PROTECTING FOOD SECURITY IN AFGHANISTAN WITH CLIMATE CHANGE: IS THERE A ROLE FOR WATER TRADING?

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Abstract

Climate change, population growth, and poorly developed water-sharing institutions in many arid countries have raised the importance of establishing irrigation institutions to adapt to the growing fluctuations in water supply. Afghanistan, a country where water supply fluctuation has a long history, is characterized by poorly designed and enforced water sharing rules, resulting in unreliable economic welfare and periodic food shortages. Previous research on this problem has dealt with targeted regions in the country with a limited range of policy proposals evaluated. To date little research has systematically examined national scale alternative water-sharing rules to protect food security for an agrarian society to flexibly adapt to uncertain future water supplies. This is especially important, as more frequent, long term drought is a consequence of climate change. This paper's contribution is to examine the economics of several water allocation policies in order to maximize and protect food security under drought conditions and to meet the food requirements of a growing population. Moreover it makes southern region of Afghanistan being more wheat productive, as they've start getting some water. An integrated empirical optimization model is developed to maximize economic welfare and consumer surplus with the constraint of protecting food grain security. Findings show that under a water-trading scenario, higher wheat production could be achieved. Finally, our results provide an encouraging message to the policy makers, water managers, and farm managers at the national level who seek food security, rural livelihoods, and effective water-sharing institutions.

Background

Afghanistan continues to suffer from water shortage and lack of successful water policies to support and enhance food security, especially in southern region, where there is neither wheat production nor sufficient water deliveries. Climate change is an important factor affecting Afghanistan water availability and agricultural production. Afghanistan climate varies from dry cloudless summer to severe cold winters that reach -69 degree C. Afghanistan's geography makes water runoff capture and storage difficult without reservoirs and dams.

Gaps

No national scale analysis in Afghanistan been done to assess impacts of water trading as an arrangement to adapt to long term drought and emerging climate challenges.

Objective

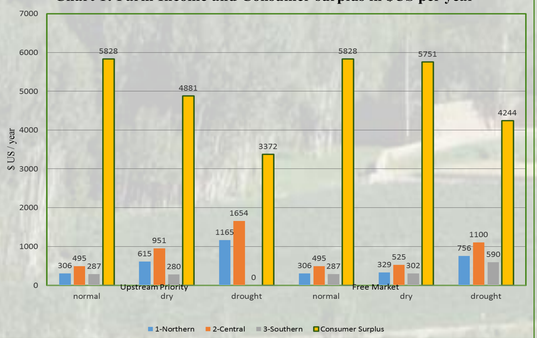
Conduct a national scale assessment of alternative water sharing arrangements to adjust to drought and climate change.

Results

Chart 1 shows total farm income and consumer surplus by region in Afghanistan, water sharing rule, and water shortage scenario. Results show that the customary water allocation rule in Afghanistan is less efficient compared to a water-trading arrangement. Under a free market system, both farm income and consumer surplus raises total national welfare compared to the upstream priority system. Results show that total farm income is less under free water markets because those free markets increase crop production and reduce crop prices. However, total national welfare increases under unrestricted water markets despite the fact that farm income in the upstream regions does not benefits from those markets.

The establishment of water markets increases national economic welfare in all three Afghan regions. As shown in Chart 1, the southern region of Afghanistan receives zero farm income when upstream priority system is implemented. When unrestricted water trading is applied, that makes redistributing the nation's water resources and, therefore, creating economic opportunity to grow crops and support agrarian livelihoods in the southern region. Although, the northern region receives reduced income and higher consumer surplus thanks to reduce crop prices. This reduction in farm income is due to the more efficient overall water allocation among various regions of the country, producing a higher overall national water-related welfare.

Chart 1: Farm Income and Consumer surplus in $US per year



Methodology

An optimization framework is used to optimize wheat production and ensure water deliveries to the southern part of Afghanistan. The methodology includes Data, Integration, and Policy analysis.

• Data

Data for year 2012 were used, as this year was one of the most successful years for wheat and other grain production, and water availability. Data are:

- Crop water requirement data used to determine the amount of water needed to maintain food security rates and maximize consumer welfare.
- Land in Production pattern by crop and by province in 1000 hectares.
- Crops are: Wheat, Rice, Barley, Maize, Nuts, Industrial Crops, Fruits, and Vegetables.
- 34 Afghanistan Provinces are combined into 3 major regions, and each major region has several sub-regions, Figure 1.

- Net benefit per unit land for each province :

Net revenue per ha = (Price per ton * yield in tons per ha) – production cost per ha

• Integration

- Farm income

Price is measured in $US/metric ton, yield in metric tons/ha, and cost of production in $US per ha. Calculating total farm income is essential in this model to help farmers and policy makers to make better decisions. Moreover, it will help to know the cost and the benefit of applying each water allocation rule, water drought scenario, and crop pattern.

