



COLUMBIA WATER CENTER WHITE PAPER

Shifting Crops, Saving Water

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Summary

India has made tremendous strides towards self-sufficiency in food grains in the last half century. The Green Revolution, marked by higher yielding varieties, chemical fertilizers and pesticides and the provision of irrigation are some of the key factors that contributed to this growth. The targeted grain procurement programs and the food storage and distribution systems have also played a role in the final outcome.

The national food security goals have led to targeted regions for the procurement of major food grains such as rice and wheat, with minimum support prices, and a variety of subsidies. The subsidies were targeted at making water for irrigation and fertilizers, widely available at affordable prices. Today, the major food grain producing regions face significant challenges with respect to water and energy. Almost half of the total agricultural land in India is now irrigated. These challenges emerge as most irrigation has switched to the use of pumped groundwater facilitated by subsidized electricity and limitations in the reliable water delivery from the surface canal systems. ***The areas targeted for rice-wheat procurement do not match the areas that would be most suitable from the perspective of adequate water availability (to match the crop water demand).***

Additionally, the government established a procurement and price support system for selected grains in order to protect producers against sudden price declines in the unregulated market. The strategy for procurement from regions that in the short term had the best agricultural productivity led to a significant change of the cropping patterns - away from traditional crops that were adapted to the local climate and soils, and to increased demand for irrigation in the targeted procurement regions.

This strategy is in need of urgent reform. The current discussion on alleviating the water stress in the country has been motivated towards targeting new areas for intensive food grain production and procurement, while shifting procurement from rice to other crops in places like Punjab where groundwater depletion impacts due to rice cultivation. Recently, the National Food Security Mission has launched an initiative to increase the production of food grains and pulses by 10 million tons and 2 million tons respectively by the end of 2012. In response, there have been several interests in targeting new areas for intensive food grain production (e.g., Eastern India) and procurement, while shifting procurement from rice to other crops such as pulses in the arid regions of North Western India.

The Columbia Water Center is currently working on developing a platform for exploring systematic solutions to water – food – energy security challenge at the national scale (while minimizing local water stress) in the face of climate variability. ***We present here a brief overview of the crop diversification analysis tools and several strategic spatial optimization scenarios.*** Given the objective of maximizing the aggregate national agricultural revenue while meeting the national food security, nutritional goals and sustainable water supply, the model identifies feasible regions and the crop choices that can support the area expansion and productivity enhancement in a sustainable manner.

We believe that our systematic analysis will provide the necessary scientific impetus at the national and local scales that could be used by both the public as well as the private sector ***to direct production and procurement strategies that promote water sustainability.*** The set of analyses as proposed here would contribute directly to informing the development of a modern agricultural supply chain for the country.

Objective

To maximize the net national agricultural revenue while meeting the National Food Security Mission's target production and the nutritional requirements of the population.

Methods: Deficit Simulation– Optimization Model

A Deficit Simulation – Optimization Model is being proposed here that determines the suitable regions and crop choices across India under both rainfed and irrigated conditions for each season (e.g. Kharif, Rabi or Summer). Figure 1 outlines the several constraints we have imposed on the model and includes:

- (a) Minimizing water stress (districts)
- (b) Irrigation water availability (districts)
- (c) Maximum cropped area (districts)
- (d) Suitability of crops based on soil type and temperature profile (districts).
- (e) National food security constraint
 - a. in terms of target production of specific types of crops and;
 - b. target nutritional requirements recommended for the entire population.

Long term data for different crop and climate parameters and demands have been used to assess the water deficits at the district level. Using the constraints and the crop water requirements thus, we develop various scenarios to come up with a crop mix that provides positive economic returns and water sustainability.

The proposed deficit simulation – optimization crop allocation model as shown in Figure 1 will serve as a platform for exploring systematic solutions to the water, food and energy security challenges faced by India in the face of climate risks and will provide a rigorous methodological background for necessary scientific guideline to implement such concerted effort at national scale.

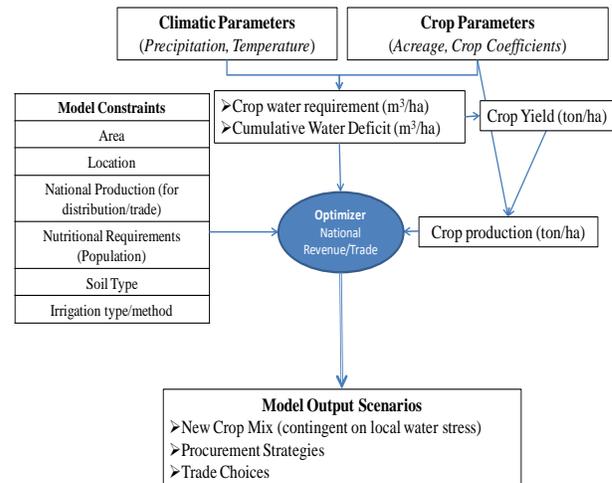


Figure 1: Proposed Optimization scheme.

