Understanding Agricultural Land System In the Big Data Era

Jinwei Dong

Institute of Geographic Sciences and Natural Resources Research, Chinese Academy of Sciences

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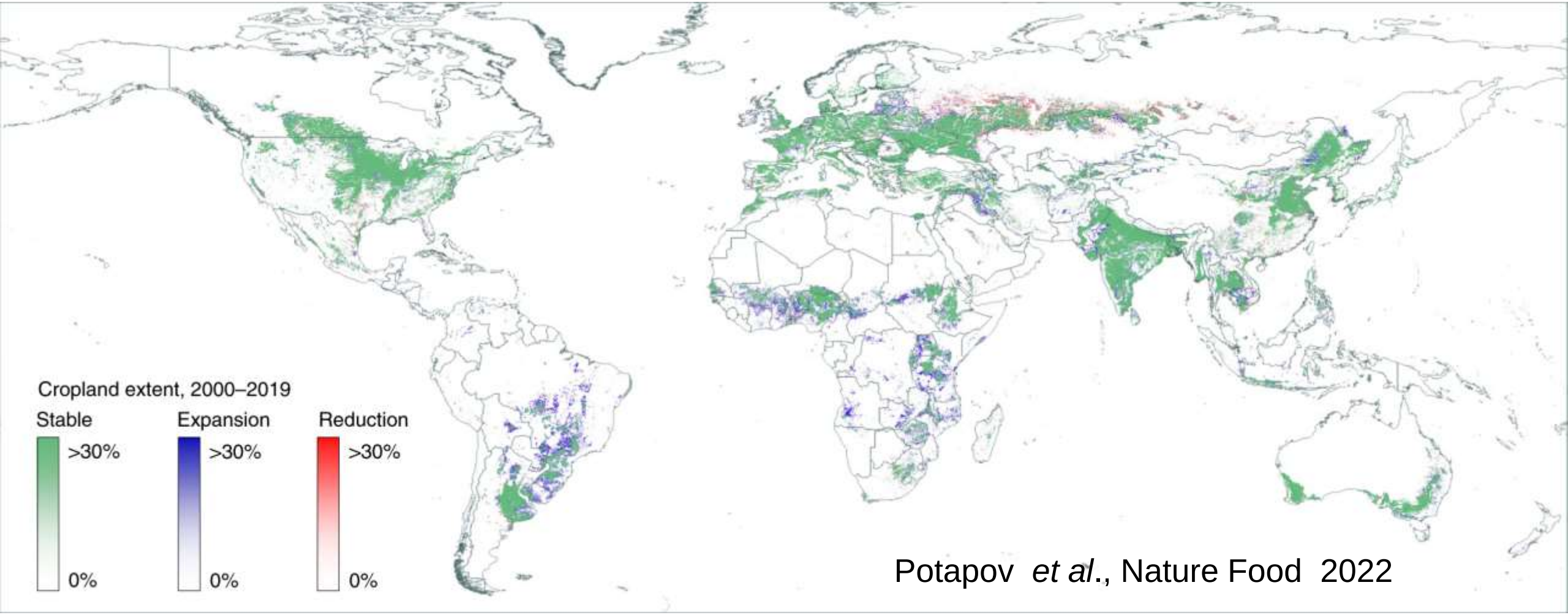
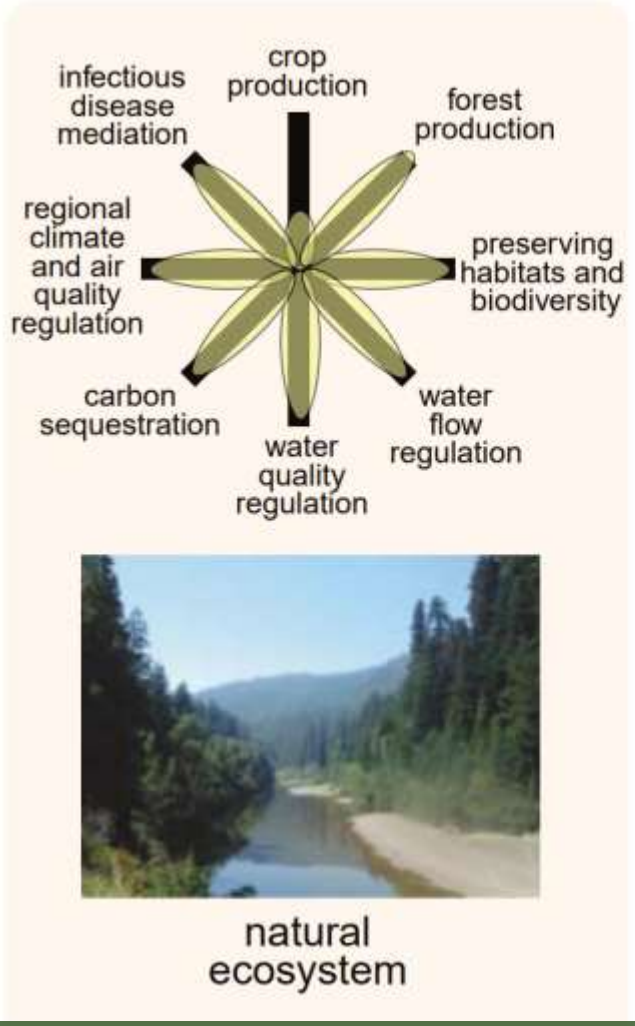
Cropland expansion due to growing population and changing diet



Potapov *et al*., Nature Food 2022

Global croplands expanded by 9% from 2003 to 2019, nearly doubling the annual rate of expansion

Understand synergies and trade-offs of cropland change consequences



Foley *et al*., Science 2005

Natural ecosystems can support many ecosystem services at high levels, but not food production, while managed croplands can produce food in abundance but diminish other ecosystem services.

Consequences of cropland dynamics are diverse and unpredictable

(Dong et al., In prep)

We face the challenge of managing trade-offs between immediate food production and maintaining the capacity of the biosphere to provide goods and services in the long term.

Emerging big remote sensing data and cloud computing platforms provide new opportunities for monitoring agricultural land systems.

Microsoft Planetary Computer

PIE-Engine

CASEarth

Big Earth Data Science Engineering Program

amazon.com web services

AI Earth

Scientific Questions

- **How to track agricultural land use changes (e.g., changes in crop types and irrigation methods) in different dimensions by using multiple remote sensing data and cloud computing?**
- **What are the consequences of agricultural land use changes and their trade-offs and synergies?**

