Public Disclosure Authorized

Public Disclosure Authorized

WPS6464

Policy Research Working Paper 6464

Blue Water and the Consequences of Alternative Food Security Policies in the Middle East and North Africa for Water Security

Donald F. Larson

The World Bank
Development Research Group
Agriculture and Rural Development Team
May 2013

Policy Research Working Paper 6464

Abstract

In the Middle East and North Africa, food security and water security are tightly entwined. In particular, choices about the extent to which food security policies rely on trade rather than domestically produced staples have stark consequences for the region's limited water resources. This paper builds on previous modeling results comparing the cost and benefits of policies to protect consumers against surging international wheat prices, and expands the analysis to consider the consequences of the policies for water resources. A self-sufficiency policy is analyzed as well. Results suggest that trade-based food security policies have no significant effect on the sustainability of water resources, while the costs of policies based on self-sufficiency for water resources are high. The analysis also shows that while information about the water footprint of alternative production systems is helpful, a corresponding economic footprint that fully measures the resource cost of water is needed to concisely rank alternative policies in economic terms that are consistent with sustainable outcomes.

This paper is a product of the Agriculture and Rural Development Team, Development Research Group. It is part of a larger effort by the World Bank to provide open access to its research and make a contribution to development policy discussions around the world. Policy Research Working Papers are also posted on the Web at http://econ.worldbank.org.
The author may be contacted at dlarson@worldbank.org.

The Policy Research Working Paper Series disseminates the findings of work in progress to encourage the exchange of ideas about development issues. An objective of the series is to get the findings out quickly, even if the presentations are less than fully polished. The papers carry the names of the authors and should be cited accordingly. The findings, interpretations, and conclusions expressed in this paper are entirely those of the authors. They do not necessarily represent the views of the International Bank for Reconstruction and Development/World Bank and its affiliated organizations, or those of the Executive Directors of the World Bank or the governments they represent.

Produced by the Research Support Team

Blue water and the consequences of alternative food security policies in the Middle East and North Africa for water security

Donald F. Larson[1]

Key words: Food security, water security, Middle East, North Africa, wheat, water footprint, strategic storage

JEL classification: O13, Q15, Q18, Q25, Q56

Sector Board: Agriculture and Rural Development

[1] Donald F. Larson, Research Development Group, World Bank. The author would like to thank Jan Lundqvist and two anonymous reviewers for their valuable comments on earlier drafts, as well as workshop participants who attended a presentation of the results during World Water Week 2012 in Stockholm. The study received support at the World Bank from the Knowledge for Change Program, under a grant titled "Storage and Trade Policies for Improving Food Security," and a Research Supplemental Budget grant, titled "Precautionary Food Stocks with an Application in North Africa and the Middle East" (RSB 126641).

This essay examines the practical problem of how to account for water resources in a comparative analysis of alternative food security policy instruments. In an earlier paper, my co-authors and I analyzed alternative ways of dealing with spikes in global food prices in the Middle East and North Africa (MENA) using a model that combined competitive storage pricing and trade (Larson et al. forthcoming). In that paper, we did not address the effects of the policies on water use, a shortcoming addressed here. The original paper examined two distinct approaches: a direct market intervention based on a strategic storage program, under which wheat supplies are built-up during normal times and released to dampen domestic wheat prices once they reach critical levels; and an indirect targeted subsidy program that provides the poor with cash payments to offset the effects of high prices on their incomes. Both policies rely on trade, although the storage policy creates space for countries to act autonomously for brief periods when prices are exceptionally high. An approach that was not examined in the original analysis but is considered here is a self-sufficiency policy, under which countries fully detach from global markets to independently produce what they consume. In this paper, I briefly recap the economic costs of the first two policies, exclusive of the implicit shadow price for water resources in the region. I then go on to describe the water footprints of the three alternative approaches and relate the findings to the process of making evidence-based decisions about food security policies.

A sticking point for the type of analysis presented here is finding a way to value water so that comparisons can be made among alternative outcomes for incomes, food security, and resource sustainability. The difficulty originates in the fact that local characteristics largely determine the renewability of water resources, in combination with the fact that water is rarely priced in a way consistent with its sustainable use. To make matters worse, there is usually little political consensus about how water resources should be rationed, absent markets, even though water enters the economy in fundamental ways as a consumption good, a factor of production, and a provider of ecological services. The problem is a general one for natural resources, which are often under-priced if priced at all.

In exceptional cases, policy makers have been able to reach agreement on sustainable levels of use and establish rules that apportion a fixed annual draw down of resources among competing uses. Examples include the tradable permit systems used to allocate annual catches of fish, or limit the annual release of pollutants into the atmosphere. Importantly, once sustainability limits are set by policy makers, markets can be used to discover a price consistent with the efficient use of the resources. Conveniently for economists, price discovery also allows the value of the resources to enter the normal calculus of economic analysis (Larson and Parks 1999; Considine and Larson 2006; Considine and Larson 2012). Without this however, less satisfying forms of analysis are needed to explain the consequences of policy for the resource's sustainable use.

More specifically to the problem at hand, prices are the common denominator needed for economic comparisons that jointly consider food security and water security. However, because fully representative prices for water are missing, variations in the consequences among food security policies for water security either go unmeasured or are evaluated in qualitative rather than quantitative terms. This makes any subsequent ranking of policy alternatives dependent on subjective valuations

In the case of MENA, wheat and water are both essential components of daily life. In absolute and per capita terms, the region consumes large quantities of wheat and depends on imports for most of it, a dependency driven in large measure by the region's limited supplies of water. Food policies have grave consequences for the poor and potentially important impacts on government budgets, and these are the policy features focused on in our original analysis. At the same time, food policies can have important consequences for water demand; therefore, deciding upon a sustainable approach to food security requires considering whether the policy is consistent with sustainable water use. In this paper, I argue that the set of trade-based policies that are most cost-effective for food security are also the ones most consistent with sustainable water policy in MENA. Still, this is easier to demonstrate in MENA where water is scarce than is generally the case. This underscores a general result of the paper: that economic footprints for water are needed to complement current physical measures.

