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Climate Change and Increasing Aridity: The Fate of Agriculture and Rural Communities in the Middle East and North Africa

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Introduction

This paper reviews options for confronting the increasing aridity expected in the Middle East and North Africa (MENA) region as climate change progresses during the next century and as these changes affect agriculture and rural communities. The agricultural sector remains by far the largest user of water in the region, and it is certain to suffer from a significant decline in water availability. That decline will greatly reduce the welfare of those dependent on agriculture unless important measures are taken to improve water use efficiency, enhance economic growth, and directly attend to the needs of rural residents. Our paper assumes a goal of improving economic and social welfare, with particular interest in safeguarding the welfare of the poor, who are disproportionately employed in agriculture and/or are residents in the rural communities that depend on agriculture.

The MENA region is the most water-scarce region of the world, where scarcity is measured as the volume of water available annually to each resident. Total actual renewable water resources (TARWR) in the region averages less than 1,000 m^3 per year per capita. As shown in figure 8-1, 15 of 21 MENA countries fall below this level, with many falling well below. While 6 of 21 countries have more than 1,000 m^3 per capita per year, three of these countries have declining TARWR levels that are likely to soon fall

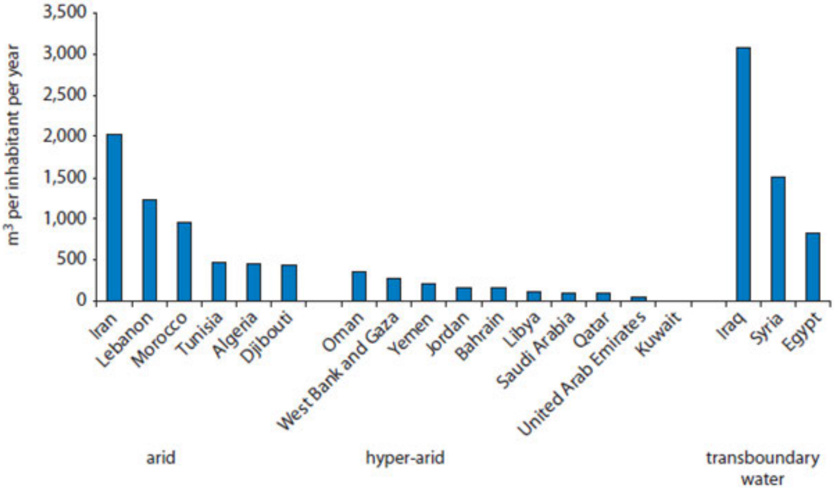

Figure 8-1. Total actual renewable water resources per capita in the MENA Region.
Source: World Bank 2007.

below 1,000 m^3 as their populations increase (see table 8-1). MENA countries vary in terms of the sources of their water supply, the nature of water demand, and their economic resources, reflecting different levels of human and institutional development. Thus, some countries are better situated than others to confront the problems faced.

Climate change is expected to increase average temperatures, decrease precipitation, increase extreme climate events, and raise the Mediterranean Sea level, causing loss of coastal agricultural areas. Water availability will decline from traditional sources such as precipitation, surface catchment and storage, and underground aquifers. Simultaneously, population growth will increase the number of water claimants. As water availability shrinks and urban demand increases, history suggests that the amount of water available to agriculture and rural communities will decline. This is the harsh reality that must be faced. The question is how best to face this challenge.