Agricultural land system monitoring efforts in our group

Big Remote Sensing Data

+

CASEarth
Big Earth Data Science Engineering Program

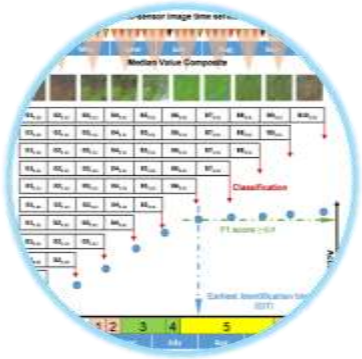
Cloud Computing Platform

+

Innovative Algorithms

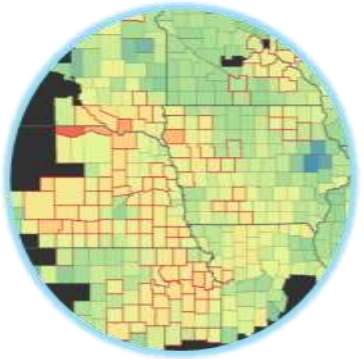
Cropland Mapping

Crop Mapping



In-season Crop Mapping

Irrigation Mapping

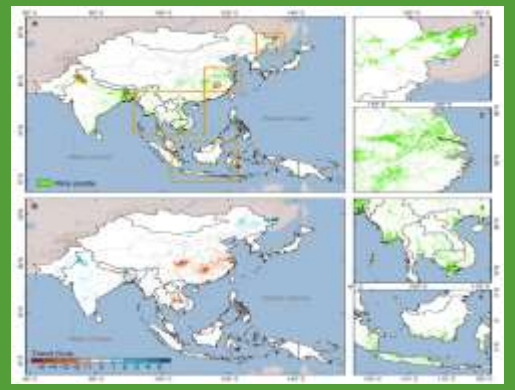


Conservation tillage Mapping

RS-based agricultural land system datasets from our group

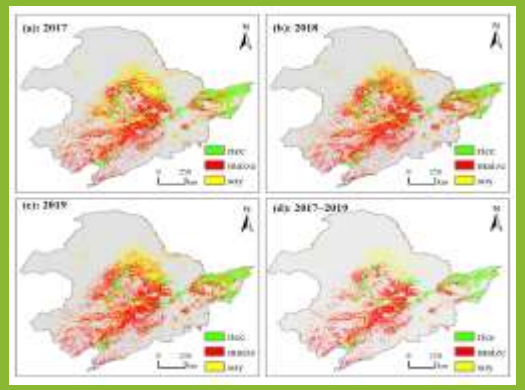
Rice maps (Asia)

The first 500-meter long time series data set of rice distribution in Asia from 2000 to 2020, through improved phenological rice extraction algorithm.



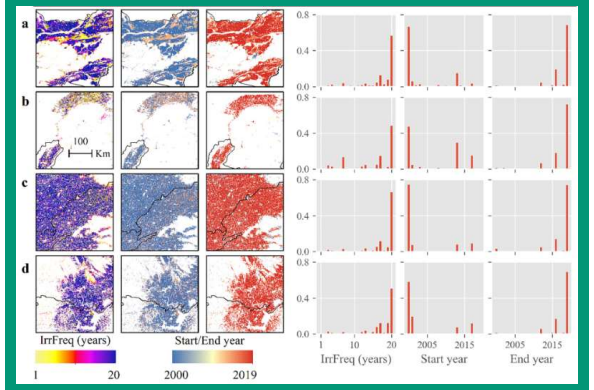
Crop maps (NE China)

High accuracy 10m resolution crop planting area maps in Northeast China from 2017-2023, through a hieratical mapping framework with feature optimization, data fusion, etc.



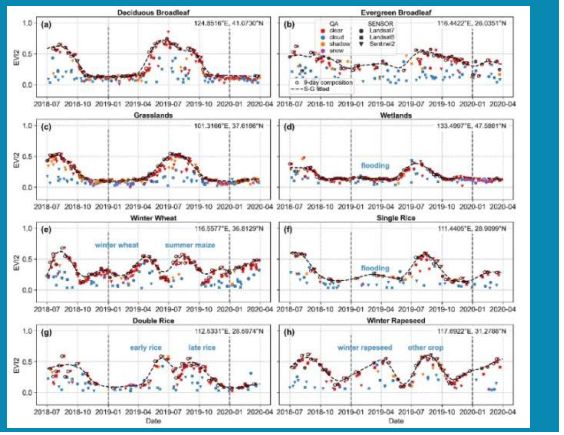
Irrigation maps (China)

Two sets of national irrigated farmland distribution data sets were completed in China from 2000 to 2020, through an automatic sample production strategy.



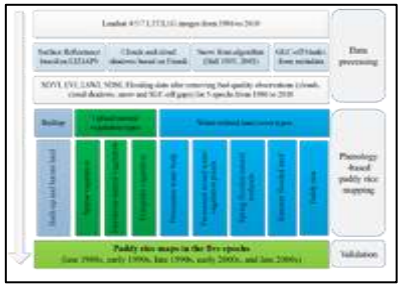
Crop phenology (China)

Crop phenology with 30 m resolution was generated in China, and fixing the problems of winter wheat sowing in autumn and rice SOS being affected by transplanting time.

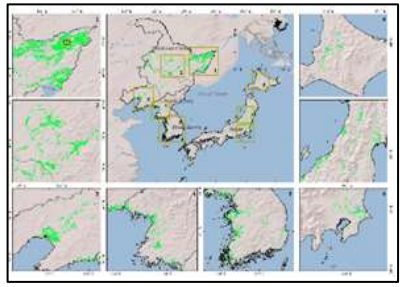


Paddy rice planting area mapping efforts

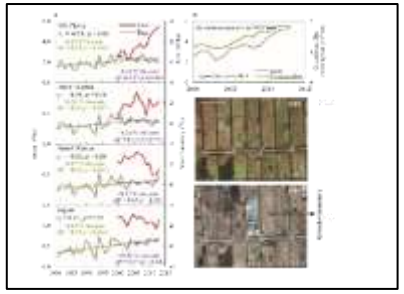
Algorithms overview of rice mapping
(Dong *et al.*, ISPRS&RS 2016)



Platform construction of rice mapping
(Dong *et al.*, RSE 2015)

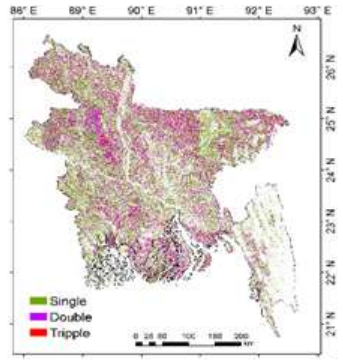


Large-scale rice mapping based on RS cloud Computing
(Dong *et al.*, RSE 2016)

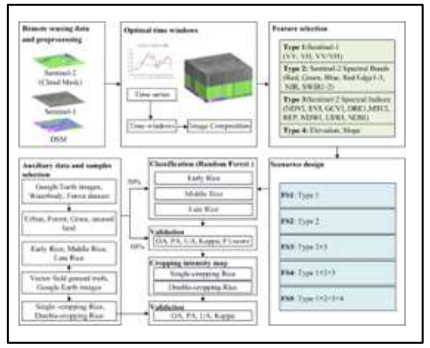


Mechanism analysis of rice expansion
(Dong *et al.*, *GRL* 2016)

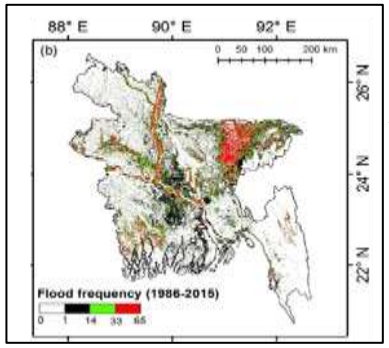
Rice mapping in cloud-prone regions
(Singha *et al.*, SD 2020)



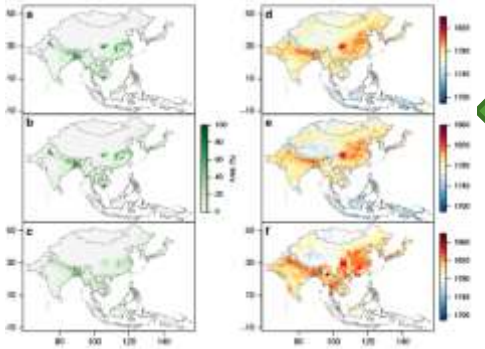
Monitoring rice cropping intensity
(He *et al.*, RSE 2016)