Background

The data in Table 1 illustrate the importance of wheat for the MENA region. On average, nearly 40 percent of the calories consumed each day in the region can be traced back to wheat. In Algeria and Tunisia, the shares are higher still, reaching 46 and 48 percent of daily caloric intake. Furthermore, the importance of wheat as a source of calories is most certainly higher for poor families whose diets generally depend more heavily on staples like bread and couscous.

Global wheat prices rose sharply in 2008, and in early 2011, with harsh consequences for the region's poor; another round of price increases occurred in late 2012 (Figure 1). Worldwide, Ivanic, Martin and Zaman (2012) estimate that the 2010-2011 surge in food prices pushed 44 million people into poverty. In Yemen, the authors estimate that poverty rates rose from 17.5 to 18.3 percent of the population simply because of rising food prices. Most concerning is that while the episode of price-driven poverty may be brief for some families, even temporary malnourishment can lead to permanent physical and mental stunting when it occurs during early childhood. The sad consequences of historical malnourishment in the region are given in the last column of Table 1.

During the most recent episodes of high food prices, governments responded in a variety of ways. In many countries, safety net programs already in place were scaled up. Included in this category are cash transfers, in-kind food transfers, work programs and targeted feeding programs. Some food importers reduced import or sales taxes and some countries offered general subsidies for consumers (Alderman and Bundy 2012; Skoufias et al. 2011; Wodon and Zaman 2010).

In a few cases, food exporters imposed or threatened export restrictions in order to lower food prices at home. Included in this group were significant wheat exporters, such as Kazakhstan, Russia and the Ukraine (Heady 2011). This class of interventions in particular heightened concerns among wheat importers in MENA, since export bans can disrupt physical supply chains. In consequence, the policies also gave impetus for governments to reconsider strategic storage strategies in order to limit the effects of price spikes and policy-driven disruptions to physical supply chains. In some cases, governments supervise the wheat supply chain in its entirety in order to manage domestic prices. This approach to food security, once common, was abandoned by most countries in the later decades of the 20th century, as the policy proved ineffective or economically unsustainable in the long run (Larson et al. 2004).

Promoting self-sufficiency is another policy element that has seen renewed interest. It has a strong political appeal for many policy makers since it reduces import dependency, thereby providing a way for governments to manage imported food price volatility and the risks of supply disruptions on their own terms. Even so, unless achieved through increases in productivity, self-sufficiency as a policy goal can be expensive to achieve, not only in economic terms but in terms of a region's natural resource base. As a whole, the volume of renewable freshwater resources available in the region on a per capita basis is quite low in comparison to other regions (Figure 2). Moreover, with the exception of Bahrain and Djibouti, most of the region's freshwater resources are already used for agriculture (Table 2). Past attempts by governments in the region to devote additional water resources to agriculture in pursuit of self-sufficiency goals largely resulted in a more rapid depletion of those resources (Al-Saleh 1992, and Allan 2001). Even now, the volumes of water used for agriculture are uneconomical in many places, were water appropriately priced; going forward, growing populations and urbanization will put further pressure on limited water resources. As a variation of national self-sufficiency, countries have also utilized sovereign wealth funds to acquire land and water resources in other countries (Deininger and Byerlee 2012).

For a long time, most governments in the region have relied on public and semi-public agencies to manage some aspect of the wheat supply chains, and in recent years those agencies have greatly expanded their capacity to hold precautionary stockpiles of wheat. The wheat stocks are strategic in the sense that the levels held go beyond what is needed in the normal course of business. Figure 3 illustrates this point. The level of current and planned wheat storage capacity for selected countries in the region is given on the left axis, while the capacity translated into months of average consumption is given on the right. On average, the reported countries will soon have the capacity to hold enough wheat to cover more than 7.7 months of consumption, with several countries holding enough wheat to meet local demand for more than a year without imports. Though not fully articulated in policy statements, the strategic reserves are meant as a buffer against a spike in food prices and as a precaution against supply disruptions.

Policy alternatives

As discussed, the analysis reported in Larson et al. (forthcoming) looks at a formal set of rules for addressing wheat price volatility using strategic stockpiles of wheat. It then compares the cost of the policy to a targeted subsidy program that issues direct payments to the poor when food prices spike. Still, outcomes from the two policies are not strictly comparable, since strategic storage policies also protect against potential supply disruptions while cash transfers do not. And while physical supply chain disruptions are rare worldwide, the history of conflict in the Middle East, the region's geography, and the crucial role of wheat imports in the everyday life of the region's citizens prompt policy makers' concern. With this in mind, the difference between the costs of the two policies can be interpreted as the cost of protecting against unlikely but potentially severe consequences of embargoes, blockades, or other supply disruptions.

Briefly, a strategic storage policy works by accumulating inventories during periods of normal prices and releasing inventories when prices exceed a trigger price in order to boost local supplies and drive down prices. The policy fails when inventories are exhausted, so a chief concern is to make sure that the stockpiling rules are robust and stocks are sufficient under a variety of contingencies. Three decision variables combine to determine the frequency of government

interventions and the probability that strategic storage levels are sufficient. The first is the trigger price itself. Setting the price high relative to historical prices means that interventions occur less frequently, but it also means that periods of moderately high prices must be tolerated. The amount of storage matters too. Storing more means that greater volumes can be released and a greater number of consecutive release periods can be sustained. And finally, the rate at which stocks are replenished matters as well. Once inventories are released, they must be rebuilt in order to address the possibility of another price spike in the short-term.

Monetary program costs

Using a calibrated model of wheat trade and storage in MENA, the costs of the two policies were estimated through stochastic simulations, where interventions are expected to be relatively rare, occurring on average once every ten years. The numerical model, described fully in Larson et al. (forthcoming), uses a rational expectations framework, where private sales and storage decisions are conditional on carryover inventories. It also takes into consideration rules that pertain to public storage.

A key result from the modeling exercise is depicted in Figure 4. It shows that the program is effective in reducing price variability (as measured by the price coefficient of variation on the right axis) in a non-linear way. Price volatility falls rapidly as stock targets reach about half (six-months) of average annual consumption, but further reductions are negligible thereafter. Nonetheless, program costs (measured on the left axis) rise linearly.