The MENA region has competent water institutions and an extensive water infrastructure. However, policy has focused on increasing water supply rather than on managing water demand. This policy is no longer adequate. The opportunities for supply enhancement are decreasing, i.e., the cost of new water supplies is rising, even if desalinization and wastewater treatment can help provide additional sources for specific needs. We argue that the MENA region will benefit greatly from implementing water

Table 8-1. Total actual renewable water resources 2008–2012

	TARWR (10^9 m^3/yr)			TARWR per capita (m^3/inhab/yr)			AFED 2025 predictions
Algeria	11.67	I	2010	329	K	2010	261
Bahrain	0.12		2010	92	K	2010	106
Djibouti	0.30	I	2010	338	K	2010	260
Egypt	57.30		2010	706	K	2010	252
Iran (Islamic Republic of)	137.50		2010	1,859	K	2010	
Iraq	75.61	I	2010	2,387	K	2010	1551
Israel	1.78	I	2010	240	K	2010	
Jordan	0.94	I	2010	151	K	2010	98
Kuwait	0.02		2010	7	K	2010	4
Lebanon	4.50		2010	1,065	K	2010	919
Libya	0.70	I	2010	110	K	2010	67
Morocco	29.00	I	2010	908	K	2010	558
Oman	1.40	I	2010	503	K	2010	365
Occupied Palestinian Territory	0.84	I	2010	207	K	2010	
Qatar	0.06		2010	33	K	2010	40
Saudi Arabia	2.40	I	2010	87	K	2010	64
Sudan and South Sudan	64.50	I	2010	1,481	K	2010	1122
Syrian Arab Republic	16.80		2010	823	K	2010	550
Tunisia	4.60		2010	438	K	2010	373
Turkey	213.60		2010	2,936	K	2010	
United Arab Emirates	0.15		2010	20	K	2010	20
Yemen	2.10	I	2010	87	K	2010	120

Note:

I = AQUASTAT estimate

K= Aggregate data

and economic reforms to allow market forces to play a larger role guiding resource allocation, e.g., in crop production and water use in general. These reforms would create economic signals at the farm level to shift agricultural resources toward higher-value export crops, which are also more management and labor intensive. Simultaneously, economic reforms would create signals at the firm level in urban areas, leading to more rapid economic growth that would create attractive employment for rural-to-urban migrants. Although economic reforms would facilitate an agricultural transformation that leads to higher-value crops and that increases labor productivity, this transformation may not fully offset the loss of jobs that will occur as water scarcity rises. Regardless, it is unlikely that agriculture can absorb the additional workers that will appear in rural areas as a result of population growth. Thus, in addition to efforts to increase agricultural productivity, policy measures to facilitate rural-to-urban migration are essential if rural poverty is to be relieved. However, urban growth alone is insufficient. Policy changes to spur investments in agricultural and rural communities are essential.

Rising agricultural productivity and successful rural-to-urban migration will not be achieved unless education is improved and water demand management becomes a focus of policy in both rural and urban areas. Education must be improved for rural residents, as enhanced human capital will be a key input in modernizing agriculture and a requirement for obtaining productive employment in the urban sector for those who migrate. If water is used more efficiently throughout the economy, more can be produced from the scarce water available. Using water more efficiently in industry and in households will also free up more water for use in agriculture. Greater use of pricing mechanisms will be needed to achieve more efficient water use. The introduction of water pricing mechanisms will be politically difficult, but using water prices that increasingly reflect the opportunity cost of water is essential for achieving longer-run success.

Reform will be difficult, but the alternative to reform is bleak. Without economic reform, the economy will grow more slowly, fewer urban jobs will be created, and those jobs will be less productive. The urban-industrial sector will absorb more water regardless as the urban population grows, and the water available for agriculture will decline more sharply. Historically, whenever urban areas have lacked water, policy-makers have immediately reduced water supplies for agriculture. In this situation, agricultural regions will produce less, generate less income, and offer fewer and less productive jobs, and the rural poor will be poorer and many will not have the resources to migrate successfully to urban areas.

This paper first presents evidence of increasing water scarcity in MENA countries and its likely consequences for agriculture and rural communities. We then explain why water-sector reform is necessary, why water reforms must also be accompanied by broader economy-wide reforms, and why establishing safety nets for poor farmers, agricultural workers, and investments in key rural communities are also essential. We end by recognizing the political challenges to this agenda and also the absence of good alternatives.