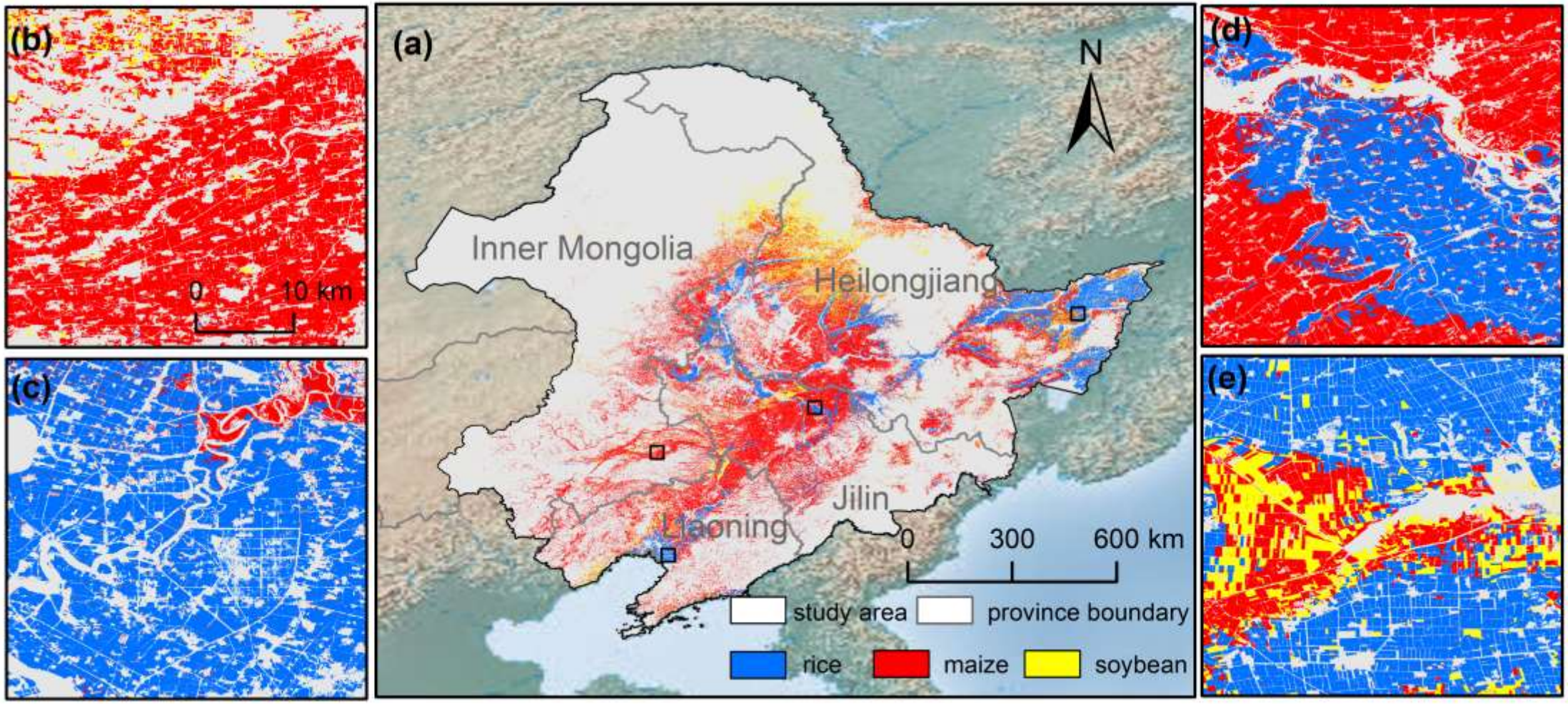
Flood impact analyses on rice
(Singha *et al.*, ISPRS&RS 2020)



Effects of rice paddies on methane concentration
(Zhang *et al* , NC, 2020)

