

Food and water insecurity: re-assessing the value of rainfed agriculture

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Abstract Rainfed agriculture has potential to produce needed cereals for the growing populations of West and Central Asia even though rainfed agriculture is perceived as risky. The value of rainfed agriculture to produce competitively should be re-assessed. This requires the concerted efforts of farmers, researchers, and policy makers to work on the technical factors that determine agricultural production as well as to address the economic policy environment. Syria is a small country with a diversified rainfed and irrigated agriculture. Rainfed and supplemental irrigation technology has improved Syria's food self-reliance, however, the policy environment is not conducive to the sustainable use of natural resources. Supplemental irrigation technology to produce wheat is used to illustrate the need to address both the technical issues as well as the economic incentives to make agricultural production competitive. Kazakhstan is a large country with a predominantly rainfed agriculture. Farmers could benefit from rainfall probabilities to use fertilizer and improved wheat varieties under rainfed agriculture as Syria did during the eighties and nineties. Implicit taxation of farmers needs to be removed and access to markets must be ensured for farmers in Kazakhstan to benefit from international wheat prices. While it is important to improve production technology, the economic policy environment needs to be addressed first to create incentives for farmers to produce commodities competitively in water-scarce regions.

Keywords Economic policies; rainfed agriculture; water scarcity; West and Central Asia

Introduction

Insecurity about water and food supply is increasing, and this is a challenge to the design of policy for sustainable economic development. In the past, investment in irrigation was looked upon as an option for securing food and fiber for growing populations. Investment in irrigation is no longer perceived as a viable solution for sustainable development. Maintaining the functionality of the existing irrigation infrastructure and reliance on sustainable rainfed agriculture is perceived as a more sensible option for economic development (Berkoff, 2002, 2003). Farmers in the dry areas of West and Central Asia face the challenge of producing competitive products for global markets. Cases in Syria and Kazakhstan illustrate this challenge for policy makers.

Syria is a small country with a range of rainfed and irrigated systems, while Kazakhstan is a large country with vast areas of predominantly rainfed cereal production. In Syria, the agricultural strategy should be based on the measured use of groundwater to supplement rainfed-cereal cultivation. In Kazakhstan, the agricultural strategy could benefit from a Markovian approach to input use (chiefly fertilizer and improved seed) along with improved management of soil moisture (winter snow and spring rainfall). Policy instruments in both countries, through the liberalization of input marketing and distribution in the agricultural system, a better incentive structure for grain prices, and access to local and international markets, are typically used to ensure the country's breadbasket. However, if

improperly used, such instruments can result in the wasteful use of domestic resources. The choices facing policy makers are not any easier than those facing the communities of farmers in low and middle-income countries, who traditionally pursue short-term goals. Only through the concerted efforts of both farmers and policy makers can sustainable and competitive input and crop choices be made that will meet the growing demand for food and fiber in dry areas.

Rainfed agriculture: decision making under uncertainty

Rainfed agriculture is not portrayed as a meaningful contributor to the agricultural economies of many dry countries because it is risky and the returns to land, water, labor, and capital appear to be low. However, if technical backstopping is used to determine the probability distribution of uncertain outcomes, and the vast areas of rainfed areas are taken into account, the expected returns are more reasonable.

Case 1. Northern Syria

Rainfed agriculture in northern Syria, as in many areas of West Asia, is largely comprised of rotations of cereals with food and feed legumes. These rotations help restore or sustain soil nutrients, reduce the risk of pests and diseases, and minimize the use of mineral fertilizers. The decision to use fertilizer is contingent upon the expectation of rainfall as the crop-growing season unfolds. Weather and market-price variations within and among seasons determine the allocation of inputs, as well as the decision on how to combine alternative rotations to achieve the farmers' goals.

Typical wheat rotations are wheat/fallow, wheat/summer crop (melon), wheat/lentil, wheat/chickpea, and wheat/wheat (continuous wheat). Two widespread rotations involve sheep grazing: wheat/vetch for lamb fattening and wheat/medic for supporting year-round sheep production. The complexity of the last two rotations prevents us from elaborating them here. However, experimental results (Rodríguez and Harris, 1994) from eight seasons of wheat rotation allow discussion of fertilizer application under rainfall uncertainty. Seasonal rainfall averaged 313 mm, with a coefficient of variation of 24%. Rainfall was less than 250 mm for two seasons, 250–300 mm for two seasons, 350–400 mm for three seasons, and above 485 mm in one season. Wheat grain yield averaged 1 ton/ha under continuous wheat and 2.3 ton/ha under wheat/fallow. Coefficients of variation for wheat-grain yield varied from 35% for wheat/melon to 55% for wheat/chickpea. Partial budgets for each N-fertilizer application in the wheat component of the rotation (0, 30, 60, and 90 kg/ha) permitted *ex post* identification of optimal fertilizer rates.