Predictions for Growing Water Scarcity

The MENA region is well known for having focused its efforts on increasing water supply. These efforts have successfully increased water availability, but at ever-rising cost, through the creation of dams and other catchment facilities for surface water and the exploitation of groundwater aquifers, including the construction of long-distance water conveyance and water distribution systems. More recently, major efforts are being made to increase treatment of wastewater for use in agriculture and desalinization for urban water consumption. Desalinization is becoming cheaper, making it another option, though water from the most efficient systems remains expensive at roughly \$0.50 per m^3 and is thus not economically viable as a general supply for agriculture.

Three major factors are causing increasing water scarcity: population growth, a need to reduce aquifer overdrafts, and climate change. Population growth is currently about 1.8% annually (UN) and is predicted to decline only gradually. If population grows at an average rate of 1.3%, population will nearly double within 50 years. Rising population implies that water per capita will decrease sharply unless more water can be found.

Unfortunately, water availability is expected to decline, not increase. The MENA region has steadily increased groundwater extraction, but many of the aquifers contain fossil water and enjoy little to no recharge. The MENA region is already suffering from over-extraction of groundwater aquifers and aquifer water contamination due to saltwater and/or sewage intrusion in some regions (Shetty 2006). Thus, many MENA countries are seeking to reduce rather than increase groundwater extraction. [Increasing supply from groundwater extraction has reached its limit.]

Climate change will cause acceleration of the hydrologic cycle that will also reduce the availability and the quality of water resources. Increasing surface temperature and declining rainfall will cause a decrease in surface water and a declining water table for groundwater. Rainfall will become less predictable, with greater frequency of drought and a higher probability of desertification in some regions, and, ironically, a higher probability of extreme climate events that will include flooding. Climate change will cause the Mediterranean Sea to rise, increasing coastal flooding and salt-water intrusion in coastal agricultural lands (Shetty, 2006; Sowers, et al., 2010).

Climate models predict a major reduction in precipitation in the MENA region, e.g., an average 10 to 25% decline by the end of the twenty-first century (UNDP 2007/08; Suppan et al. 2008). The effect is expected to be most severe in the eastern Mediterranean. The decrease in precipitation will combine with higher average temperatures to increase evaporation, reducing water availability to plants by even more. Oroud (2008) predicts the average water yield in Jordan will decrease by 45 to 60% due to a 10% decrease in precipitation and a temperature increase of 2°C, with similar expectations for Syria. Suppan (2008) predicts an increase of up to 4.5°C in mean temperature and a decrease of up to 25% in precipitation by the end of the century, with combined effects leading to a decrease of 23% of the Upper Jordan catchment. The Arab Human Development Report predicts that countries such as Lebanon and Morocco will experience a 10 to 15% decrease in water supply for every 1°C increase in mean temperature. Barghouti (2010) predicts the decline in the per capita TARWR index will be severe even by 2025, with that in Iraq decreasing by 35%, Morocco by 38%, and Yemen by 40%. Clearly, climate change is expected to have a strong negative effect on water and, thus, agriculture.

Water Scarcity and Agriculture

Agriculture varies in its importance across countries in the MENA region. As shown in table 8-2, agricultural value added as a share of GDP is less than 10% in 14 countries, but more than 20% in 2 countries. Six countries