Figure 5 shows the cost of an alternative policy of issuing direct payments when wheat prices spike. The compensation is set at the difference between the trigger price used under the strategic storage policy and the prevailing domestic price of wheat, which in turn is determined by the prevailing international price of wheat. As the figure shows, the average cost of the program is quite low at $53 million per year. This low average comes about in part because the trigger is set so that interventions are infrequent. All the same, when interventions are needed, the price tag can be high. In simulation, the policy included one year in which costs fell just short of $US 1.4 billion. Even so, the policy is inexpensive when compared to a strategic storage policy where recurring costs of nearly $US 960 million is needed to achieve significant reductions in price volatility. In fact, even when the subsidy program is extended to include everyone, regardless of need, the average cost of the subsidy program is $US 142 million per year.

Program costs in water

What then are the consequences of the policies for water? To get to that answer, it is important to note that both the strategic storage and the targeted subsidy programs are based partly on trade and that this has consequences for water use. Specifically, in the simulations used to evaluate the competing policies, domestic supplies fluctuate some in response to rising and falling prices but average production varies around the current production and trade levels used to calibrate the model. This provides a baseline for evaluating the effects of the policies on water resources (Larson et al., forthcoming).

In an ideal world, the traded price of wheat would include the full cost of the water, inclusive of externalities, and other inputs used to produce it, as would the domestic price of wheat. Under these conditions, the full resource costs of water and all inputs would be properly accounted for in

the price-based economic analysis already reported. As noted, this is not the case; however, it is possible to say something about the consequences of the policies for sustainable water practices.

Because of the interactions of climate and agronomy, the amount of water used to produce wheat varies depending upon the conditions under which it is produced. In recent decades, scholars have worked to calculate the average amount of water used to produce wheat, based on where it was produced. This physical measure is referred to as the water footprint of wheat from a given location, or the virtual water content of wheat. Because of their interest in sustainable practices, economists and others who study water policy distinguish among types of water based on how easily the water resources are renewed. Consequently, information about differences in the water footprints of imported and domestically produced wheat can be used to say something about the consequences of food security policies on sustainable water use.

Based on Mekonnen and Hoekstra (2010), Figure 6 reports the water content of wheat imported into the region, based on points of origin, and compares it to the water content of wheat produced in Egypt, which, for lack of a more comprehensive measure, is taken as representative of wheat produced in the region. As the figure shows, on average about 2,300 cubic meters of water is needed to produce wheat imported into MENA, while wheat in Egypt requires about one-third less water, roughly 1,500 cubic meters. However, there are differences in the nature of the water used. As is generally the case for food grains (Aldaya, Allan and Hoekstra 2010), traded wheat is primarily grown in rainfed environments, so that roughly 95 percent of the water used is renewable "green water". In contrast, most wheat grown in MENA relies on irrigation, that is, "blue water", which is subject to competing uses in diverse locations. More non-potable recycled "grey water" is used to produce wheat in MENA as well.

The data in Figure 7 were generated by projecting these water-use rates onto the production and trade statistics used to calibrate the model. The figure shows that, on average, the annual volumes of water used to produce the wheat consumed in the region were about equally divided between domestic and foreign sources.

But is this outcome a good one? To start to answer this question, it should be kept in mind that the water outcomes described in the table are driven in part by water policies in the relevant domestic and foreign markets. In an absolute sense, because water is generally mis-priced water, the outcomes could only be optimal by chance. However, taking a more pragmatic approach, the answer depends on how domestic blue water is valued from the vantage of a policy maker in MENA.

For didactic purposes, write out the wheat profit function, $\pi^i = pf^i(x^i, z^i) - w^i x^i + c^i(z)$ where p is the price of wheat at the border; where $f^i(x, z)$ is a production function representative of how wheat is produced in country i; where x^i is the water used and $z^i$is a vector of all other inputs used to produce wheat in country i; where w^i is the minimum price of water in country i consistent with sustainable use; and where c^i is the total cost in country of all other inputs z used to produce wheat. Holding prices and other inputs constant, maximized profits are characterized by the condition: $p(\partial f^i/\partial x^i) = w^i$. Now consider two regions, $i \in \{d, r\}$ where d represent domestic production in MENA and r represents the world of exporting countries. A ratio of the corresponding first-order condition gives:

$$\frac{\partial f^d}{\partial x^d} / \frac{\partial f^d}{\partial r^d} = \frac{w^d}{w^r} \qquad 1)$$

In words, equation 1states that for trade in wheat to result in an optimal water-resource outcome, the ratio of marginal products of the virtual water used to produce wheat in MENA and wheat imported into MENA must equal the ratio of their respective sustainable shadow prices.

Returning to problem at hand, the average amount of water used to produce a ton of wheat in MENA is 1,500 m^3 and 2,300 m^3 is used to produce imported wheat. If average and marginal rates are nearly the same, then equation 1 can be used to evaluate whether the trade in virtual water implicit in traded wheat is optimal. Plugging in the two water footprints then suggests that the trade-off between domestic water used to produce wheat and the virtual water obtained by importing wheat is optimal only if the predominately blue domestic water is worth 1.53 times the value of the predominately green, imported virtual water. As already discussed, since the trade in virtual water implied by the trade in wheat is not driven by markets, there is no reason to think that this is an optimal outcome. More to the point, since the water used to produce imported wheat is rain-fed, its sustainable shadow prices (the denominator in the right-hand side element of equation 1) is likely quite low, suggesting that more wheat (and more virtual green water) would be imported, if true resource costs were considered.

In a similar way, it is possible to look at the water content implicit in a strategic storage policy. The cost of the program, denominated in categories of water is given in Figure 8. Because, at the margin, it is imported wheat that is stored, the costs of the storage program grows linearly in all types of water; however, because most of the imported grain is rainfed, the virtual water stored under the program is mostly green.

What about solving the problem of volatile food prices by producing more at home? In theory, this could be accomplished by expanding irrigation to the point where the region is self-sufficient. It is important to note that while irrigated production is less volatile than rainfed production, supply uncertainty and risk and remain. So what would self-sufficiency cost in terms of water resources and what would the consequences be for food certainty?

