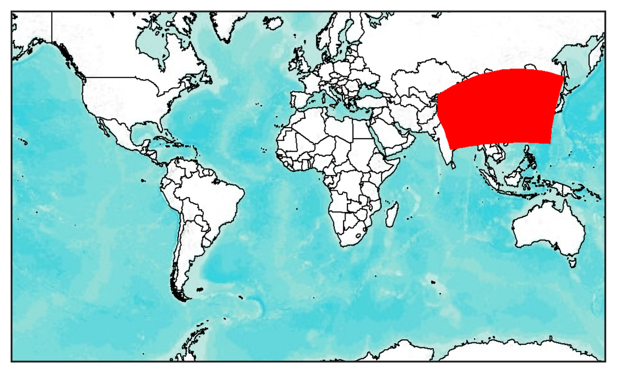
Food, Feed, Fuel:

Allocating impacts of water quantity stress across crop uses in China

Background

The water-food-energy nexus is a way of studying the interrelations between many natural resource allocation challenges that are increasingly impacting our lives. One of the major challenges within the nexus involves the impacts of competing claims over natural resources on equitable and sustainable access to food, water, and energy. While several datasets look at water use by sector, they often look at agriculture as a single industry. In reality, agricultural products can go to several different uses, including direct human consumption, livestock feed, and biofuel energy. As water shortages increase with the progression of climate change and water quality is increasingly harmed by human impacts, some agricultural land will likely have to be fallowed. This could have varying impacts by crop use based on spatial distribution and proximity to water sources.