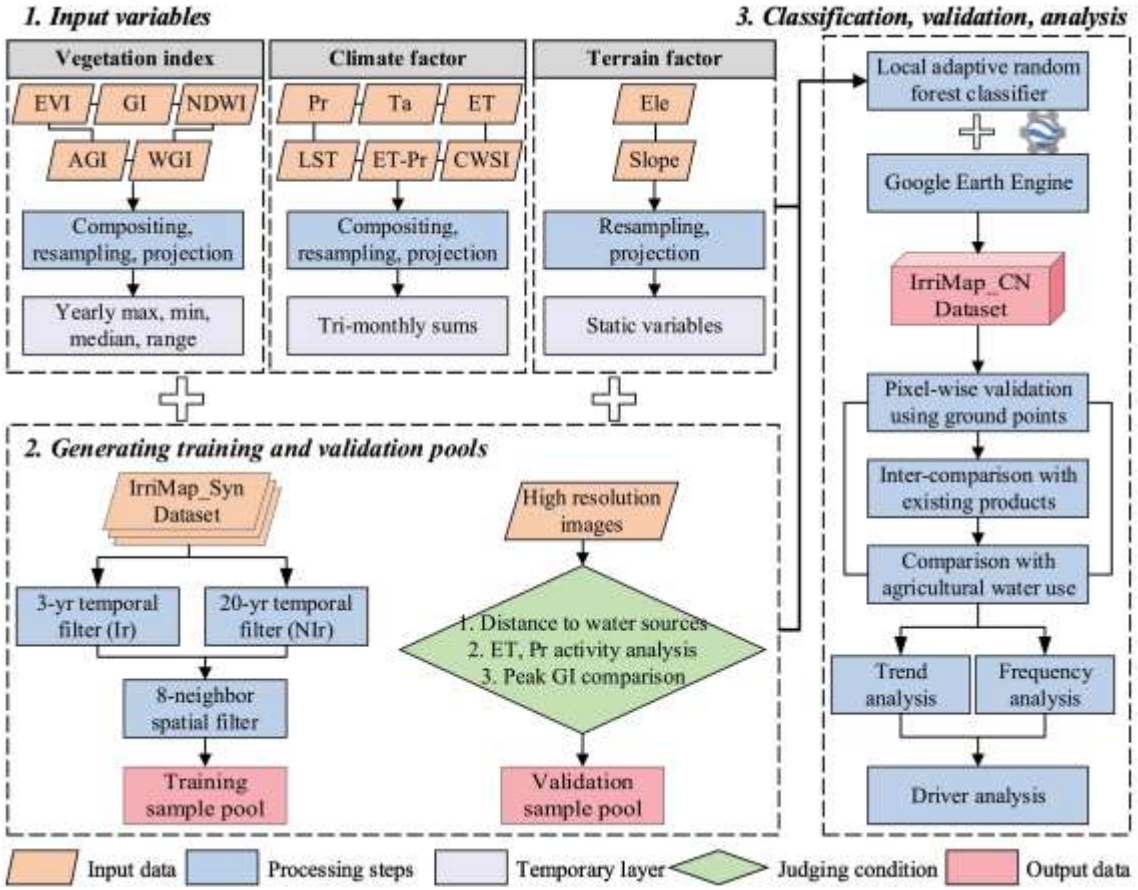


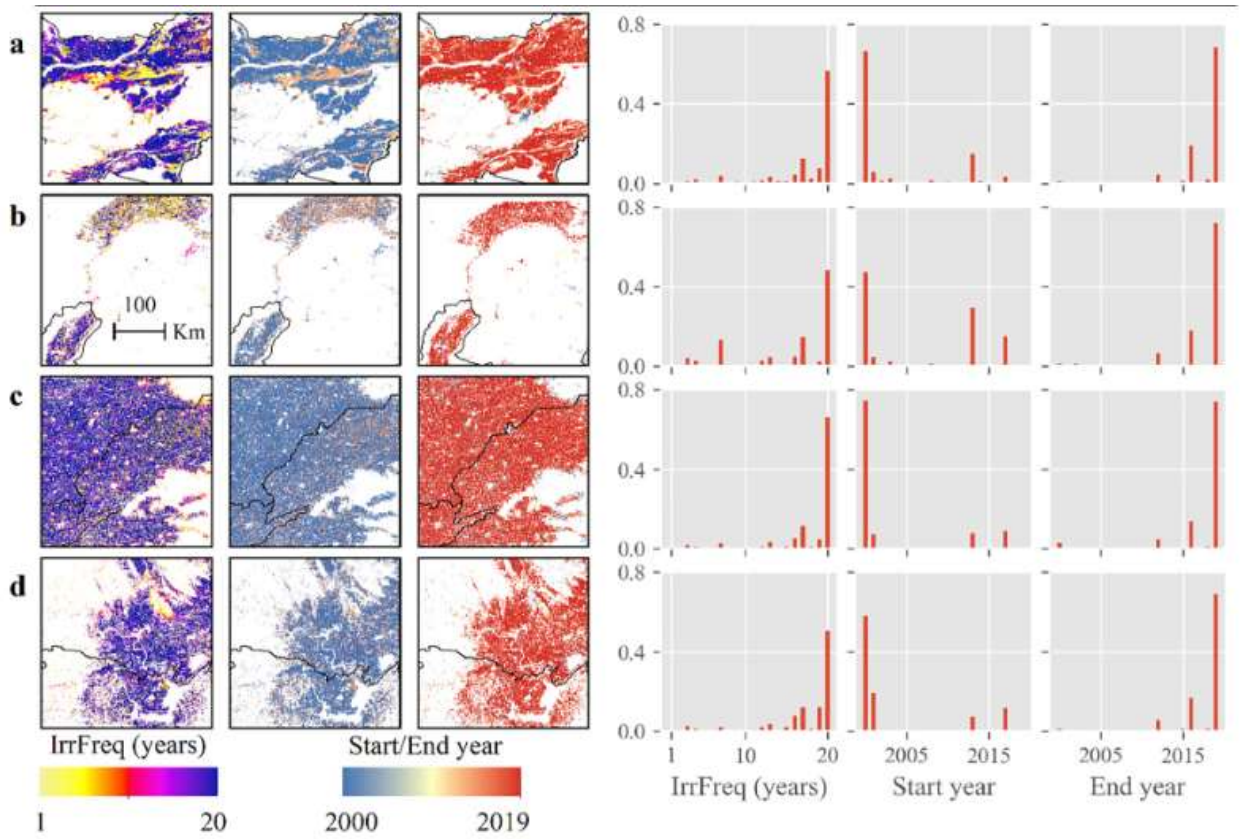
10m resolution crop type maps in Northeast China



(You, Dong, et al., 2020, *Scientific Data*)

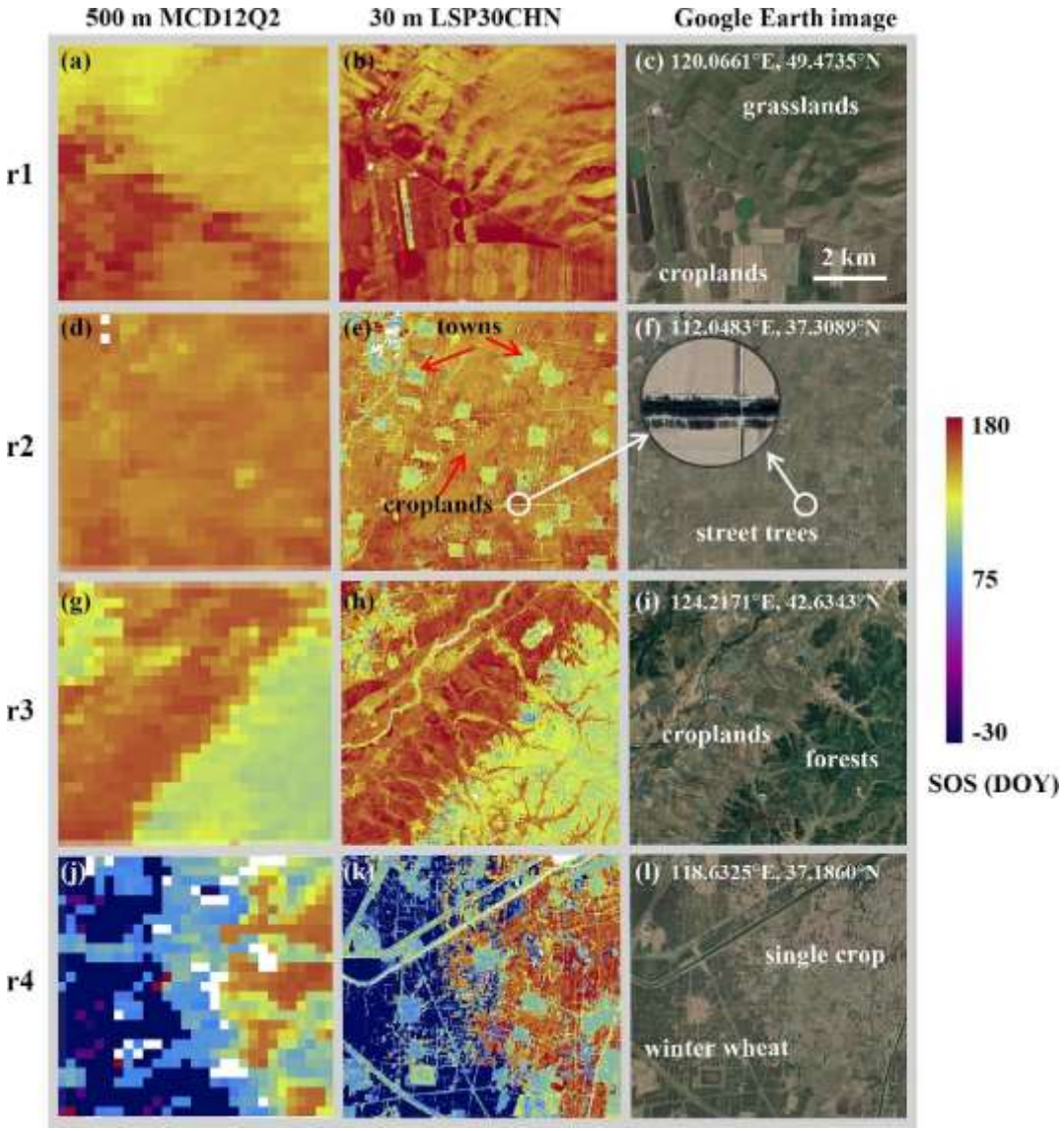
Annual irrigation maps across China in 2000–2019

