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Protecting food security when facing uncertain climate: Opportunities for Afghan communities

Dina Salman [a], Saud A. Amer [b], Frank A. Ward [c,*]

[a] Water Science and Management Program, New Mexico State University, Las Cruces, NM, USA
[b] U.S. Geological Survey, Reston, VA 20192 USA
[c] Department of Agricultural Economics and Agricultural Business, Water Science and Management Program, New Mexico State University, Las Cruces, NM, USA

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ABSTRACT

Climate change, population growth, and weakly developed water management institutions in many of the world's dry communities have raised the importance of designing innovative water allocation methods that adapt to water supply fluctuations while respecting cultural sensitivities. For example, Afghanistan faces an ancient history of water supply fluctuations that have contributed to periodic food shortage and famine. Poorly designed and weakly enforced water allocation methods continue to result in agriculture sector underperformance and periodic food shortages when water shortfalls occur. To date, little research has examined alternative water sharing rules on a multi-basin scale to protect food security for a subsistence irrigation society when the community faces water shortage. This paper's contribution examines the economic performance of three water-sharing mechanisms for three basins in Afghanistan with the goal of protecting food security for crop irrigation under ongoing threats of drought, while meeting growing demands for food in the face of anticipated population growth. We achieved this by formulating an integrated empirical optimization model to identify water-sharing measures that minimize economic losses while protecting food security when water shortages occur. Findings show that implementation of either a water trading policy or a proportional shortage policy that respects cultural sensitivities has the potential to raise economic welfare in each basin. Such a policy can reduce food insecurity risks for all trading provinces within each basin, thus being a productive institution for adapting to water shortage when it occurs. Total economic welfare gains are highest when drought is the most severe for which suffering would otherwise be greatest. Gains would be considerably higher if water storage reservoirs were built to store wet year flows for use in dry years. Our results light a path for policy makers, donors, water administrators, and farm managers, who shoulder the burden of protecting food security and rural livelihoods in the world's poor dry communities.

1. Introduction

Many of the world's poor, dry communities have suffered a long history of unreliable water supplies aggravated by little capacity to mitigate costs of water shortage. This weak capacity includes poorly designed and weakly enforced water sharing institutions. In few countries outside Afghanistan do these weak institutions present a larger, older, and more compelling barrier to food security. In addition, damages resulting from war and civil strife have made the problem worse.

There has been no shortage of scholarly attention to given to food and related water challenges in as well as outside the country. For example, scholarly work dealing with inadequate or inaccessible water supply was found to present a serious constraint to protecting food security (Walters and Groninger, 2014). Weak water infrastructure, a poor water allocation system, and damaged irrigation infrastructure all have challenged reliable food security in the northern part of Afghanistan (Gohar et al., 2013). Well-defined water allocation systems resting on a foundation of consistently and impartially administered law are comparatively rare in low income dry non-western countries, which contributes to continued poverty in the face of weak food security (Ward et al., 2013). A recent study summarized the development of an analytical framework to inform policies to improve food security and farm income for a northern region in Afghanistan (Gohar et al., 2013).

One work investigating opportunities for improved agriculture productivity examined how the northern part of Afghanistan could

* Corresponding author.
E-mail addresses: dinasalm@nmsu.edu (D. Salman), samer@usgs.gov (S.A. Amer), fward@nmsu.edu (F.A. Ward).

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secure a more productive farming sector with better designed and implemented water institutions (Torell and Ward, 2010). An analysis of dietary adequacy found that the northern part of the country often sufferers chronic iron deficiency due to weak and unreliable food security. Water-related challenges during wartime conflicts were examined, in which water shortages led to unreliable food security as well as expanded needs for refugee food aid (Chabot and Dorosh, 2007). A complementary work described conditions in Afghanistan during the immediately preceding period of armed conflict in which the country suffered an inadequate food security locally (Lischer, 2007).

Analysis of water sharing institutions found that both water saving technologies as well as more effective water sharing methods would help many parts of Afghanistan ensure water delivery to downstream water users (Thomas and Ramzi, 2011). A study in "post-conflict" Afghanistan found a compelling need for assistance to renovate the water sector (Habib et al., 2013). Recent work examining connections between groundwater and surface water identified a path forward to protect farm income and food security in Afghanistan by conjunctively managing surface water with groundwater. An earlier innovative work described development of an optimization model to improve the economic performance of land in production. It examined trade-offs between economics and ecological goals (Assfalg and Werner, 1992). A work on drought and food security described impacts of drought conditions and water shortages on vegetable production in the Balkh River Basin (Walters et al., 2012).

