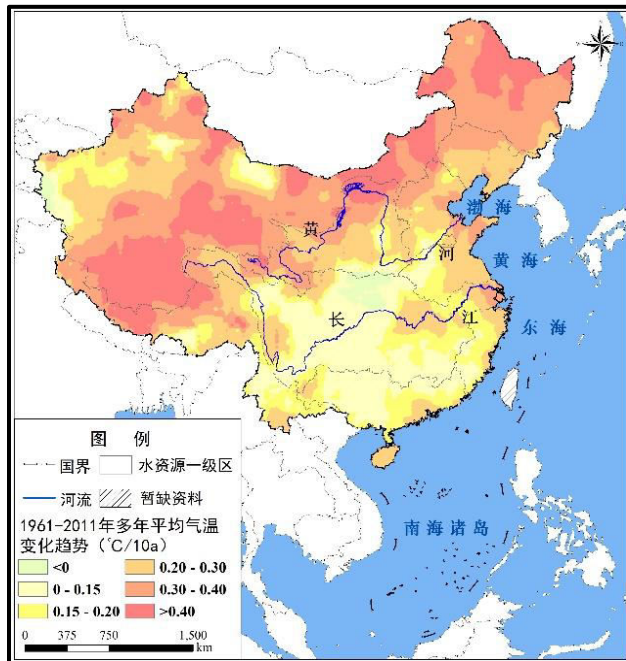
Miao et al. Optimizing the structure of food production in China to improve the sustainability of water resources. STOTEN. 2023

# 变化环境下的水-粮食-土地关系

## Water-food-land nexus under a changing environment

水和土地资源限制了粮食生产，而次优的粮食生产结构增加了水压力。人类活动显著改变了土地利用，与此同时，气候变化加剧了全球水资源的不均衡分布。中国是全球气候变化的敏感区和影响显著区，需加强研究协调水与粮食、土地和社会经济的发展。

Water and land resources constrain food production. Human activities have significantly altered land utilization, meanwhile climate change is exacerbating the uneven distribution of water resources globally. It is necessary to strengthen research and coordinate the development of water, food, land, and social economy.





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