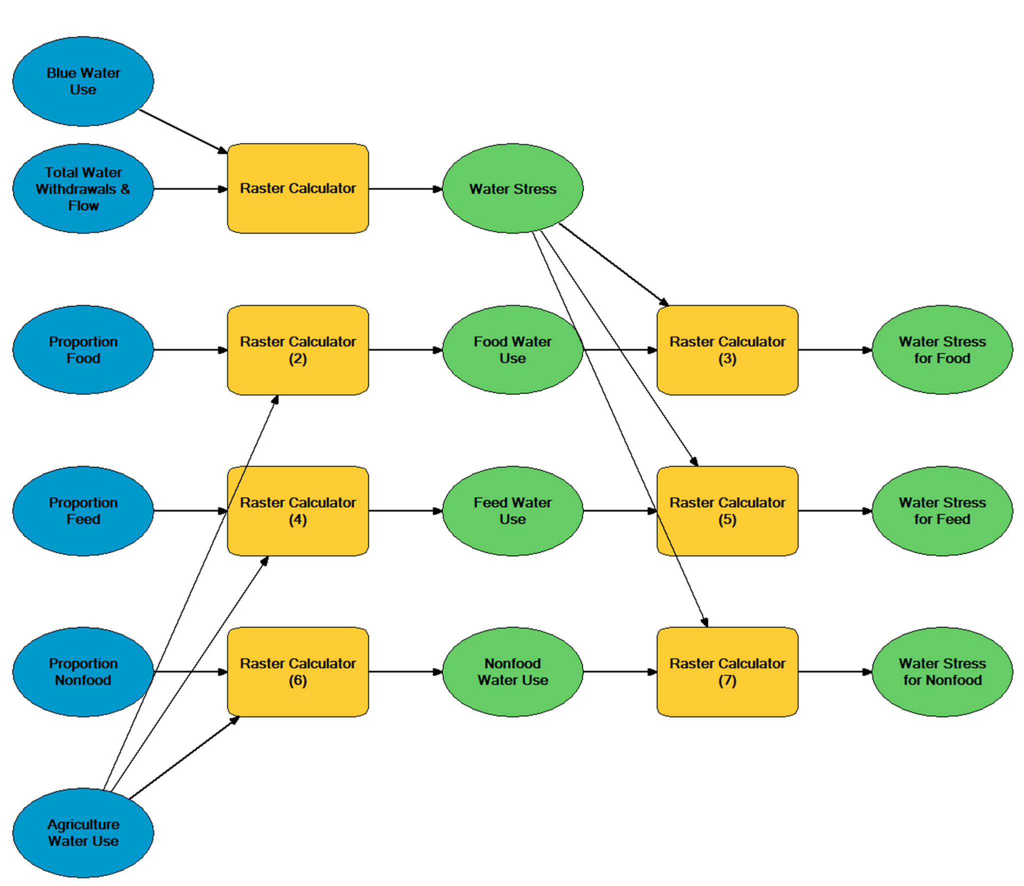


China's agricultural system is of great importance to global water and food supply. While the Northeast part of the country has approximately 60% of the arable land, it has only about 14% of the freshwater resources. Were China not able to meet their own food needs, their purchases on global markets could have severe impacts on world food prices.

Methods

To generate an index for water stress, raster calculator was used to combine data on blue water use, total annual water withdrawals, and available flow. To generate a layer of water use by crop allocation, raster calculator was used to combine total agricultural water use and proportions of agricultural production allocated to food, feed, and fuel. These layers were combined to generate a water stress index for each crop allocation type. In order to