Table 8-2. Share of agriculture 2008–2012

	Percentage of total country area cultivated (%)			Total economically active population in agriculture (1,000 inhab)			Share of agriculture (%)	Agriculture, value added to GDP (%)		
Algeria	3.54	E	2009	3175	E	2010	21	6.92	E	2010
Bahrain	5.00	E	2009	4	E	2010	1	0.86		1995
Djibouti	0.09	K	2009	285	E	2010	74	3.86	E	2007
Egypt	3.68	E	2009	6619	E	2010	25	13.99	E	2010
Iran (Islamic Republic of)	10.88	K	2009	6553	E	2010	22	10.06	E	2008
Iraq	10.91	E	2009	436	E	2010	5	8.57	E	2003
Israel	17.34	E	2009	51	E	2010	2			
Jordan	3.17	E	2009	113	E	2010	6	2.93	E	2010
Kuwait	0.84	E	2009	14	E	2010	1	0.46	E	2003
Lebanon	27.56	E	2009	28	E	2010	2	6.39	E	2010
Libya	1.17	E	2009	71	E	2010	3	1.87	E	2008
Morocco	20.28	E	2009	3008	E	2010	25	15.38	E	2010
Occupied Palestinian Territory	36.05	E	2009	110	E	2010	8	14.34	E	2003
Oman	0.44	E	2009	318	E	2010	29	1.86	E	2004
Qatar	1.29	E	2009	8	E	2010	1			
Saudi Arabia	1.60	E	2009	515	E	2010	5	2.58	E	2010
Sudan and South Sudan	8.14	E	2009	7124	E	2010	52	23.63	E	2010
Syrian Arab Republic	30.59	E	2009	1337	E	2010	20	22.93	E	2009
Tunisia	30.17	E	2009	805	E	2010	21	8.01	E	2010
Turkey	31.00	E	2009	8068	E	2010	32	9.60	E	2010
United Arab Emirates	3.16	E	2009	148	E	2010	3	0.97	E	2009
Yemen	2.75	E	2009	2314	E	2010	39	7.64	E	2010

Note:

E = External data

cultivate more than 20% of their total national area, while 12 countries cultivate less than 5% of total area.

Although agriculture accounts for a relatively small share of GDP in most countries, it accounts for 80% of total water use in MENA countries, reaching more than 90% in six of 19 countries (see table 8-2) Domestic (household) use ranges from 3 to 45%, but in 8 countries household use is less than 10% and in another 7 it is about 20%. These data show substantial scope for increasing water availability to domestic users and industry as population growth and urbanization occur, but with agriculture suffering a significant decline in water availability. For example, when water stress threatened water supply, Israel decreased water allocated to agriculture from 80% to 56% from 1985 to 2003 (Molle and Berkhoff 2006). Jordan, Morocco, and Tunisia have also begun to increase water use efficiency in agriculture and move water from agriculture to industrial and municipal uses (Shetty 2006).

The decrease in water availability will require a reduction in the area planted to crops. The combined effect of scarcer water and higher temperatures will also decrease crop yields. Many crops in the MENA region are already cultivated at the extremes of tolerance to heat and salinity, and yields of these crops are expected to decrease. For example, Eid et al. (2007) predict a decline of 9 to 19% in crop yields for a temperature increase of 2°C, which is the lower limit of temperature increase at the end of the twenty-first century predicted by climate models.

Declining cropped area and crop yields will reduce agricultural employment. Currently, agriculture accounts for a large share of regional employment (28% in Egypt, 44% in Morocco, 50% in Yemen) (WDI database), though the proportion varies widely, being less than 10% in 11 countries, more than 20% in 11 countries, and with 4 more than 30%. It is not unreasonable to anticipate that as water availability declines, agricultural employment will decline as well, even if not fully proportionately. In those MENA countries where agriculture is "small"—whether in terms of the shares of workers employed or output produced—adjustment will be easier if for no other reason than that the displaced workers and entrepreneurs will be a small part of the whole and thus more easily absorbed in other activities. The decline in agriculture, employment, and incomes and in the viability of agricultural communities will create stress, but these countries are more likely to achieve an attractive transition than are countries where the adjustment will be large. In the latter, the number of displaced workers will be greater and they will be a larger proportion of the total labor force. In these countries, there is special incentive to begin planning now for transition.

Rural Communities and Rural-to-Urban Migration

Historically, in the economic development process most of the population is initially employed in agriculture and resident in rural areas. As economic development occurs, higher incomes lead consumers to spend a larger proportion of their incomes on manufactures and services, with consequent increase in the industrial and service sectors that are located mainly in urban areas. Workers in industry usually have higher productivity and earn higher wages than those in agriculture, and those higher wages are one factor causing rural workers to migrate to towns and cities. Accordingly, the proportion of workers active in agricultural activities and/or resident in rural areas steadily diminishes. The movement of workers from less-productive to more-productive jobs benefits both workers and the economy.