There is little available information on the relative variability of rainfed and irrigated production in MENA, but it is possible to get at a rough answer by borrowing coefficients from a study by Assefa et al. (2012), which puts the coefficients of variation of rainfed and irrigated wheat yields in Kansas at 0.24 and 0.15. (It is likely that rainfed wheat is more variable in MENA than in Kansas, but the net effect would be to move the starting point for the production variability line up the left axis and steepen the slope.) Based on these numbers, Figure 9 shows the cost in blue water of obtaining greater levels of self-sufficiency, as domestic production (right axis) goes from zero to 67.4 million tons of production, an amount sufficient to cover annual consumption in the region. On the left axis, the graph also shows the decline in production uncertainty as the share of irrigated production grows. On the horizontal axis, the graph also shows that the resource cost of increasing self-sufficiency climbs and reducing production variability grows from zero to more than 61 billion cubic meters of blue water, a volume equivalent to more than two-thirds the annual discharge of the Nile River, based on an estimated flow of 250 cubic meters per day.

In the case of MENA, most policy makers concur that self-sufficiency is an unrealistic policy objective, since the share of available blue water required for self-sufficiency is so large. However, the question of whether MENA should be more or less self-sufficient in wheat is harder to answer because the economic footprint of water, that is, its opportunity cost is largely unknown. In other words, a physical measure of the effects of a food security policy may be sufficient to inform a choice among alternatives, but only when the tradeoffs are extreme.

Conclusions: Policy choices and mixed metrics

The results of the analysis for each policy alternative are summarized in Table 3. In terms of program costs, the analysis shows that targeted subsidies are, on average, much less expensive to finance than a strategic storage program, even when the storage program is designed to respond to rare price spikes. The model simulations suggest that protecting the poorest 40 percent of the population in MENA using vouchers or other direct transfers would cost $US 53 million annually, while protecting everyone would cost about $US $142 million. This compares to the average annual cost of $US 959 million estimated under a strategic storage program.

Under each of the three scenarios, the additional costs to water security would be negligible. This is because trade remains open under the policies, leaving domestic production unaffected. As a consequence, the annual domestic consumption of blue water remains constant, regardless of which policy is implemented.

This is easy to see in the case of direct payments, since vouchers rather than physical supplies of wheat are distributed. Still, the result holds under the strategic storage regime as well. Specifically, under a storage program where the storage target is set equivalent to 40 percent of annual consumption, accumulated wheat stockpiles would require about 69 billion cubic meters of water to produce. However the water consumption, which is stored virtually, would originate outside the region. What's more, most of the total, 65 billion cubic meters of stored virtual water, would come from renewable sources. (Recall Figure 8.) In addition, as discussed in Larson et al. (2013), a public storage program in MENA would result in lower private storage outside of MENA, so much of the estimated virtual water stored under the policy would be stored elsewhere were a version of the targeted subsidy program implemented instead. For all of these reasons, the net effect on domestic water consumption would be nil.

The opposite is true of policies that promote increased self-sufficiency. In the case of MENA, the cost of self-sufficiency in terms of blue water is quite high, driving the demand for blue water from 36.4 billion cubic meters annually to nearly 61 billion. As discussed, an already high portion of blue water in MENA is devoted to agriculture and it is unlikely that a self-sufficiency program could be sustained, especially given projected increases in the region's population.

Taken together, these results constitute the main finding of the paper: trade-based food security policies need not adversely affect the sustainability of domestic water resources, but policies that emphasize greater self-sufficiency will.

The analysis also reveals the need to develop economic footprints for water that correspond to the physical measures already developed, and this constitutes a second finding. Because, in general, water is not priced in a way consistent with sustained levels of use, comparisons among food policy

outcomes become complex and subjective. Based on very rough measures, a ton of wheat imported into MENA results in a global net savings of 882 cubic meters of blue water, and 321 tons of grey water, but these savings come at an expense of 1,944 tons of renewable green water. But what does this mean for food security policy? Should MENA strive to be less self-sufficient in wheat? Probably so, but without a better knowledge of the opportunity costs of water, it is difficult to rank alternative solutions succinctly in economic terms.

The dilemma of trying to match environmental and economic outcomes is a well-established one and the reason why valuation methods are a pillar of environmental economics. Though the arguments around methodology are technical and sometimes obtuse, the methods themselves are important because they are used to inform real debates about decisions that have crucial consequences. Food and water are deeply entwined for policy making in the Middle East and North Africa, and producing food is just one of several uses of the region's limited supply of water. Finding a way to value water, to judge its economic footprint, is a needed first step to managing water resources in responsible and sustainable ways.

Bibliography

Aldaya, M.M., J.A. Allan, A.Y. Hoekstra. 2010. Strategic importance of green water in international crop trade. Ecological Economics 69(4), 887-894.

Alderman, Harold and Donald Bundy. 2012. School feeding programs and development: are we framing the question correctly? World Bank Research Observer 27(2), 204-221.

Allan, J.A. 2001. The Middle East Water Question. London: I.B. Tauris Publishers.

Al-Saleh, Mohammed Abdullah. 1992. Declining groundwater level of the Minjur Aquifer, Tebrak area, Saudi Arabia. The Geographical Journal 158 (2), 215-222.

Assefa, Yared, Kraig Roozeboom, and Chuck Rice. 2012, Yield trends and variability in four major crops of Kansas. Available on the internet at: www.ipsr.ku.edu/CEP/Hyperlink_Documents/Posters2012Symposium/AssefaPoster.pdf

Breisinger C., O. Ecker, P. Al-Riffai and B. Yu. 2012. Beyond the Arab Awakening: Policies and Investments for Poverty Reduction and Food Security. IFPRI Food Policy Report. Washington: International Food Policy Research Institute.

Considine, Timothy J. and Donald F. Larson. 2006. The environment as a factor of production. Journal of Environmental Economics and Management 52(3), 645–662.

Considine, Timothy J. and Donald F. Larson. 2012. Short term electric production technology switching under carbon cap and trade. Energies 5(10), 4165-4185.