For all rotations, as rainfall increased, the optimal application of N increased, with a clear soil-moisture carry-over from season to season. Optimal gross margins for wheat/wheat averaged only 1,580 SL/ha (42.5 SL = US\$ 1.0), with a coefficient of variation of 241% (ranging from –3,150 SL/ha in the 1989/1990 season to 8,000 SL/ha in the 1991/1992 season). Optimal gross margins for wheat/lentil averaged as much as 9,900 SL/ha (coefficient of variation of 59%, ranging from –140 SL/ha in the 1989/1990 season to 21,000 SL/ha in the 1985/1986 season). *Ex post* optimization of N fertilizer showed an adjustment for rainfall in the previous and current seasons. If the farmers were to apply the average optimal fertilizer rates for each rotation, regardless of past and present seasonal rainfall, they would earn less than if they adjusted for rainfall. The financial benefit of adapting fertilizer application to variable seasonal rainfall averaged 14% for all rotations (5% for wheat/fallow, 3% for wheat/melon, 4% for wheat/lentil, 22% for wheat/chickpea, and 36% for continuous wheat) (Rodríguez and Harris, 1994). A simple rule was developed by Pala *et al.* (1996) for N fertilizer rates: 30 kg/ha in dry years to 60 kg/ha in wetter years in rainfed areas and 100 kg/ha under supplemental irrigation (defined as the application of

small amounts of irrigation to essentially rainfed crops normally grown at that location to increase and stabilize yield levels). This recommendation was applied widely in the country in the following years.

Average wheat yield, for both rainfed and irrigated systems, in Syria increased from 1.85 ton/ha in 1991 to 2.40 ton/ha in 1998 (Mazid *et al.*, 2003). Their assessment of the effects of different management factors in wheat productivity showed that 34% of this yield increase was due to the use of improved varieties, 24% to fertilizer, 23% to irrigation, and 19% to improvement in land- and crop-management practices. Currently, the average yield of rainfed wheat is about 2.2 t/ha. Under supplemental irrigation it is 4 t/ha (A. Mazid, personal communication). Out of the 1.5 million hectares planted to wheat in Syria, 60% is rainfed and 40% is under supplemental irrigation. Supplemental irrigation in wheat production is of paramount importance, not only because of wheat's contribution to the national food-security policy but also because of sustainability concerns (Rodríguez, 2003).

Case 2. Northern Kazakhstan

Wheat and other cereals are grown in mainly the rainfed areas of northern Kazakhstan. Production of bread and durum wheat is concentrated in the Akmola, Kostanai and Northern Kazakhstan Oblasts. As part of the ex-Soviet Union, this area was the main producer of wheat for the region. Currently, the wheat sector is trying to cope with the new reality of decreasing demand due to low quality and limited markets.

Kazakhstan has the potential to produce enough wheat not only to meet its domestic needs but also to compete for the central Asian markets with major producers such as Australia, Canada, and the United States. This production can only come from rainfed agriculture, which means both the technical and market constraints must be removed. Technical constraints include: a) restoration of production potential; b) raising annual production based on intensive technology; and c) improving grain quality.

Drought conditions for wheat production are defined as a year in which rainfall is less than 250 mm. Semi-drought conditions are defined as a year in which rainfall is 250–350 mm. Favorable conditions are when annual rainfall is above 350 mm. The level of precipitation determines the yield. Deep penetration (1–1.5 m) of moisture into the soil takes place when winter snow is 60–120 mm. The summer rainfall (130–200 mm) is also very critical. Furthermore, its occurrence determines sowing date, level of fallow, and yield. Farmers allocate an area to wheat cultivation or leave it fallow depending on the weather. In the spring, when soil moisture is 90 mm or more per meter of the soil profile, farmers devote a greater area to wheat than to fallow. The increase in area under fallow in dry years results in increased production of wheat the following year.