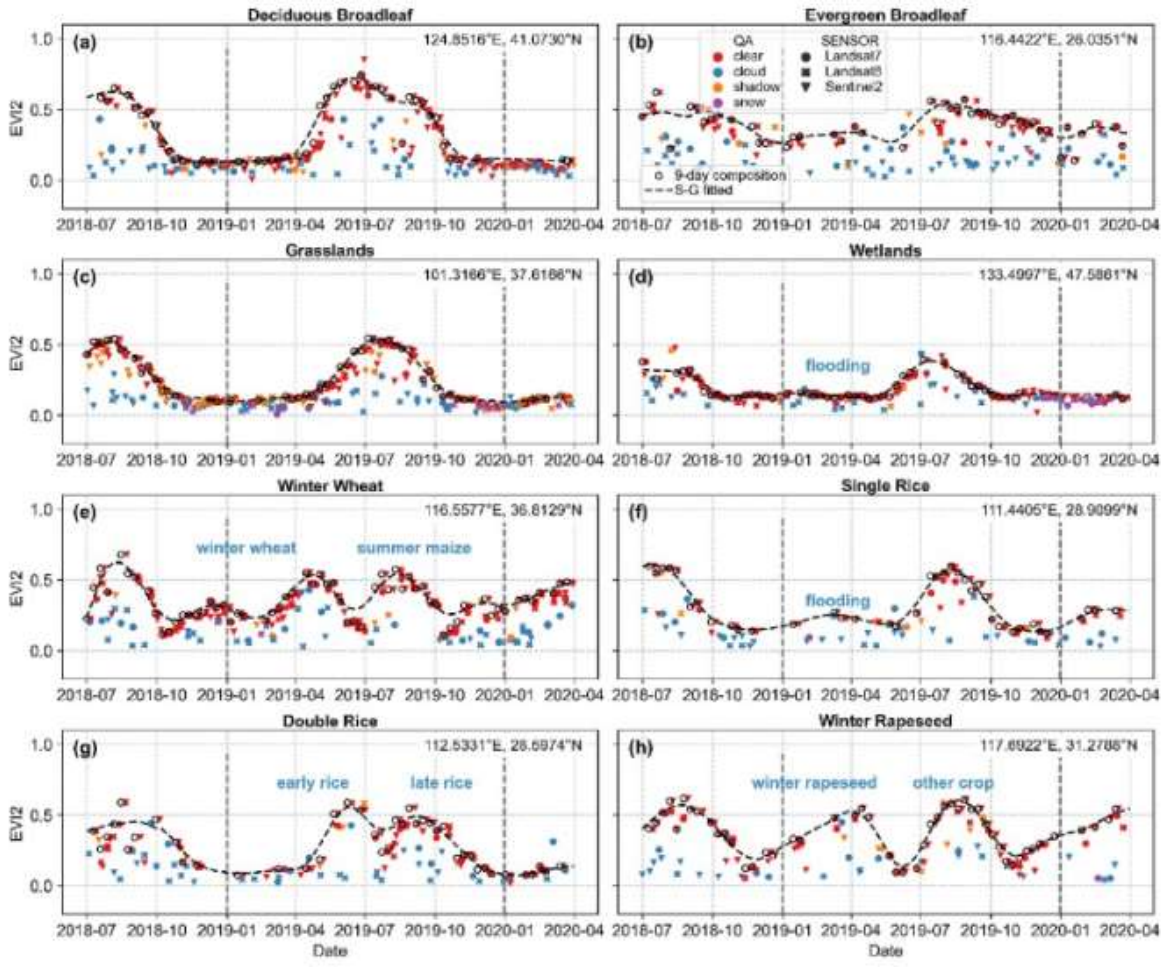




(Zhang *et al*., 2022, *Remote Sensing of Environment*)

A robust and unified land surface phenology algorithm for diverse biomes and growth cycles in China

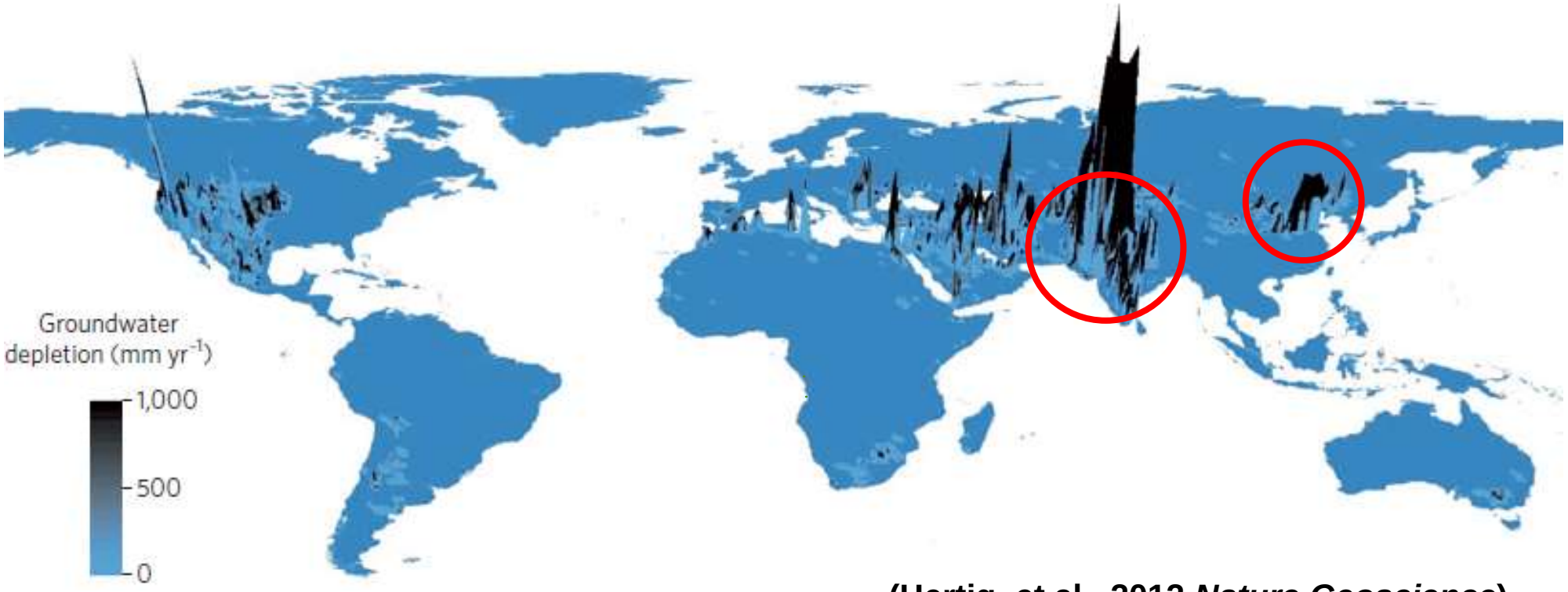




(Yang *et al*., 2023, *ISPRS P&RS*)

