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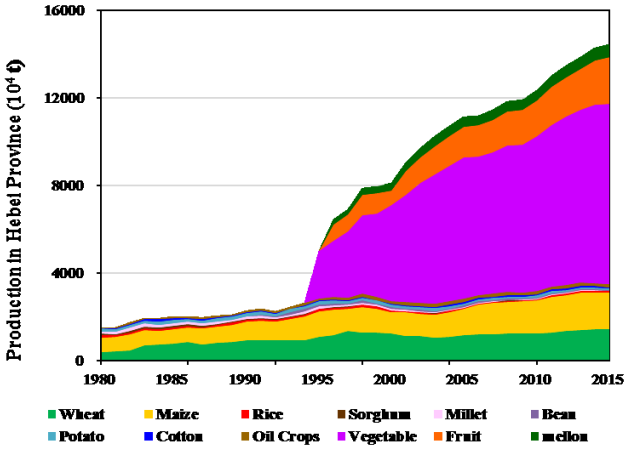
Optimizing planting structure for sustainable food production under limited water resources

Like many places in the world, the agricultural production in the North China Plain relies mainly on the irrigation by groundwater, causing the groundwater table dropped averagely 1 meter in some areas per year in the past decades. In India where the groundwater overdraft is serious, groundwater overuse has increased by 500% in the past 50 years (Sayre, 2019). Groundwater depletion has become a hotspot issue of global concern.



With the mechanization and modernization of agriculture production, and farmers' pursuit of economic benefits, North China Plain has formed a planting structure dominated by winter wheat-summer maize, vegetables and fruits. Production of these 4 major crops has increased 10 times than 50 years ago, accounting for 90% of total water deficit in the region (Policy Brief 1).

Hebei Plain contributes about 6% of China's food production, but its water resources is only 0.8% of the total water resources of China. In the piedmont plain of Taihang mountain, the shallow aquifer has declined from 10 meters in 1970s to 48 meters at present (Luo et al. 2018).

Great efforts have been taken to improve the water use efficiency (WUE) in agricultural irrigation in the Hebei and broad North China Plain. As a result, the WUE for wheat production has increased by 22% to 24%, and the WUE for maize growing has increased by 47% (Zhang et al, 2017).

In many parts of the world, after using water saving technologies, total water consumption at regional level is often observed increasing other than decreasing because the expansion of farmland offsets the water saved. In Hebei plain, rapid urbanization and industrialization in the past decades left no place to further expand the farmland. Instead of continuing planting wheat and maize, farmers tend to plant more water-consuming vegetables and fruits because they bring more economic benefits. As a result, increased WUE didn't force down the total water consumption either. Therefore, from long-term perspective, changing and optimizing the planting structure shall be taken into account for policy making to achieve reasonable food production scale under limited water resources.

FACTS GLOBAL

- ✓ *Two-thirds population worldwide live in water shortage regions, and global water use is still increasing by 1% per year (UN World Water Development Report, 2018, 2020).*
- ✓ *Agriculture irrigation consumes about 70% of fresh water, among which about 40% is from groundwater (Siebert et al., 2010).*
- ✓ *Irrigated farmland worldwide has doubled in the past 50 years (Foley et al., 2011).*

FACTS IN HEBEI PLAIN

- ✓ *Current cropping system of winter wheat and summer maize, plus the highly water-consuming fruits and vegetables account for 90% of total water deficit in the region (Luo et al. 2022).*
- ✓ *Annual average precipitation is 542mm in Hebei plain. 12.3 billion cubic meters is needed to irrigate 10.17 million hectares cropping land in the Hebei plain (Luo et al. 2022).*
- ✓ *Food surplus of wheat, vegetables, fruits, eggs, milk and aquatic products are common at present and in the future (Luo et al. 2022).*

This policy brief will discuss if and how planting structure optimization can sustain the food production. Four scenarios are discussed in (Luo et al. 2022), which takes into account comprehensively the population growth, people's diet change to more meat, vegetables and fruits, regional water resources, effects of the South-to-North Water Transfer project, farmers' economic benefits, regional food self-sufficiency and national food security.

The four planting structure scenarios optimized by sustainable water use and maximum food production:

Scenarios	Assumption of scenarios	Change in land and water use
S1: Present trend	Agricultural production in the region will maintain its current trend, with the planting structure optimized.	Total use of land and water will decrease slightly after optimization, with 2% of land use reduction and 8% water saving potential.
S2: Coordinated food production, water use and economic outcome	A compromise among food production, limited water resources and economic benefits is attempted.	Total land use for water consuming wheat, vegetables, and fruits is decreased by about 6%. Total water saving potential is about 15%.
S3: Maximum grain output capacity constrained by regional water resources without external water	Grain production potential is maximized under the premise of regional water resources, namely without the South-to-North Water. Production of vegetable and fruits only meets local demand.	Total land use for water consuming crops will be largely reduced by 28%. Total water saving potential has to achieve 54% to get the water balance.
S4: Regional self-sufficiency of winter wheat	Agricultural production will meet only local demand. The planting structure will be thus adapted, considering the water from the South-to-North Water Transfer project.	The sown scale of wheat, vegetables and fruit will decrease by 22%, 82% and 73% respectively. Total water saving is 46%.

Policy Implications

Hebei Plain plays a strategic position in food production and food security for China in the history. It is not sustainable if the present planting structure continues (scenario 1). 1.8 billion cubic water (15%) can be saved under scenario 2 when the food production, water use and economic benefits are attempted to be coordinated. Without external water diversion from the South-to-North Water Transfer project, the available regional water resources can maximum supply the need of 75% of wheat consumption in the region, implying the needs to import food (scenario 3). From long perspective, regional self-sufficiency for wheat supply with low level surpluses of vegetable and fruit production is highly suggested, which still requires external water supply to achieve the balance between groundwater exploitation and replenishment (scenario 4).

Policies in agriculture and water resources shall be co-designed to achieve sustainable agriculture production with limited water resources, including i) Under the premise of ensuring national food security, down-scaling the food production to regional self-sufficiency is probably the eventual path to reverse the trend of groundwater depleting; ii) making affordable use of water from the South-to North Water Transfer project for agricultural production through for instance, governmental subsidized low price; iii) Optimizing the planting structure in all scenarios is needed and welcome.

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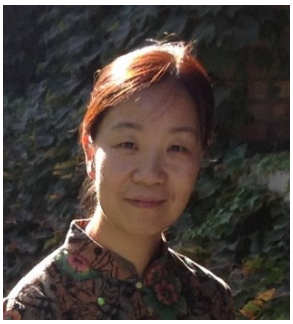

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