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Surface water expansion due to increasing water demand on the Loess Plateau

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Introduction

- **Objective:**
  - Examine spatial-temporal variability of surface water bodies on the Loess Plateau and identify drivers (climate change vs. human activities).
- **Background:**
  - Surface water bodies (reservoirs, lakes, rivers) are critical for agriculture, industry, and domestic use.
  - The Loess Plateau faces water scarcity and soil erosion, addressed by hydraulic projects like dams and reservoirs.
  - Uncertainty exists about the impact of these projects on surface water dynamics.
- **Significance:**
  - Understanding surface water changes aids sustainable water resource management.

Study Area and Methods

- Location: Loess Plateau, northwest China (632,520 km², elevations 200–3000 m).
- Climate: Temperate continental monsoon, annual precipitation 150–800 mm (mean <350 mm), concentrated in June–September.
- Land Use: 32.12% crops, 41.58% grass; includes seven provinces (Qinghai, Gansu, Ningxia, Inner Mongolia, Shaanxi, Shanxi, Henan).
- Challenges: Severe soil erosion, increasing water demand due to economic growth.

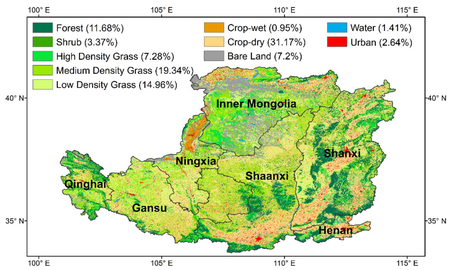

Fig.1 Land use types and provinces of the Loess Plateau.

- **Data Sources:**
- Surface Water : JRC Global Surface Water (JRC-GSW) dataset (30 m resolution, 2000–2020) from Landsat 5, 7, 8.
- Precipitation: China Meteorological Administration.
- Water Withdrawal: Yellow River Water Resources Bulletin (provincial data for agriculture, industry, etc.).
- **Analysis:**
- Classified water bodies: permanent, seasonal, wet season (June – September), dry season.
- Categorized water bodies by size: 0.01–1, 1–5, 5–10, 10–20, 20–50, >50 km².

Results

- **Spatial Distribution:**
- Permanent water area increased by ~1000 km² (1200 km² in 2000 to 2200 km² in 2020).
- Small water bodies (<1 km²) doubled in number (6721 to 14,028), contributing 99.3% of the increase.

- **Temporal Variability:**
- Permanent, wet, and dry season water increased significantly (52.80, 45.08, 86.88 km²/y, respectively; P< 0.01).
- Seasonal water slightly decreased (-5.35 km²/y).
- Intra-annual peaks in spring and a utumn, lower in summer/winter.
- Large water bodies (>5 km²) remained stable in number and area.

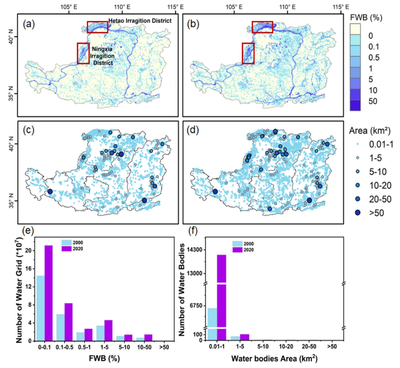

Fig.2 Spatial distribution of fraction of water bodies (FWB) in 2000 and 2020.

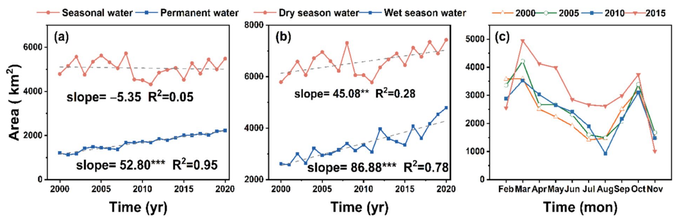

Fig.3 Temporal trends in permanent, seasonal, wet, and dry season water areas.

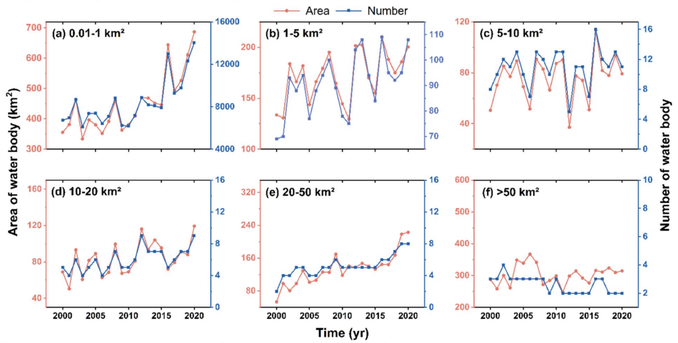

Fig.4 Area and number of water bodies by size categories.

- **Driver Analysis:**
- Water withdrawal (R^2=0.46) showed a stronger correlation with surface water expansion than precipitation (R^2=0.2).

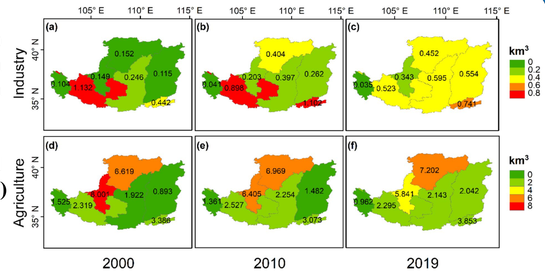

Fig.5 Industrial and agricultural water withdrawals by provinces in (a) 2000, (b) 2010 and (c) 2019.

- Eastern provinces (Shaanxi, Shanxi, Henan) showed positive correlation with water withdrawal; western provinces (Qinghai, Ningxia) with precipitation.

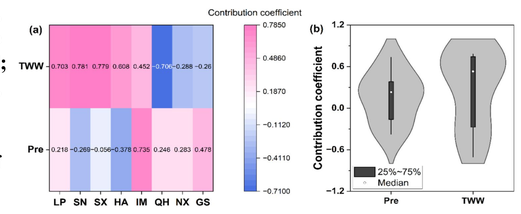

Fig.6 Contribution coefficients of precipitation and water withdrawal.

Discussion and conclusions

- **Key Findings:**
- Surface water expansion is driven by small-scale hydraulic projects (check dams, reservoirs) due to increasing water demand.
- Agricultural irrigation (80% of withdrawal) and industrial growth are major contributors. Precipitation has a limited role compared to human activities.
- **Implications:**
- Hydraulic projects support economic and ecological goals but may face sustainability challenges (e.g., silting, natural carrying capacity limits).
- Need for improved water efficiency and sustainable management.
- **Limitations:**
- Data accuracy affected by image quality and interpolation methods.
- Did not account for groundwater interactions or evaporation losses.