Consequences of agricultural land use changes

Challenges of Groundwater Depletion in Irrigated Agriculture

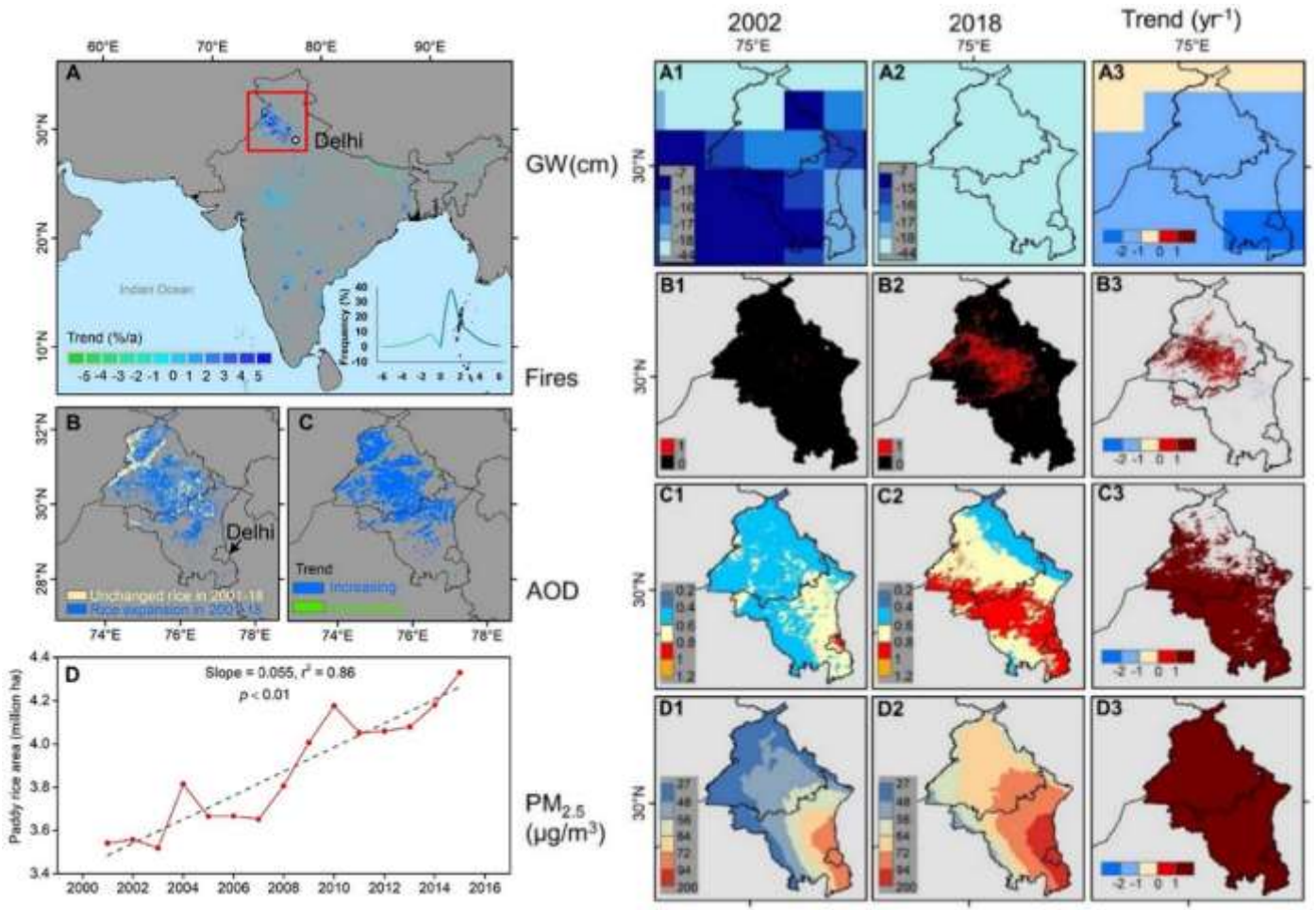


(Hertig. et al., 2012 *Nature Geoscience*)

- **Long-term intensive agricultural irrigation has made the North China Plain, the Indus River Plain, and the Great Plains of the US with the most severe groundwater resource depletion in the world.**

“Food-water-air quality" Nexus in India's breadbasket

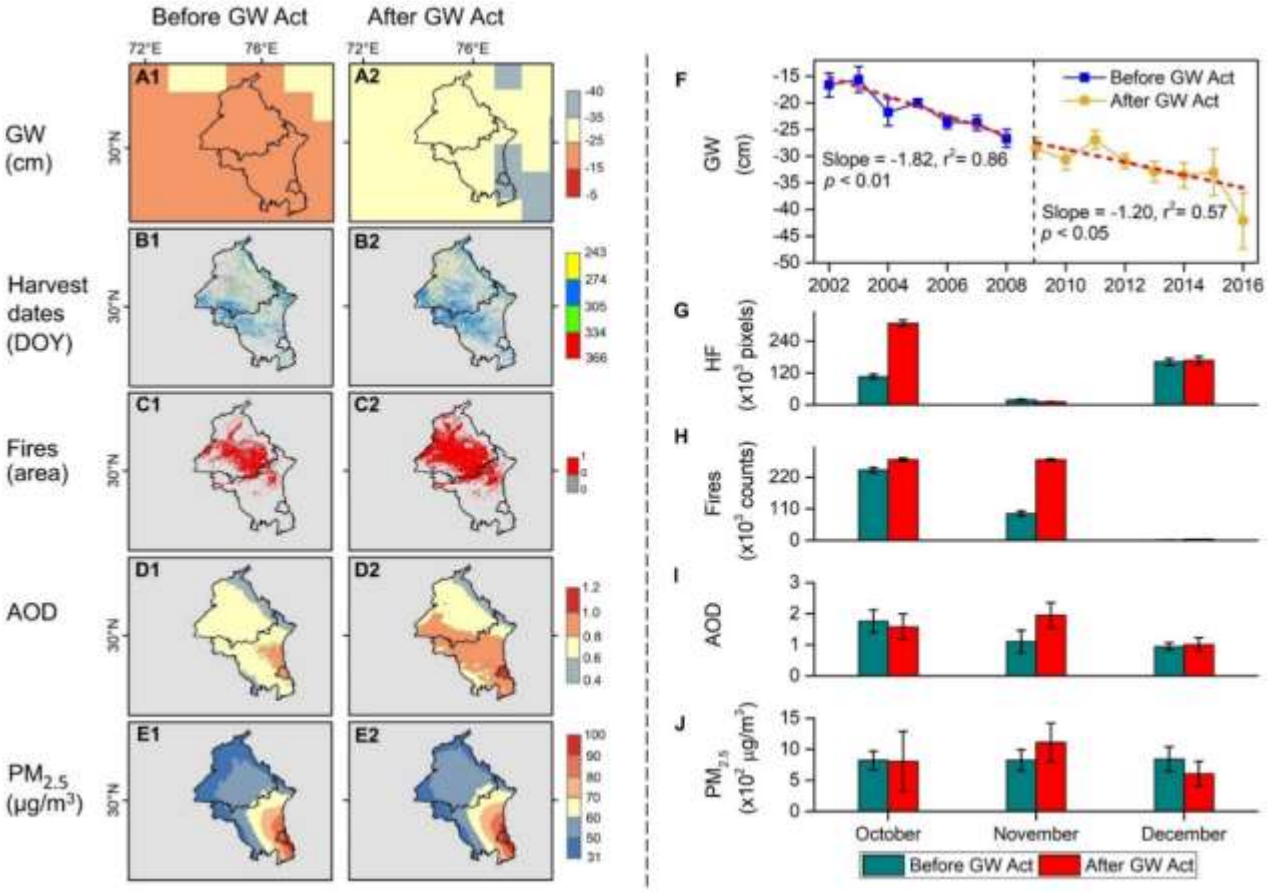
Trade-offs between food and water security, also between food and air quality



1) **Rice planted area has expanded dramatically**, from 3.5 million hm^2 in 2001 to 4.3 million hm^2 in 2015;
2) **Groundwater reserves are continuously declining** at a rate of 1.5 cm/a.
3) **Increasing fire number** from 35,426 in 2002 to 57,918 in 2018, and the burned area increased from 500 km^2 in 2002 to 15,780 km^2 in 2018.
4) From October to December, **the PM2.5 concentration increased** from 127.69 $\mu g/m^3$ in 2002 to 167.97 $\mu g/m^3$ in 2018; and the AOD increased from 0.93 to 1.21. Thus, **straw burning made local air pollution worse**.