evaluate the difference between water use and water stress for each crop allocation, Band Collection Statistics was used. This generated correlation and covariance statistics for each set of crop allocation maps.

Next, the raster layers for water use and water stress were converted to point layers in order to perform statistical analysis. Normal QQ Plots were generated through the Geostatistical Analyst Toolbar in order to visually compare the distribution of values on a quantile basis.



Results

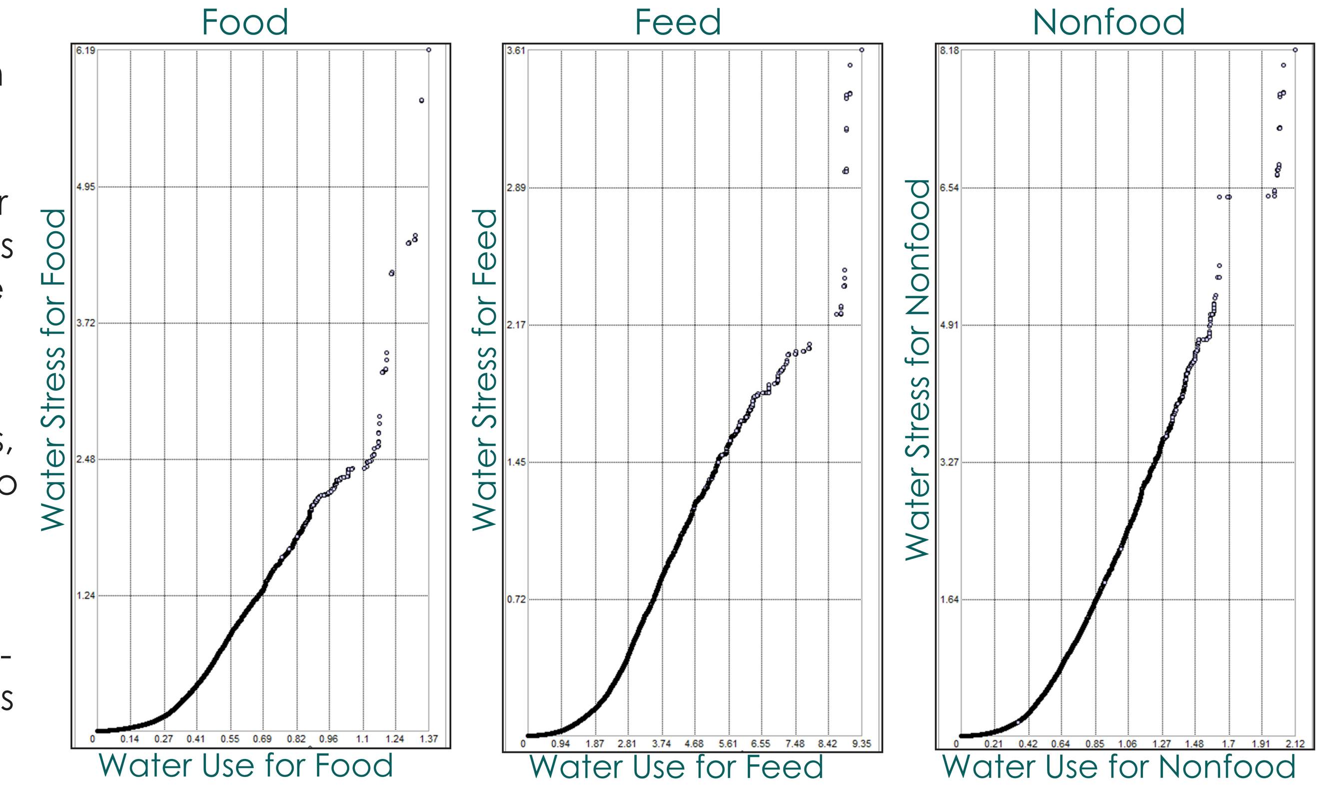
Water use by crop allocation was highest for food, followed by feed and by nonfood (including fuel). This is due to the relative importance of these three crop allocations to the Chinese agricultural sector. Overall, food comprised 58% of China's agricultural water use, feed comprised 33%, and nonfood comprised 9%.