Deininger, Klaus and Derek Byerlee. 2012. The rise of large farms in land abundant countries: do they have a future. World Development 40(4), 701-14.

FAO (2012a). AQUASTAT. Rome: Food and Agriculture Organization of the United Nations.

FAO (2012b). FAOSTAT. Rome: Food and Agriculture Organization of the United Nations.

Heady, Derek. 2011. Rethinking the global food crisis: The role of trade shocks. Food Policy 36(2), 136-146.

Ivanic, Maros, Will Martin and Hassan Zaman. 2012. Estimating the short-run poverty impacts of the 2010-11 surge in food prices. World Development 40(11), 2302-2317.

Lampietti, Julian, Michelle Battat, Arnold De Hartog, Donald F. Larson, and Dana Erekat. 2012. The grain chain: food security and managing wheat imports in Arab countries. Washington: World Bank.

Larson, Donald F. and Paul Parks. 1999. Risks, lessons learned, and secondary markets for greenhouse gas reductions. World Bank Policy Research Working Paper 2090. Washington, World Bank.

Larson, Donald F., Jock R. Anderson and Panos Varangis. 2004. Policies on managing risk in agricultural markets. World Bank Research Observer 19(2), 199-230.

Larson, Donald F., Julian Lampietti, Julian, Christophe Gouel, Carlo Cafiero, and John Roberts. forthcoming. Food security and storage in the Middle East and North Africa. World Bank Economic Review.

Mekonnen, M.M. and A.Y. Hoekstra. 2010. A global and high-resolution assessment of the green, blue and grey water footprint of wheat. Hydrology and Earth System Sciences 14, 1259-1276.

Skoufias, Emmanuel, Sailesh Tirwari, and Hassan Zaman. 2011. Can we rely on cash transfers to protect dietary diversity during food crises? Estimates from Indonesia. World Bank Policy Research Working Paper 5548. Washington: World Bank.

USDA. 2011. United States Department of Agriculture, Foreign Agricultural Service, Production, Supply, and Distribution Database.

Wodon, Quentin and Hassan Zaman. 2010. Higher food prices in Sub-Saharan Africa: poverty impact and policy responses. World Bank Research Observer 25(1), 157-176.

World Bank. 2012a. Development Data. Washington, World Bank.

World Bank. 2012b. Global Economic Monitor, Commodities. Washington: World Bank.

Tables and figures

Table 1: Selected wheat statistics, average 2005-07

	Net trade (imports-exports) thousand tons	Domestic consumption thousand tons	Imports share of consumption percentage	Average share of calories from wheat percentage	Prevalence of child stunting percentage
Algeria	5,405	7,883	69	46	15.6
Bahrain	27	27	100	—	9.0
Egypt	7,569	15,267	50	35	30.7
Iran	510	15,200	3	43	16.6
Iraq	3,772	6,209	61	—	27.5
Jordan	848	830	102	38	8.3
Kuwait	294	294	100	23	3.8
Lebanon	313	450	69	30	15.0
Libya	1,430	1,455	98	40	21.0
Morocco	2,673	7,075	38	41	21.6
Oman	147	147	100	—	9.6
Saudi Arabia	85	2,500	3	27	-
Syria	-556	4,306	-13	39	28.6
Tunisia	1,596	2,933	54	48	9.0
United Arab Emirates	514	514	100	29	-
Yemen	2,166	2,311	94	38	59.6
MENA	26,793	67,404	40	39	
Rest of the World	-26,793	548,788	-5	19	

Notes: Estimates of the share of daily calories derived from wheat are taken from FAO (2012b). Data on stunting from Breisinger, Ecker, Al-Riffai and Yu (2012). The remaining data are from USDA (2011).

Table 2: Renewable water resources and agricultural water use in MENA, 2009

Country	Agriculture's share of freshwater withdrawals (percentage)	Renewable internal freshwater resources per capita (cubic meters)
Algeria	63.95	321.89
Bahrain	44.54	3.42
Djibouti	15.79	344.00
Egypt	86.38	22.58
Iran.	92.18	1756.97
Iraq	78.79	1132.17
Jordan	64.96	115.30
Kuwait	53.87	-
Lebanon	59.54	1,143.68
Libya	82.85	95.81
Morocco	87.38	916.72
Oman	88.42	516.20
Qatar	59.01	35.049
Saudi Arabia	88.00	89.52
Syrian Arab Republic	87.53	355.92
Tunisia	75.96	401.84
United Arab Emirates	82.84	21.62
Yemen	90.74	90.02

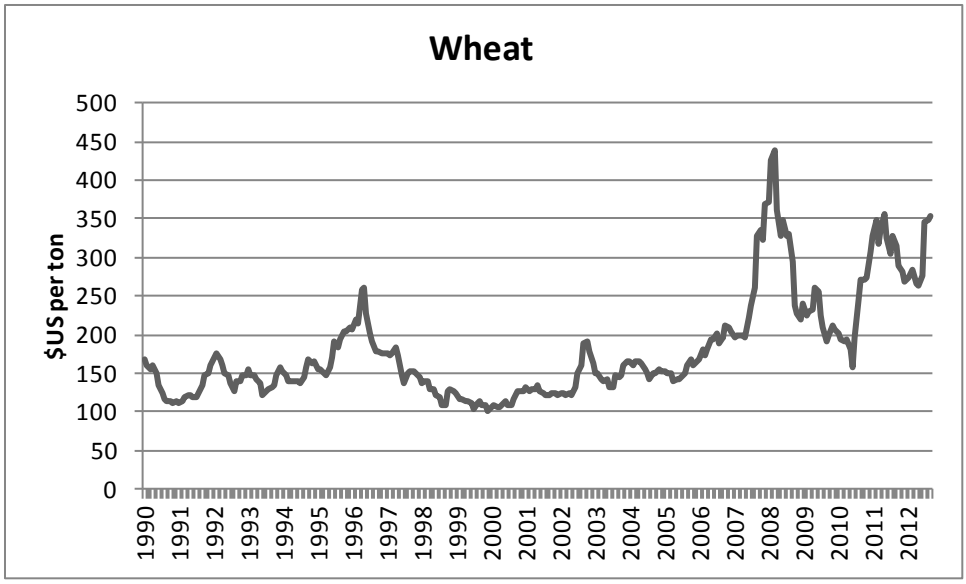
Source: World Bank Development Data (2012a)