(Singha *et al*., 2021 *Global Environmental Change*)

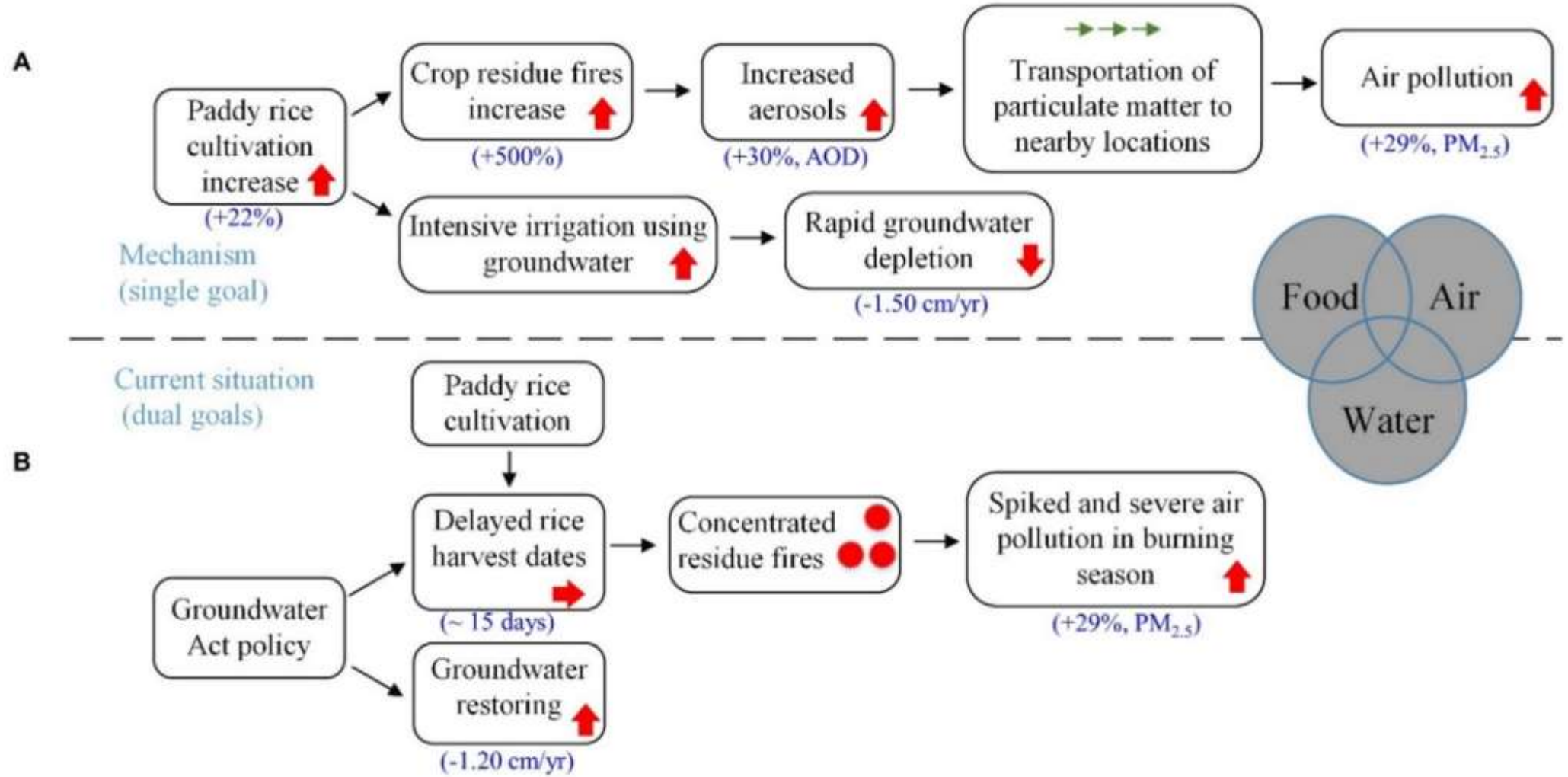
Groundwater protection actions implemented since 2009 have aggravated local air pollution



1) **The rate of decline in groundwater storage has decreased** from 1.82 cm/a to 1.2 cm/a since the 2009 groundwater protection policy.
2) **The backward postponement of rice planting and harvesting has caused straw burning to cluster in November**. Previously, October was the month with the highest number of fires up to 37,573 per year. After the implementation of groundwater protection actions, the highest number of fires was in November, up to 54,955.
3) **AOD also increased** from 1.10 in 2002 to 2008 to 1.95 in 2009 to 2018, and PM2.5 in November increased from 827.12 μg/m^3 in 2002 to 2008 to 1110.16 μg/m^3 in 2009 to 2018.

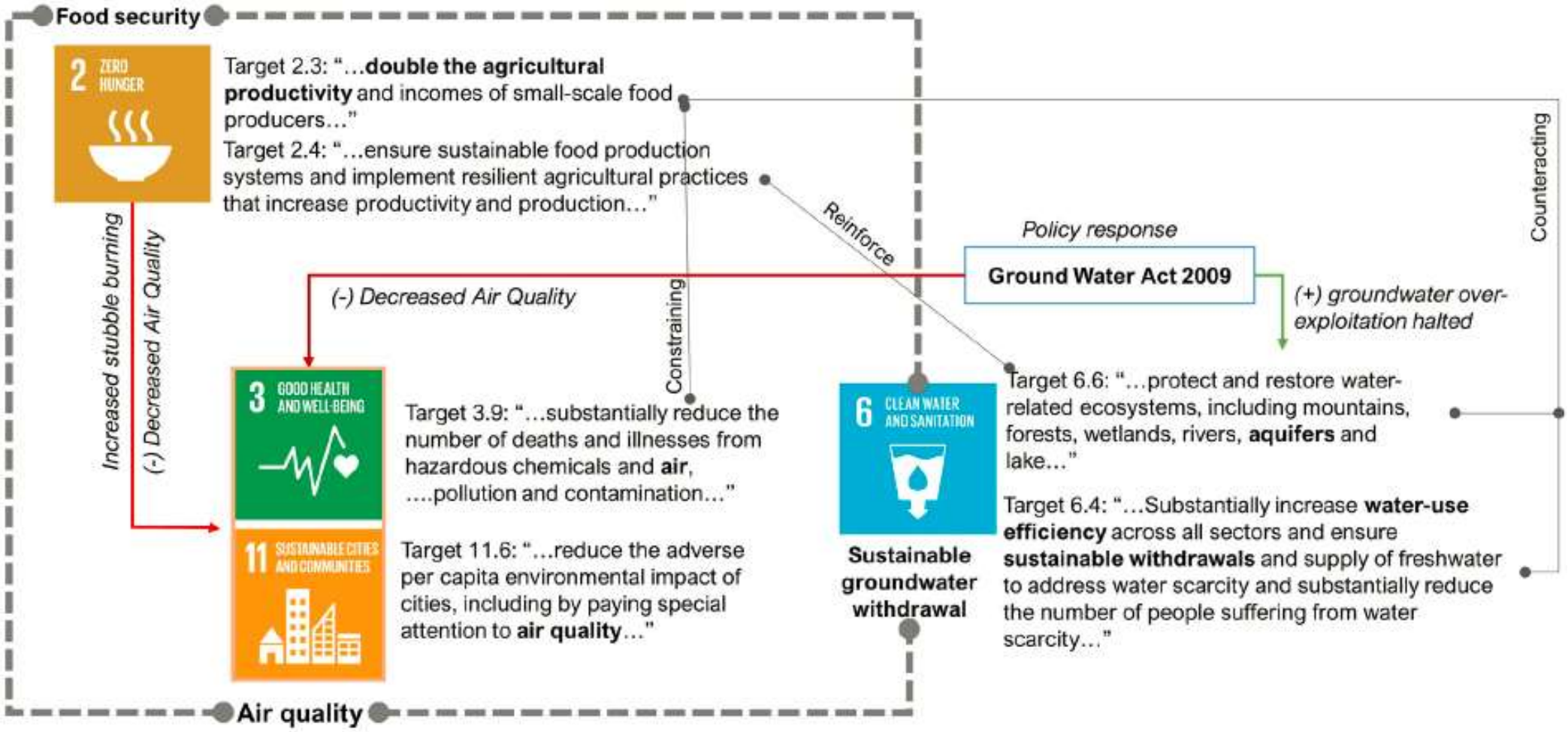
(Singha *et al*., 2021 *Global Environmental Change*)

Mechanisms of the "food-water-air quality" Nexus in India's breadbasket



(Singha *et al*., 2021 *Global Environmental Change*)