When combined with water stress, allocations shifted slightly. The correlation between water use and water stress was 75.3% for food, 77.4% for feed, and 79.5% for nonfood. This correlation is relatively high, so percentage of water use and percentage of water stress were close. Food comprised 56% of water stress, feed comprised 35%, and fuel comprised 9%.

By plotting the data from each water use and water stress layer against standard normal distribution in a Normal Quantile-Quantile (QQ) Plot, we see that water stress has a more extreme right skew than water use for all three crop allocations. This means that high water stress is more intensely concentrated than high water use.

Given this distribution of impacts, water shortages in China are likely to cause the most stress to crops used for direct human consumption. The next steps for policymakers should be to identify whether lands currently used for feed or for nonfood crops can be converted to food production.

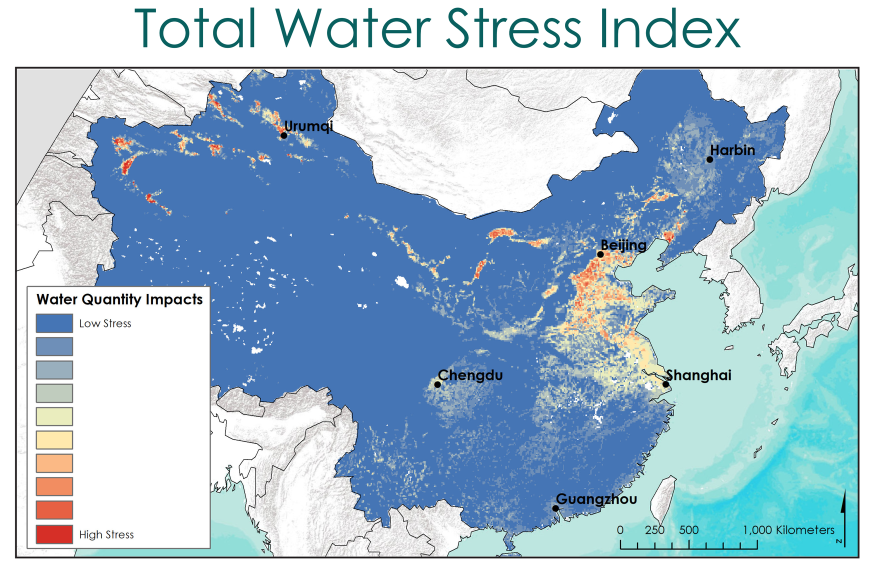
Quantile-Quantile Plots



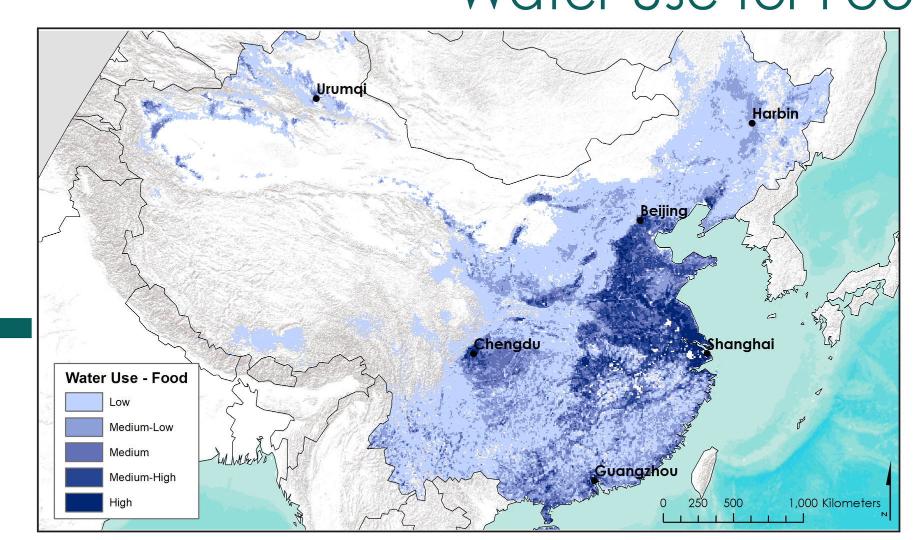
Research Question:

How does water stress vary across crop allocations (food, feed, fuel) in China?