An investigation conducted in connection with dams and infrastructure described the potential value and limitations of that infrastructure to increase the water production to meet increased water demand (Ragab and Prudhomme, 2002). Analysis conducted for a region in the nearby Amu Darya Basin showed that groundwater management capacity needs to be developed because of the considerable quantity, quality, and reliability of groundwater resources found there (Rakhmatullaev et al., 2010). An innovative work described approaches to increase the reservoir capacity in various regions of Afghanistan to meet demands of water users in Turkmenistan, Uzbekistan, and Tajikistan. That work found that applying water laws or assigning new water permits in Afghanistan that deviate from the customary irrigation systems presents numerous cultural and institutional challenges (Wegerich, 2010).

One work investigated various approaches to enhance water availability for various Afghan regions, due to water shortage risks they face (Micklin, 2002). A work focusing on salinity management found that in the Kabul region, high rates of salinity have occurred during serious drought conditions (Houben et al., 2009). An optimization framework was later developed for irrigation management, based on a versatile linear programming-based model that can be used to optimize crop choice and water allocation within several Afghan irrigation districts (Reeling et al., 2012).

A work examining military activities assessed impacts of then-recent armed conflicts in Afghanistan on the farming sector (Groninger and Lasko, 2011). Another work addressing connections between social challenges and water shortages found that many Afghans have faced refugee status both inside and outside the country, partly because of the costs of adapting to water and food shortages (Sharp et al., 2002). A study conducted for the Amu Darya Basin found that construction of the proposed Rogun Dam would confer considerable economic benefits to Afghanistan, Uzbekistan, Turkmenistan, and Tajikistan (Jalilov et al., 2013). Another work identified important gains that could be secured by applications of remote sensing to investigate the economic accessibility of irrigated areas that rely on groundwater during, especially when shortages of surface water occur (Pervez et al., 2014).

Many water-related journals have established a long track record of publishing works that integrate the disciplines of hydrology, irrigation, economics, and policy brought to bear on the discovery of resilient adaptations to drought and climate stress. Several such works have been published in this Journal since 2012 alone. For example, one analysis examined the design of incentives for irrigation water saving measures to contribute to wetlands protection (Nikouei et al., 2012). Another investigated the economic performance of water storage capacity expansions in the northern part of Afghanistan (Gohar et al., 2013) although it was limited to a small region of the country. Climate adaptation policies were investigated for the Murray Darling Basin in Australia (Kirby et al., 2014).

An analysis of economic incentives was conducted for a region in China to assess the reform of irrigation management (Wang et al., 2014). Economic impacts of water conservation programs for adjusting to drought were investigated for a region in the Rio Grande Basin (Ward, 2014). A policy analysis was conducted for the Niger Basin using a sophisticated integration of hydrology, economics, and institutional analysis (Ward and Kaczan, 2014). Water appropriation rules to complement irrigation infrastructure were investigated as measures to promote food security in a northern region of Afghanistan (Gohar et al., 2015). A basin scale integrated hydroeconomic model was developed for policy analysis for a region in Spain (Kahil et al., 2015). An integrated multi-objective basin scale model was developed and applied to inform debates over climate and drought for a basin in central China (Hu et al., 2016). An optimization model was developed to investigate opportunities for storage capacity expansion for crop irrigation in the headwaters of a drought prone basin in American Southwest (Ward and Crawford, 2016).

Despite the numerous important achievements described above by authors of these many works, no multi-basin scale analysis in Afghanistan and few elsewhere have been conducted to assess the resilience of alternative water sharing systems for adapting to a range of water supply conditions. Compounding the challenges brought on by poorly designed and weakly enforced water institutions is the difficult physical terrain of Afghanistan presenting considerable barriers to the efficient transport of food, water, and people. Another problem posed by its high mountain environment is the heavy spring and summer snowmelt runoff, making it difficult to capture and store river water. This difficulty is raised by the absence of storage reservoirs with sufficient capacity for multi-year carryover storage. With emerging evidence of climate change, both the quantity, timing, and duration of snowpack located at higher elevations could change, affecting in unknown ways, important sources of water for many regions in the country (Campbell, 2015). The country's steep terrain raises the vulnerabilities brought on by existing weaknesses in national finance, water administration, and engineering expertise.

A further challenge facing water policymakers in Afghanistan comes from the fact that the country is landlocked without a viable nationally-linked road transport system, making it difficult to ship food and grains cheaply and efficiently at a nationally networked scale. An efficient transportation network and supporting institutions to promote widespread water trading would also augment the gains from intra-basin trading in food grains.

Water of the right quality, quantity, timing, location, and price for irrigated agriculture remains one of Afghanistan's most pressing needs. The United Nations recently estimated that Afghanistan's population of about 31 million stands to grow by nearly 70–80 percent by 2050 to 55–56 million. Such an increase stands to raise demands placed on the country's currently stressed water resources as well as risking new challenges to its food production system. Moreover, global climate change may alter precipitation patterns in the country, further aggravating the mismatch between