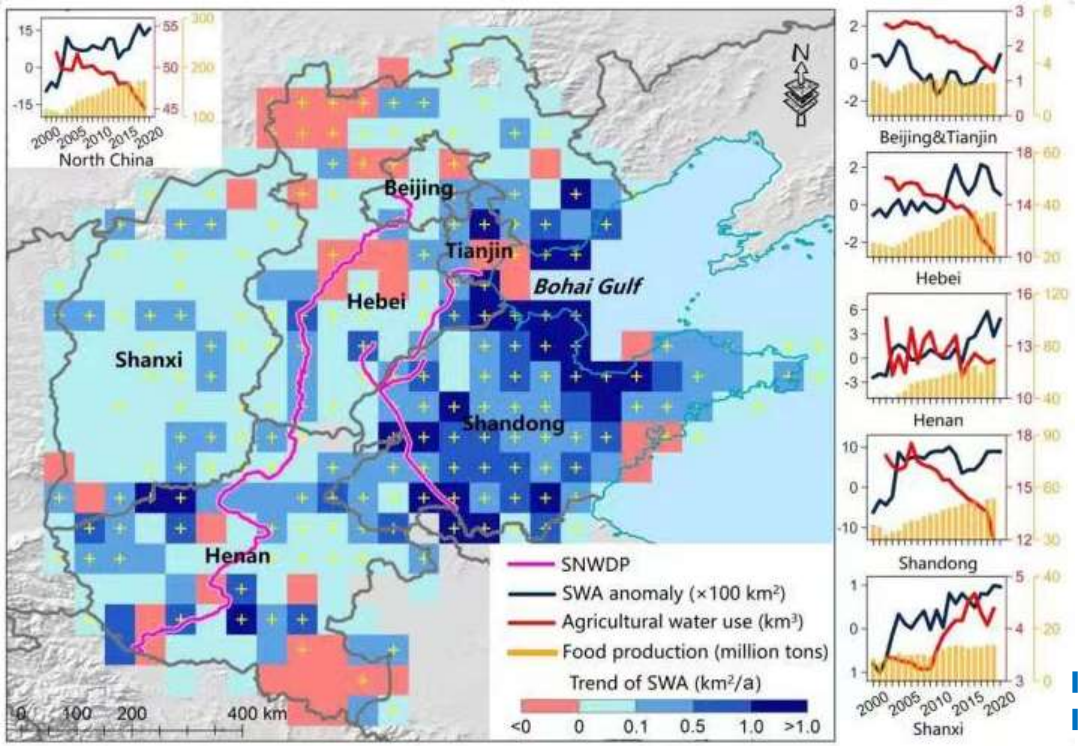
Synergies and trade-offs of SDGs arising from rice expansion



(Singha *et al*., 2021 *Global Environmental Change*)

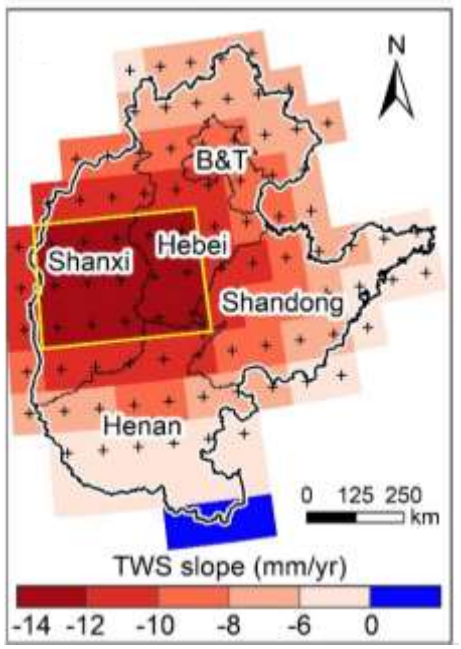
Nexus of Food, Water, Air, Ecological Security in Northeast China

Food, Water, and Ecological Security in North China Plain

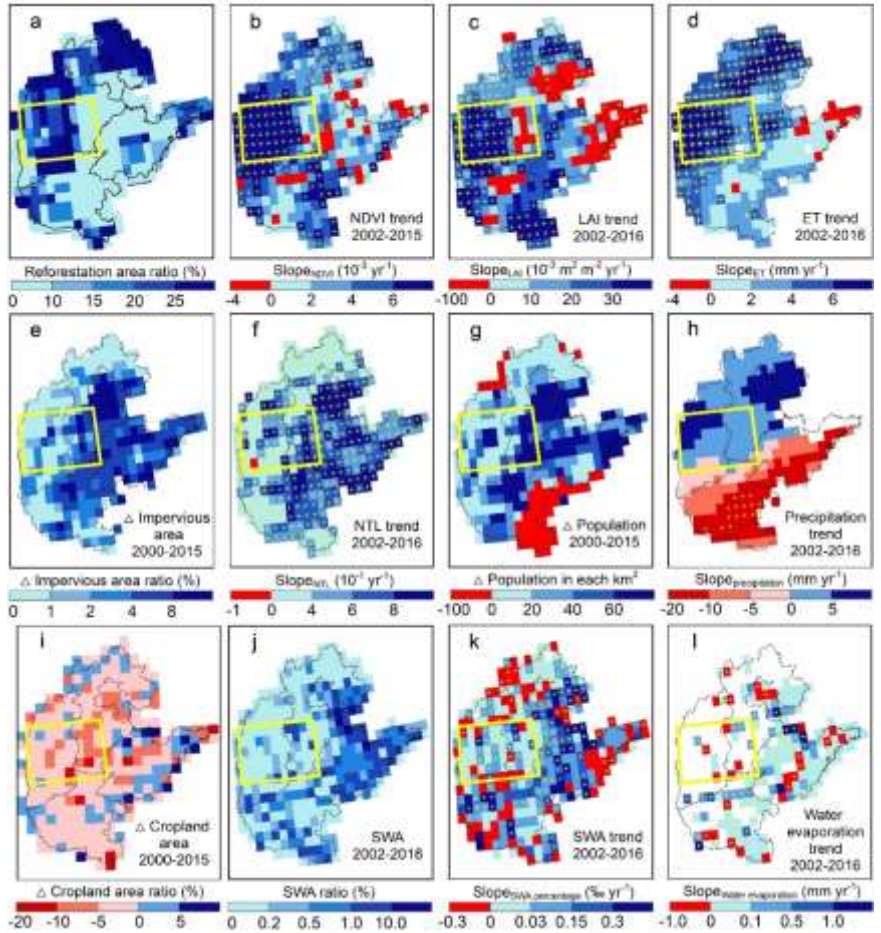


Grain production continuously increased while agricultural water use significantly decreased, suggesting that **the conflict between water and food has been alleviated.**

(Zhou *et al*., 2023
***Agricultural and Forest Meteorology*)**



Total water storage (TWS) continuously declined, **the most rapid TWS depletion happened in the western parts of the plain, which was the "hotspot" identified.**



Significant greening as ecological restoration programmes has been found in the hotspot region.

Increasing evapotranspiration induced by afforestation is new driver for TWS depletion in ER regions.

Take Home Message

1) The big remote sensing data and cloud computing provide an unprecedented opportunity to track agricultural land use changes with more details, so did the synergies and trade-offs resulting from land use changes.

2) Agricultural expansion and intensification have exacerbated concerns related to water security and air pollution, affecting human well-being. However, policies that solely target specific issues may inadvertently create new challenges in other domains.

3) Our findings underscore the importance of reconciling trade-offs of different SDGs like SDG 2 (food security), 3 (health and well-being), 6 (access to clean water), and 11 (urban air quality).

THANKS!

Jinwei Dong, Email: dongjw@igsnrr.ac.cn

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