{(Net revenue per ha = (Price per ton * yield per ha) – production cost per ha) * Total number of lands in production.}

- Food Security and consumer surplus

Northern Afghanistan has an abundant water supply that is close to areas of wheat production. Most of Afghanistan's wheat production occurs in the northern region; in fact, wheat production in the northern region exceeds the northern region's demand for wheat. The extra wheat production drives prices up, due to the wheat monopoly of the northern part leading to escalated farm income. In this model, we applied economic theory of consumer surplus and economic welfare. Consumer surplus is a theory of how much a consumer can save as a difference between the purchase price and the actual price in the market. In addition, consumer surplus is an indication of price difference of crops under basic priority system compared to the suggested allocation rule (unrestricted water trading).

Consumer surplus is measured as:

0.5 * [{Intercept by region and crops used to calculate the regional crops demand function – crop price} * Production of each crop by each division].

• Policy analysis

- Water appropriation rules

By applying different water-sharing rules, policy makers and water managers will decide on policy that makes water available to other parts of Afghanistan suffering from water and wheat shortages. Water is assumed to be transported through Afghanistan naturally, unless withdrawn for use by upstream riparian.

Mirabs are elected by their respective community to manage, observe, maintain, and make sure of distribution's fairness among water buyers and sellers. DAI, 2006 concluded after examining and studying the Mirabs system of management, that it needs to be in a legal and formal modality as it doesn't have this format currently [DAI, 2006].

Water allocation systems are:-

- **Upstream priority**

  Under this arrangement, the top water user near river basin can consume their full water allocation, and whatever left from the top sub-regions or water users it goes to the next lower ones. Next lower sub-regions or water users will also take their full water needed, and whatever left will go to the next divisions and so on till the whole amount of available water is gone.

- **Free market**

  For this water shortage allocation rule, an optimization framework has been applied to get the most economic benefits that maximize food security efficiency when a drought occurs.

- **Different water drought scenarios**
  - Normal water scenario: when water amount is available as same amount of year of 2012.
  - Dry water scenario: when there will be only 75 % of year of 2012 water level.
  - Drought water scenario: when there will be only 50 % of year of 2012 water level.

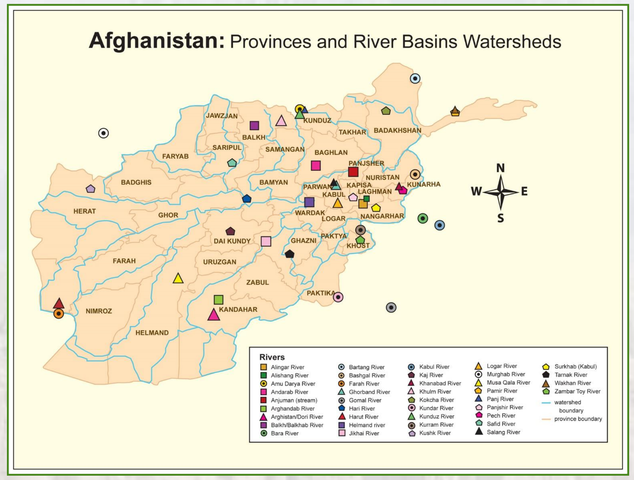


Figure 1A: Map of Afghanistan showing rivers locations across Afghanistan, watershed boundaries, and province boundaries.

Chart 2: Shadow Price of Water Averaged over regions, Afghanistan 2012 ($US per 1000 cubic meters)

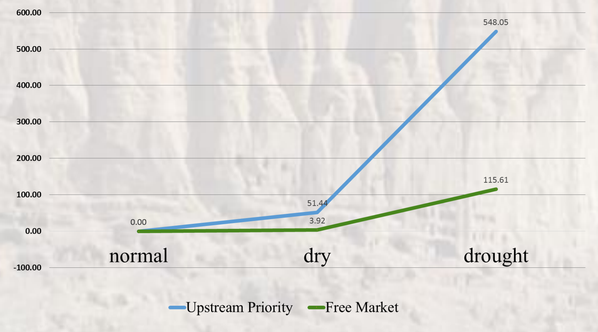


Chart 2 presents results of the shadow price, or the marginal value of one more unit of water, measured in $US per 1000 cubic meters of water, averaged over all regions. The shadow price is the value of each extra unit of water if it can be secured from available water sources. An example a policy debate that needs to be informed with this information is when downstream water users are presented with an opportunity to secure more water from other locations than is available from their current supply. The shadow price summarizes the economic value of this additional water if it could be made available.

Shadow prices are elevated when water shortage levels become more severe.