Preliminary Results

Figure 2 shows the district wise spatial distribution of the current cropping pattern in India for 12 major crop varieties currently procured at the national scale. The crops are grouped into cereals (rice, bajra, maize, jowar and ragi), pulses (tur and other pulses), and oilseeds (groundnuts, sesamum, soybean, nigerseed and sunflower) in Kharif (June-July-August-September) - the predominant rainfall season.

We can clearly see that the arid regions of North Western India (e.g. Punjab and Haryana) and the Indo Gangetic Plains are the regions where rice is the major cultivated crop, accounting for more than 75% of the net cropped area in a district. ***In other words, much of the semi-arid areas of the country which experiences high variability in rainfall are currently targeted for food grain production and procurement.***

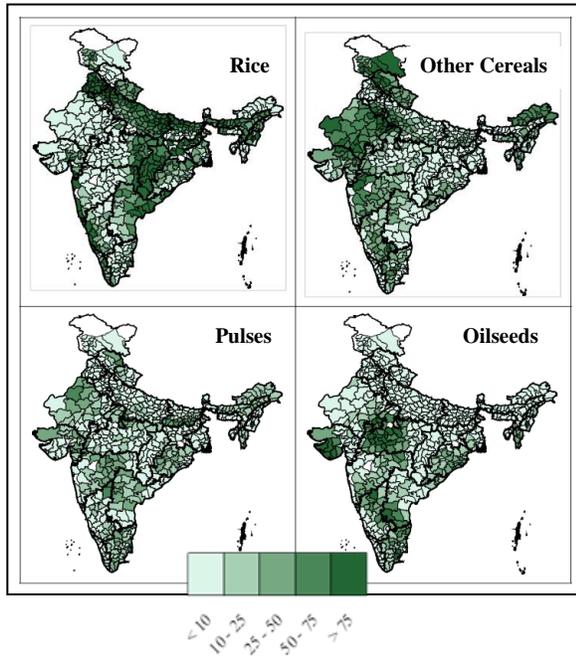


Figure 2: Current cropping pattern in India as percentage of net cropped area in the Kharif season.

Given the above, we propose that crop choices in the drier regions need to shift towards higher cash value, lower water using crops, and a national scale crop diversification needs to be pursued, in a manner that is both water and climate informed. This is motivated towards developing a platform for exploring systematic solutions to water – food – energy security challenge at the national scale in the face of climate variability.

Figure 3 shows the spatial distribution of the optimal cropping pattern under rainfed condition - as the fractional increase or decrease from current cropped area in each district for rice, other cereals, pulses and oilseeds. A fractional increase (decrease) for a crop in a district indicates that the model allocates an area that is greater (lesser) than the current cultivated area under that crop in that district.

It is shown here that the model proposes a greater than 75 % reduction in cultivated area of rice for the districts in Punjab. We can also see that there is a slight increase in cultivated area of rice over the states in Eastern India (Orissa, West Bengal, Bihar etc). The cropping pattern in the arid regions of Punjab, Haryana and Rajasthan are replaced by higher monetary valued pulses and oilseeds which are also less water intensive.

The results as shown here are preliminary and developed only for rainfed conditions. We have to further assess and refine the crop mix under irrigated conditions using different soil types and irrigation requirements/infrastructures. Such a model formulation for irrigation per district will allow the ability to bring in the consideration of energy requirements for pumping or the cost of the surface irrigation system development. This can provide a safety mechanism for the user in terms of reliable water supply and for the overall water sustainability in that region.

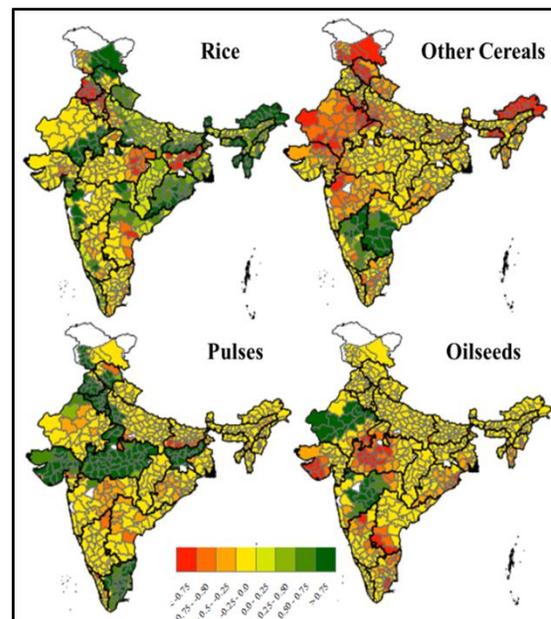


Figure 3: Optimal cropping pattern in India as percentage of net cropped area in the Kharif season.