Table 3: Policy outcomes and costs

Policy and outcome	Average annual program costs	Annual domestic blue water demand
Targeted subsidies protecting 40 percent of the population against price spikes. Risk of supply chain disruptions remain.	$US 53 million	36.4 billion m^3
Extend the above program to cover 100 percent of population	$US 142 million	36.4 billion m^3
A strategic storage policy that caps domestic wheat prices, reduces wheat price volatility by 1.83 points, and guards against unlikely but dangerous extended supply disruptions.	$US 959 million	36.4 billion m^3
Self-sufficiency and a 9-point reduction in the CV of wheat production		61 billion m^3

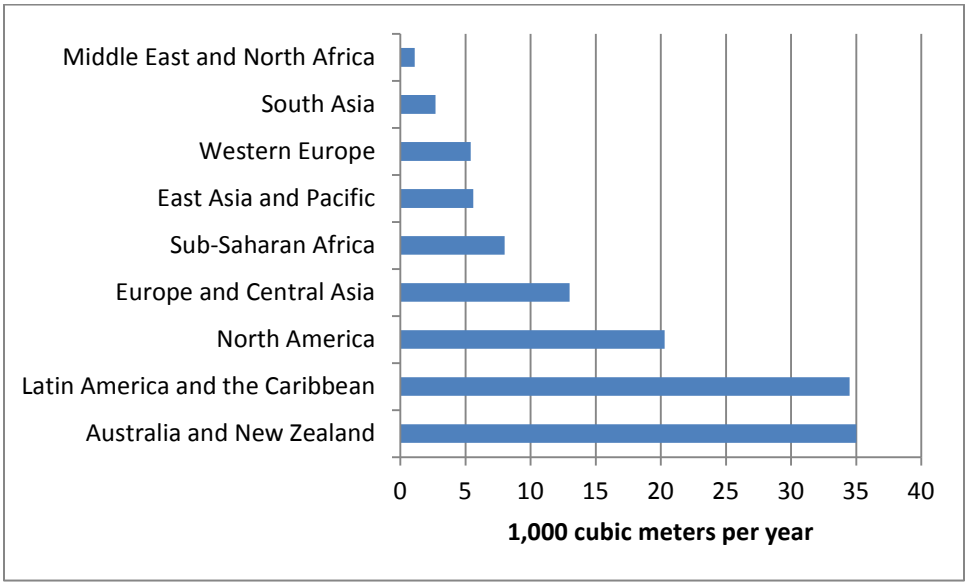
Note: Globally, importing a ton of wheat into MENA results in a net savings of 882 m^3 of blue water and 321 m^3 of grey water, offset by a net increase of 1,944 m^3 of green water. See Larson et al. (forthcoming) for a full discussion of the model and simulation results.

Figure 1: Monthly hard red wheat prices, January 190 to November, 2012



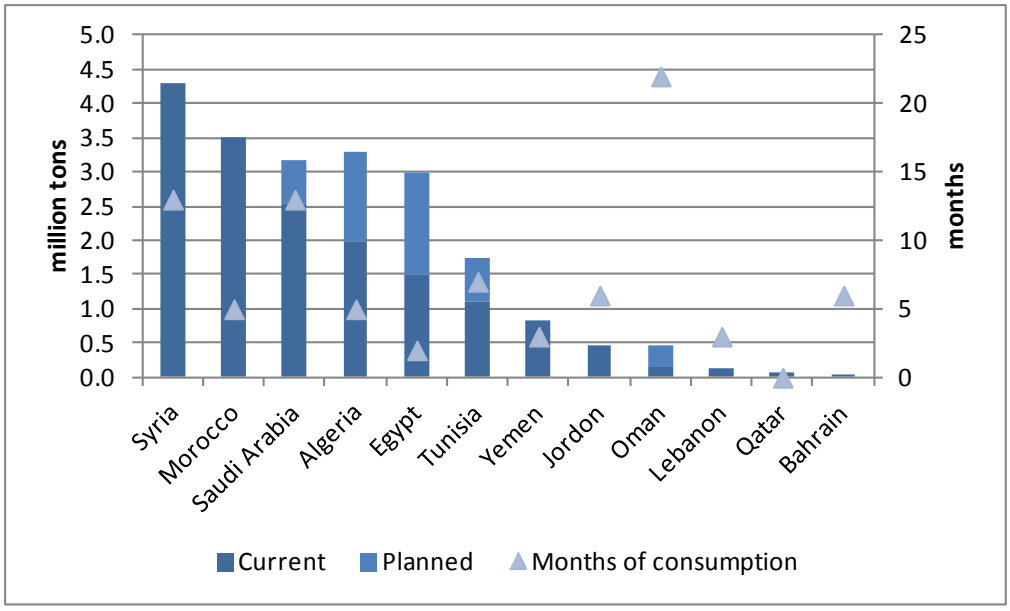
Source: World Bank (2012b)

Figure 2: Renewable water resources per capita, by region.