Shadow prices that occur under the hypothetical free market show a consistent pattern for all three regions, but always show lower values than would occur with an upstream priority arrangement. Free markets reduce effective scarcity of water, moving it to where it has the greatest economic value. The free market shadow price is 78% lower than under drought conditions of upstream priority water use.

These results present an important message to the national Afghan water managers and policy makers, who may want to improve upon the customary water-sharing arrangements by encouraging the adoption of new water sharing arrangements

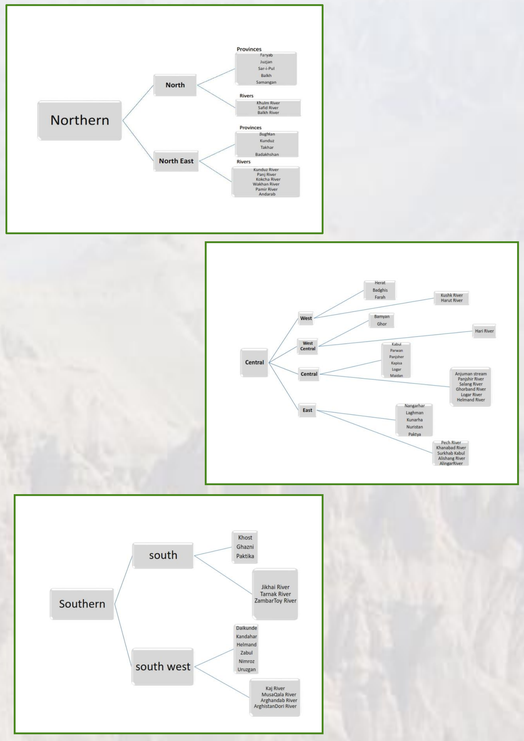


Figure 1B: Charts listing the sub-regions, provinces, and rivers for the northern, central, and southern regions

Chart 3 shows grain production summed over all regions by water-sharing arrangement and water shortage scenario. Crop patterns change according to the water shortage scenario with the objective of maximizing overall national water-related welfare. Wheat is the main staple for most Afghans and Afghanistan's most important grain crop is wheat, which must be supplied to meet growing demand for food grains. The average per capita wheat consumption in Afghanistan is 186 kilograms per year, higher than most other parts of the world [Persaud, 2012]. By comparison, in the US average per capita wheat consumption is 61 kilograms per year [USDA, 2013].

Results show falling rice production in the face of drought, as the optimization model favors Afghan preferences of wheat to rice by a factor of five. Under upstream priority, results show higher production overall favoring northern and central Afghanistan, in which production is greatly restricted when drought occurs. Compared to free market, wheat production can be found in the southern division of Afghanistan, even in the drought condition.

Chart 3 : Grains Production, Summed over regions, by Shortage Sharing Arrangement, and Water shortage Scenario, Afghanistan, 2012, (1000 metric tons/year)

Conclusion

An upstream priority allocation system is the customary allocation system in Afghanistan. Despite the rarity of free market allocations of water in Afghanistan and other neighboring countries, free market allocations present advantages.

Results point to the greatest national economic efficiency for adapting to shortages that are secured by free market. An upstream priority system achieves economic welfare for the northern region and somewhat for the central region of Afghanistan. This holds true under dry conditions when water is reduced to 75 percent of full supply.

Under dry scenario (50 percent), the southern region suffers most from shortages in the face of an upstream priority system, since this region gets nothing at all and upstream users take all the water.

This lack of water leads to heavily restricted crop production, higher farm income because of higher crop prices in the northern region, and a higher water shadow price because of an overall greater water scarcity. Results show that under upstream priority, the southern region in Afghanistan suffers from zero wheat production and reduced consumer surplus, and the nation's economic welfare suffers with approximately 76 percent higher average prices under both dry and drought conditions.

For the free market, results are shown to be a better strategy for the same amount of water. By establishing an institution that supports free market, water is distributed to where regions where it has the highest economic value. Free market water-sharing practices have value in protecting food security, or high consumer surplus in the face of reduced supplies.

Under free market water allocation, farm income, water use, shadow prices, and land in production show the best results. Free market conditions serve the national Afghani community better than the customary way of sharing water during periods of water shortage. However, under free market conditions, total national farm income is lower due to the rule of spreading farm income to all regions of Afghanistan rather than northern region only. This occurs because the southern region would receive no income at all under the upstream priority system.

Shadow price shows the value of water under different water shortage scenarios. Results show that under free market the average shadow price is lower than under upstream priority allocation by 73, 51, 66 percent for normal, dry and drought water shortage scenarios, respectively. Free market will not harm the northern and the central regions, but it will give the southern region of Afghanistan the opportunity to secure their food supply.

Overall, free market water-sharing yields more grains production and must be considered preferable to upstream priority water allocation.

Acknowledgements

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