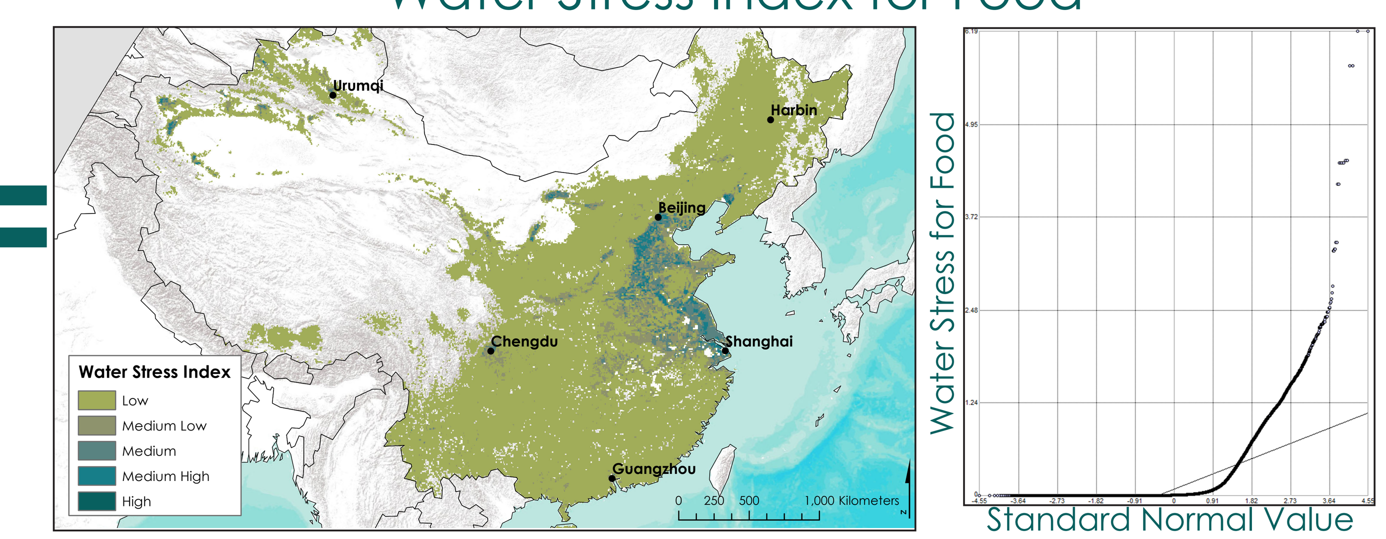
Total Water Stress Index



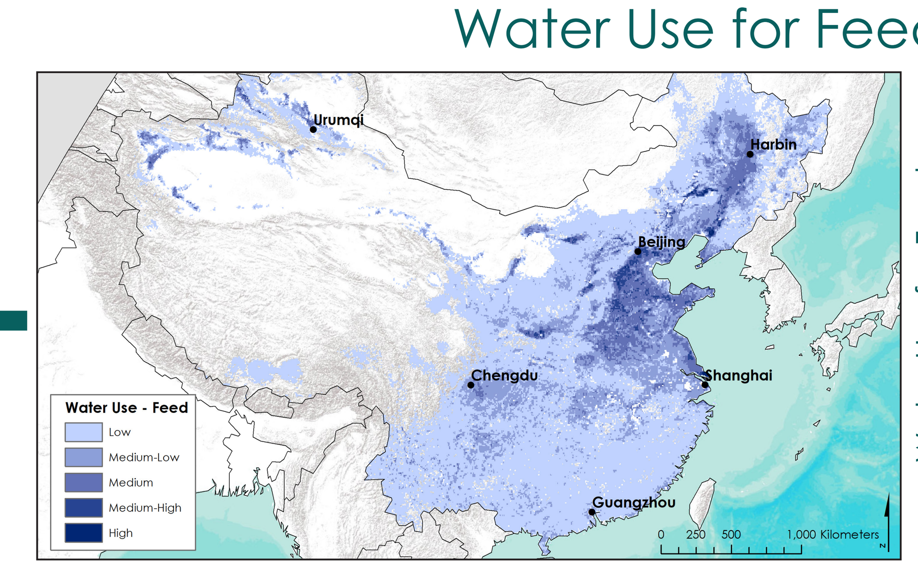
Water Use for Food



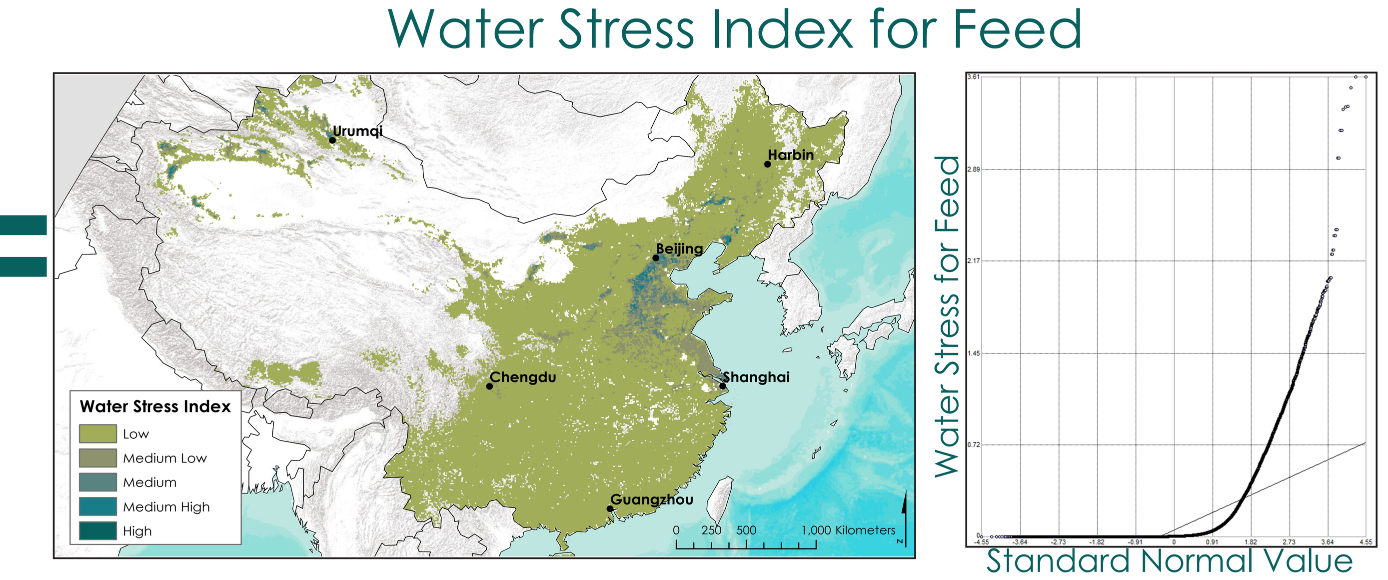
Water Stress Index for Food



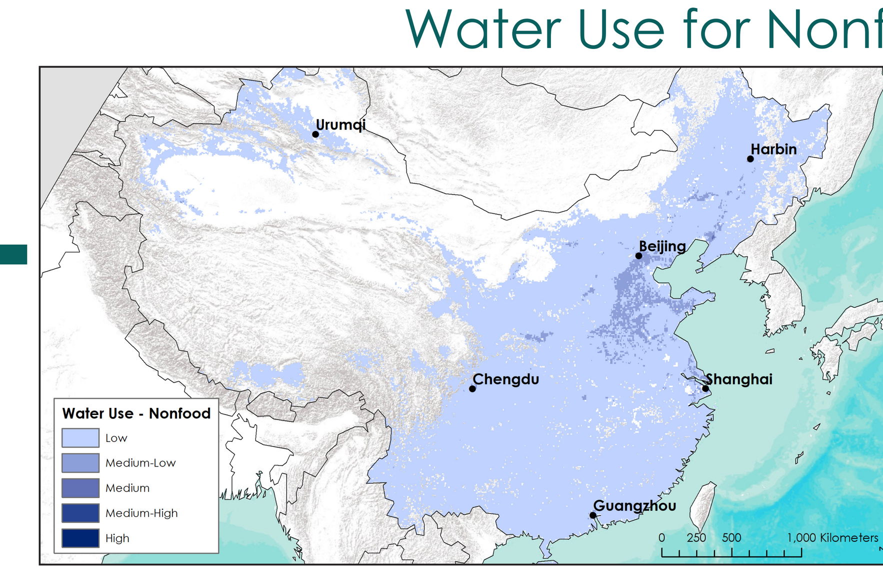
Water Use for Feed



Water Stress Index for Feed



Water Use for Nonfood



Water Stress Index for Nonfood

Limitations

While the water stress model included blue water use, the use of surface and groundwater for irrigation, as an input, the water use layers use all agricultural water withdrawals. This means that the model also looks at green water, or the water stored in plant life. This limitation means that the model is biased towards crops that are grown in larger supply, not just crops that use a large amount of irrigation water.

Another limitation is that available water stress data was not available at the granularity needed for this analysis, so water stress was calculated for catchments and then converted to a fine-grain raster layer.

As each crop has its own proportions for each allocation, analysis of potential policy responses would need to evaluate water stress allocation on a crop-basis. Existing crop-level data is available, but cleaning would be necessary to allow a model to connect crop-level water data with crop-specific allocation proportions.

As climate change advances and water stress increases, it will be important to update water stress data to ensure data accuracy. Included water stress data came from 2010, but water stress indicators advance quickly.

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References:

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Reig, P., T. Shiao & F. Gassert. *Aqueduct Water Risk Framework*. World Resources Institute, (2013).

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Data Sources:

University of Minnesota
Water Footprint Network
World Resources Institute, Aqueduct
ESRI Data Maps
Projection: WGS_1984_UTM_Zone_50N
Scale: 1:25,000,000

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