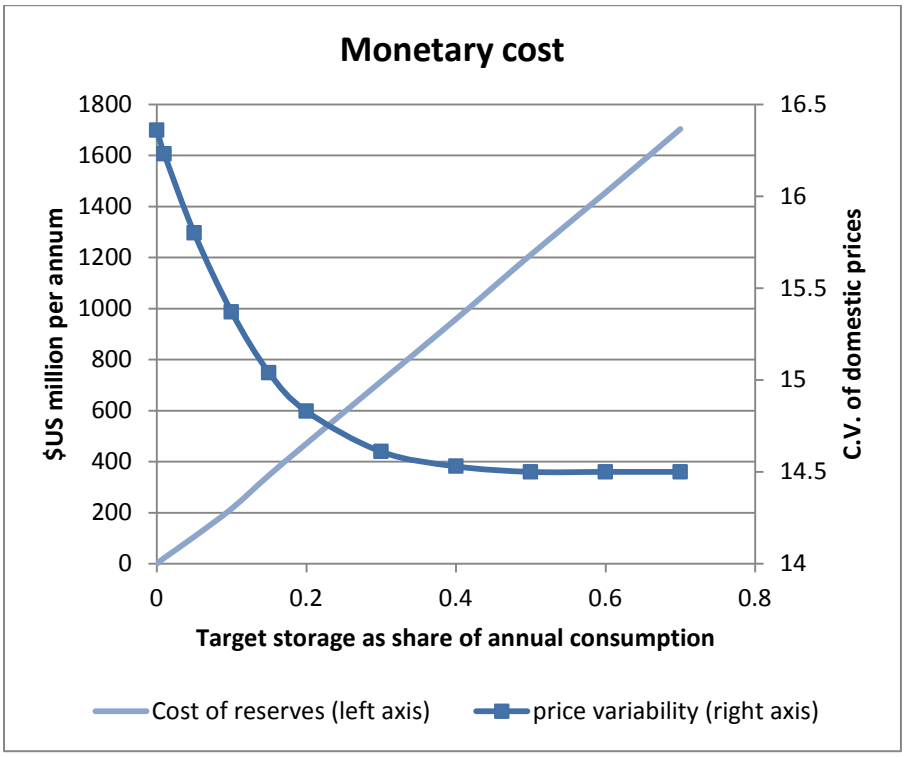
Source: FAO (2012a) AQUASTAT data for 1998-2002.

Figure 3: Planned and existing storage.



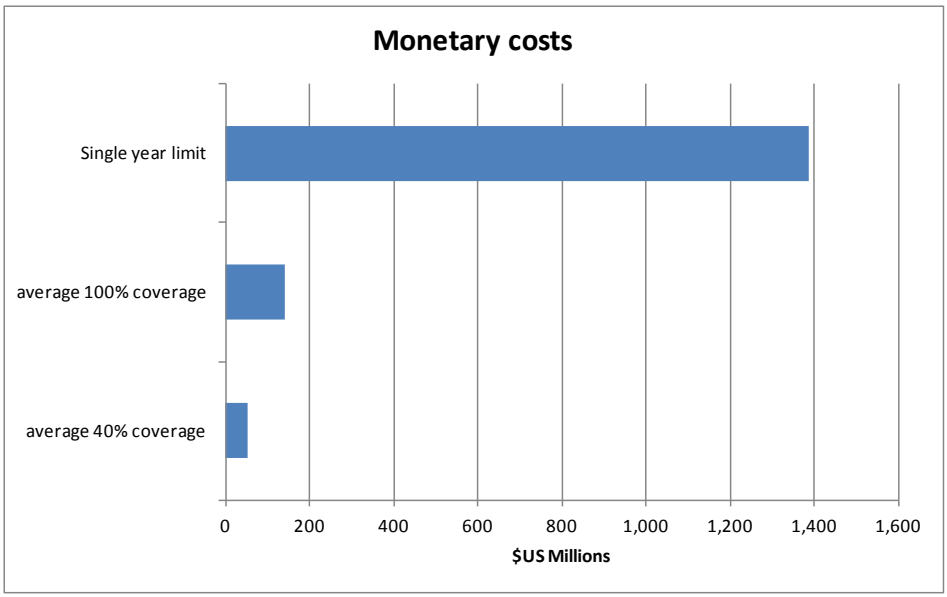
Source: Lampietti et al. (2011)

Figure 4: Strategic storage levels, reductions in price volatility, and program costs.



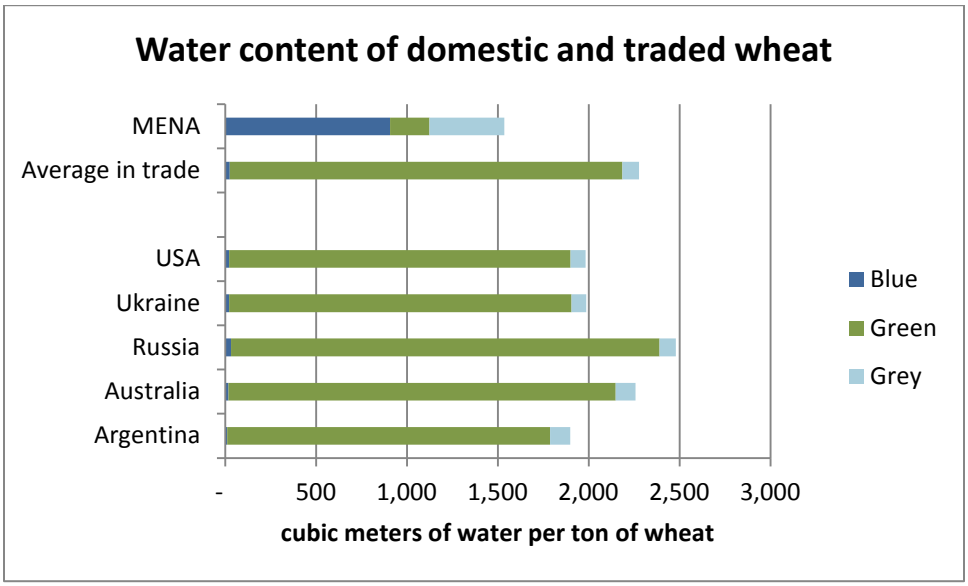
Source: Larson et al. (forthcoming).

Figure 5: Average and extreme program costs for targeted subsidies.