One major constraint in reaching production potentials in northern Kazakhstan has been the conservative attitude of individual farmers toward making risky decisions. This is particularly true of small farmers with limited financial resources, as they tend to be risk averse. There are three main perceived risks. The first is whether to plant or leave a field fallow. It depends on soil-moisture carry-over. The second is the decision of what to plant: wheat, barley, or other crops. It depends on the farmer's perception of the rainfall outlook during the season. The third concerns the degree of financial resources available to invest in improved wheat varieties (drought and rust resistant) and fertilizer. Given this context, it is essential to know the correlation between rainfall and yield, which affects both private and social profitability, and the cost per ton of wheat production, which determines the competitiveness of a commodity in domestic and external markets.

The policy environment

Case 1. Groundwater irrigation in Aleppo, Syria

The Aleppo Province in northwest Syria comprises a cross-section of four out of five agricultural stability zones (Ahmad and Rodríguez, 1998). Annual precipitation in the “high rainfall” section of the study area exceeds 350 mm, with at least 300 mm in two years out of three. The main crops are cereals, food legumes, fruits, vegetables, and summer crops. The “low rainfall” part of the study area has 200–250 mm annual rainfall, with no less than 200 mm in one year out of two. There is limited production of vegetables, food legumes, and wheat where irrigation is available. Because the area includes the outskirts of Aleppo City, it is affected by the local agricultural product market, which is continually growing to satisfy the higher and more diverse demands of urban dwellers. As one might expect, poverty is inversely related to the availability of water and arable land (Rodríguez, 2003).

Price incentives have induced farmers to adopt a cropping pattern that has pushed the agricultural frontier to the drier areas. Wheat is the dominant crop produced under rainfed and supplemental irrigation in Aleppo. The main source of water for irrigation is groundwater; low rates of recharge, due to the geomorphology of the area, the increasing number of wells and unrestricted extraction, as well as the demand for agricultural products, explain the trend of declining water tables (Wagner, 1997). Use for supplementary irrigation of wheat is the tip of the iceberg of excessive use of groundwater in agriculture (20% of the annual usage according to Rodríguez *et al.*, 1999). Unclear property rights and low cooperation among irrigators interact with economic incentives and result in the misuse of groundwater (Rodríguez, 2003).

The official price of wheat grain increased dramatically, from 5,700 SL/ton in 1988 to 9,500 SL/ton in 1991 (1990 prices). This increase coincided with the extremely low rainfall during the 1988/1989 and 1989/1990 seasons. While rainfed wheat production is financially and socially profitable, wheat grown under supplemental irrigation is largely dependent on location (stability zone) and the level of irrigation (Table 1). When the social domestic resource cost (DRC) is accounted for, rainfed wheat cultivation uses resources efficiently (DRC < 1). Rainfed wheat in Zone 1 (350 mm annual rainfall) and Zone 2 (300 mm annual rainfall) is more efficient than rainfed wheat in Zone 3 (250 mm annual rainfall). Two scenarios of wheat grown under supplemental irrigation are presented: one where annual rainfall is 350 mm (Zone 1), with 150 mm as supplemental irrigation; and the other where annual rainfall averages 200 mm (Zone 4), with 150 mm as supplemental irrigation. In the first case, both private and social profitability are positive. In the second, private profitability is positive, but social profitability is negative when domestic resources are fully paid and DRC is below 1 (Ahmad and Rodríguez, 1998).

Because the cost of fuel for wheat production is substantial (about 25% of variable cost) the response of the social profitability of wheat to changes in the social price of diesel was

Table 1 Economics of wheat produced under different types of water availability in Aleppo, Syria

Water availability (mm)	Private profitability (SL [†] /ha)	Social profitability (SL/ha)	Domestic resource cost
Zone 1 – Rainfed (350)	7,905	6,920	0.17
Zone 2 – Rainfed (300)	7,579	5,026	0.19
Zone 3 – Rainfed (250)	1,888	1,284	0.33
Zone 1 – Supplemental irrigation [‡] (150)	16,496	8,200	0.54
Zone 4 – Supplemental irrigation [§] (150)	836	-3,643	1.62

Source: Ahmad and Rodríguez (1998).