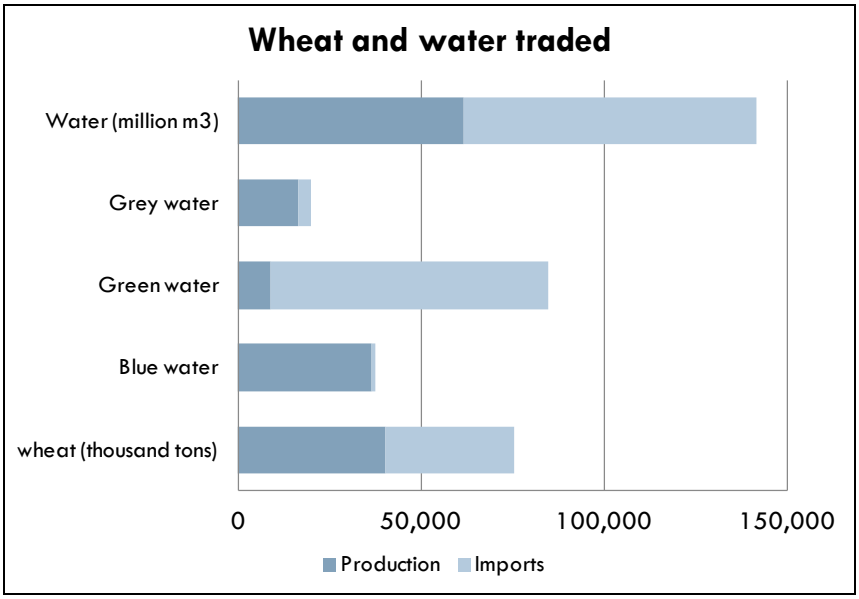
Source: Larson et al. (forthcoming).

Figure 6: Water content of domestic and traded wheat



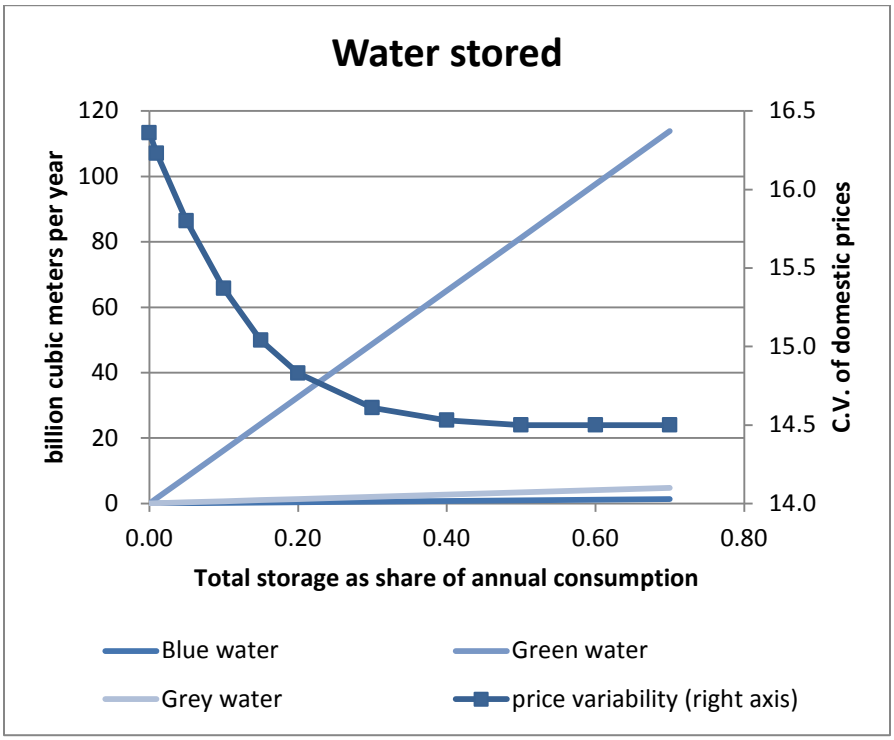
Source: Mekonnen and Hoekstra (2010). Note: value for MENA based on measures from Egypt.

Figure 7: Water content of domestic and traded wheat



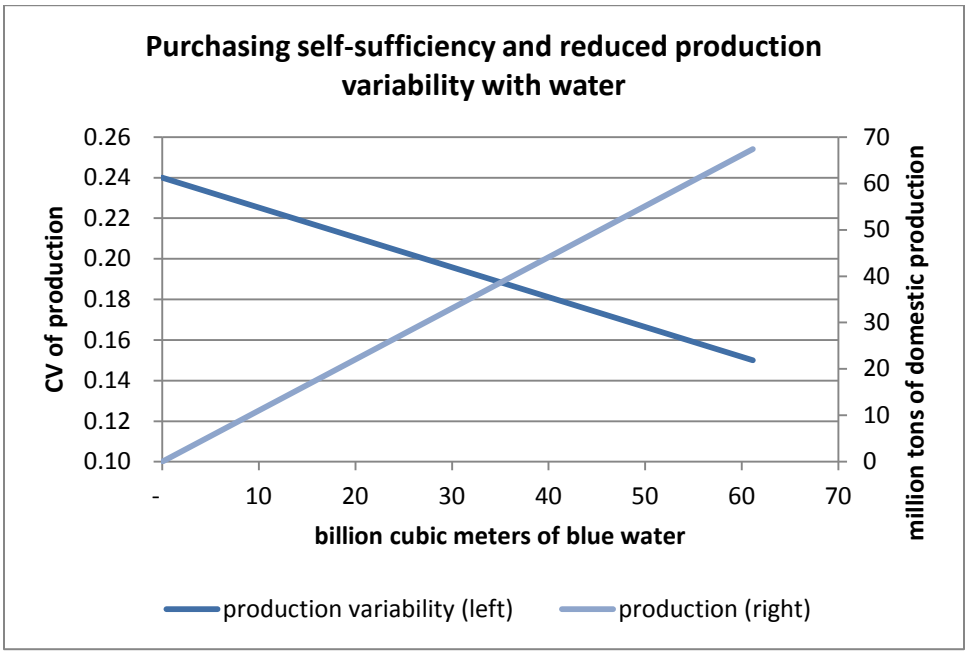
Source: Mekonnen and Hoekstra (2010), Larson et al. (forthcoming) and author's calculations.

Figure 8: Water content of domestic and traded wheat



Source: Mekonnen and Hoekstra (2010) and author's calculations.

Figure 9: The blue water cost of buying self-sufficiency and reduced production volatility.



Source: Assefa, Yared, Kraig Roozeboom, and Chuck Rice (2012), Mekonnen and Hoekstra (2010) and author's calculations.