[†]SL = Syrian pound; [‡]Rainfall = 350 mm; [§]Rainfall = 200 mm

examined by Ahmad and Rodríguez (1998) using price variants of diesel (ranging from 4 to 14 SL/L). The increasing price of diesel did not necessarily modify the unsustainable path of groundwater use. Farmers base their decisions on financial profitability and on their perception that supplemental irrigation is a vehicle than can move them from a low rainfall situation to a higher rainfall situation. The higher groundwater extraction cost due to increases in diesel prices has much less effect on the decisions made by farmers in northern Syria than the extremely attractive wheat price.

Case 2. Northern Kazakhstan

An important question facing the cereal sector is, should Kazakhstan restore its production potential, given the problem of a weak and unstable market. Under the marketing and trade regime of the Soviet Union, price and quality were not factors for farmers' decision making, but now farmers have to compete for sales to international markets. Technological innovations may lead to recapturing production potential, but, with a poorly developed domestic market system and weak external links, such a surplus may also lead to a further decline in the already low price of wheat. This is particularly true for small farmers, who are not well integrated into the market chain.

Removing marketing bottlenecks requires, among other factors, providing a better incentive structure for producers. Wheat production in the three main oblasts (Akmola, Kostanai, and Northern Kazakhstan) shows high economic profitability rather than financial profitability, indicating that the incentive structure is distorted (Table 2). The policy implication is that farmers are using domestic resources efficiently to generate value added at current international prices. If we remove the policy-induced and market distortions, farmers in these three oblasts could realize profits three times higher than the present level. The policy prescription entails removing market constraints, which include providing better marketing and trade mechanisms, especially for farmers operating under a barter economy, forced to sell their product at low prices in order to pay for inputs (Ahmad and Braslavskaya, 2003).

Wheat production should take place in favorable zones with fertile soils and in zones with high rainfall. A recent study by Ahmad and Braslavskaya (2003), based on rainfall

Table 2 Rainfall effects on wheat yield in northern Kazakhstan

	Drought	Semi-drought	Favorable
Rainfall (mm)	<250	250–350	>350
Kostanai Oblast			
Probability	9%	37%	54%
Yield (t/ha)	0.42	0.73	1.17
Cost (US\$ per ton)	104	59	37
Financial profitability	–19	0	26
Domestic resource cost	1.31	0.43	0.23
Akmola Oblast			
Probability	26%	40%	34%
Yield (t/ha)	0.75	0.74	1.2
Cost (US\$ per ton)	55	54	39
Financial Profitability	26	5	5
Domestic resource cost	.24	0.40	0.40
Northern Kazakhstan Oblast			
Probability	0%	38%	62%
Yield (t/ha)		0.90	1.14
Cost (US\$ per ton)		47	37
Financial profitability		10	24
Domestic resource cost		0.30	0.22

Source: Ahmad and Braslavskaya (2003).

data for the last twenty years, indicates that in Akmola Oblast there is a 26% chance of drought, compared to a 9.4% chance in Kostanai and almost zero chance in Northern Kazakhstan Oblast (Table 2). The average yield during drought conditions ranged from 0.42 ton/ha in Kostanai Oblast to 0.75 t/ha in Akmola Oblast. The average yield in Akmola Oblast under drought conditions was just about the average yield under semi-drought conditions in Kostanai. For this reason, there is no clear correlation between yield and rainfall in Akmola Oblast. These results clearly show that wheat production in Kostanai Oblast is non-competitive (cost per ton is higher than US\$ 100), does not carry a comparative advantage (DRC >1) and is not financially profitable. By comparison, the more favorable economic indicators in Akmola Oblast show that region to be competitive under drought conditions, with farms turning a profit.

There is an almost equal chance (37–40%) of semi-drought conditions in three oblasts. However, the change from drought to semi-drought conditions in Kostanai almost doubled yield, dramatically increasing its competitive advantage (DRC decreased from 1.31 to 0.43). The probability of favorable conditions is 34% in Akmola, 54% in Kostanai, and 62% in Northern Kazakhstan. Wheat production is competitive, profitable, and has a sizable comparative advantage under both semi-drought and favorable conditions. There is considerable potential for increasing yield from its current level of less than 1 t/ha to 2.5 t/ha, a level that has been achieved in other countries with similar conditions. In this respect, investment priority should be given to regions well suited for wheat growth. Rainfed areas, particularly in the 300 mm and above range, offer considerable potential for increased wheat production.

The first policy step is to remove the implicit taxation on the wheat producer. At present, farmers receive a price of US\$ 60 per ton of wheat, which is far below the comparable international trade parity price of US\$ 93 per ton. However, if additional production does not have external markets, it will put pressure on domestic prices to fall further. With rising input costs valued at world prices, production would be uneconomical.

Discussion

Rainfed lands with 250 mm annual rainfall and above offer considerable potential for increased wheat production in Kazakhstan. The decision for farmers to plant or fallow, and to invest in inputs, depends upon the reduction of risk factors. Rainfall-management practices need to be taken into account. Such practices could be easily spread through the extension service, in a way similar to that in which Syria capitalized on adaptive-agricultural research. To reduce risk and achieve production potential, the farmers need to be supported. Since wheat production is competitive in rainfed areas, research and other investments should be directed toward a technology package with drought and rust-resistant varieties, a rational use of fertilizer, and which, in the long run, looks at supplemental irrigation (if groundwater permits). Introducing insurance, or similar schemes that are financially sustainable, is another policy option that the government can consider to support farmers.

The policy environments of these two countries present an interesting contrast, as well as serious implications for the production of wheat. Farmers in Syria receive a wheat price that is 60% above the international price. Thus, they have a very strong incentive to produce more by investing in fertilizer and supplemental irrigation (Table 3). The obvious benefit for the country is the achievement of wheat self-sufficiency and the export of limited quantities. The cost of production is higher than trade parity prices. This cost structure also means a distorted price for diesel and credit. In our view, such a policy might not be sustainable in the medium to long term. The budgetary cost can be high, and under-pricing domestic resources could lead to depletion of groundwater. The wheat policy should thus be reviewed for both input cost and output price.

Table 3 Wheat-price policy profile in Kazakhstan and Syria

	Kazakhstan rainfed (US\$ per ton)	Syria supplemental irrigation (US\$ per ton)
International price	109	150
Farm-gate price	60	239
Cost of inputs	31	174
Profit	28	65
NPC [†] (%)	55	160

Source: Ahmad and Braslavskaya (2003); Varela-Ortega and Sagardoy (2002)

[†]Net protection coefficient

In contrast, Kazakhstan farmers receive only 55% of the world price for their wheat, indicating an implicit taxation. International prices are not passed on to the farmers, who face high market-transaction costs that include transportation, which costs as much as 80% of the farm price (Table 3). Farmers remain competitive, as the cost of production is much lower than the trade parity price of US\$ 150 per ton. However, given the low level of profit, farmers do not have any incentive to invest in fertilizers or improved wheat varieties to increase production. Average yield is well below 1 ton/ha, and the potential for improvement remains untapped as long as improved yield is seen to mean a further drop in output prices. The remedy is to remove the market constraint before the technical constraints are removed.

Conclusions

Water scarcity will increase along with growing populations, and inter-sector competition for water will continue to be a challenge for agriculture. Given this context, taking a second look at the potential of rainfed areas for food and fiber production and environmental and amenity services has become a priority area for researchers and policy makers in West and Central Asia.

Saving groundwater by using improved supplemental irrigation practices will continue to be a strategic for Syrian agriculture, but attention needs to be paid to both the sustainability of groundwater and the domestic-resource cost of the main crops grown by farmers. Defined groundwater rights, rather than higher diesel costs, could help achieve sustainable extraction rates; crop competitiveness would be a useful tool as long as the inter-temporal opportunity cost of water is taken into account. There is need for a concerted policy that correlates the price of inputs with the price of wheat grain. The assessment of competitiveness and sustainability of both rainfed and irrigated agriculture in Syria is of paramount importance.

Rainfed lands with 250 mm annual rainfall and above offer considerable potential for increased wheat production in Kazakhstan. The decision for farmers to plant or fallow, and to invest in improved wheat varieties and fertilizer, depends upon the reduction of risk factors. Rainfall-management practices need to be taken into account. Such practices could be easily spread through the extension service, in a way similar to that in which Syria capitalized on adaptive-agricultural research. However, before the technical constraints for rainfed wheat production are addressed in Kazakhstan, market constraints should be addressed. Implicit farmer taxation should be removed and access to markets should be secured to allow farmers to benefit from international prices.

Farmers will always follow the incentives that offer them the highest short-term return. In the end, there will be a balance between the farmers' financial welfare and the state's ability to achieve sustainable food security.

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