The MENA countries have been following a similar path for some decades. However, if agriculture declines as a result of growing water scarcity, rural workers may be "pushed" out of agriculture, moving in search of "any" job, not a better job, and the workers and the nation will be worse off as a result. Migration will be more difficult for those who leave and will be less likely associated with rising productivity and incomes. The remaining rural workers and their communities also will be poorer, and those who migrate to the city may be disaffected and a source of social unrest.

Empirical evidence shows that most workers want to stay where they are if they can (Findlay 2011), and, when migration occurs, many migrants move a short rather than a long distance. Indeed, migrants often do not move to the site that would be most economically attractive, but instead select an intermediate site. For example, about half of all migrants are rural-to-rural migrants in Ethiopia (Dorosh et al. 2011). The selection of destinations is influenced by preexisting social and cultural connections, not just immediate financial gain (Brooks and Waters 2010). We will return to this point subsequently, suggesting that governments should assist with the development of rural towns that can attract local migrants from smaller villages or farms within the same area, while serving as growth poles for the region.

Migration is likely to have two effects on the communities of origin. The poorest members of society are usually the least likely to move. Migrants tend to be the younger and better-educated members of a community, and their departure is likely to reduce the average productivity of the agricultural and rural labor force (Ackah and Medvedev 2010). However, many rural migrants remit income to family members that remain behind, and these remittances can significantly improve household welfare in the community of origin. Policies at origin may also provide financial infrastructure to ease the flow of remittances and to link remittances to financial access at the origin household level (Ratha et al. 2011.)

Migrant households have a higher probability of joining community groups and social networks, increasing the strength of social arrangements such as risk-sharing schemes at origin (Gallego and Mariapia 2010.) Networks help migrants with information, thereby reducing uncertainty and costs, which influences the choice of destination (Chort 2010.) With data from the Mexican Migration Project, Munshi (2003) finds that the size of the destination network increases the probability of gaining employment and expected earnings. Policies in support of migration might include supporting migrant welfare organizations at destination, with particular attention to gender. While male and female migrant networks have the same influence on women's decision to migrate, the destination of female migrants is strongly influenced by the location of female network migrants (Davis and Winters 2001.) Knowledge of these influences can help countries develop more productive and beneficial networks to assist with migration and with the flow of return remittances.

Rural Conflict

Growing water scarcity can become a source of serious conflict within and between rural communities. There is limited evidence this has occurred in the MENA region. For example, fighting has occurred between different tribes in Yemen that appears directly related to conflict over water resources (World Bank 2007). Similarly, there is evidence of a link between violence and environmental degradation in Darfur (Smith and Vivekananda 2007). However, analysis of a broad range of case studies of environmental degradation has led other scholars like Thomas Homer-Dixon to conclude that it is difficult to identify a direct link between scarcity and violence. Factors like inequality and the degree of social inclusion or exclusion seem to influence the nature and degree of conflict when it appears (Lecoutere et al. 2010).

We conclude that most MENA countries have reached a level of development in which rural communities will not dissolve into desperate poverty and conflict as water becomes increasingly scarce. Affected communities will suffer increasing stress, numerous residents will migrate, and those left behind will be poorer and increasingly marginalized. This fate, however, is severe, and policy makers should be motivated to avoid it, particularly as good alternatives exist. Further, there are MENA countries containing regions that could dissolve into desperate poverty if nothing is done.

Urban Sector

Although our focus is on agriculture and rural communities, the growth of urban population and industrialization is increasing urban water demand and thus will affect the water available for agriculture. Urban areas use less than 10% of the total water available, but their water use is rising rapidly. Potable water and sewerage services must be extended, and doing so will further increase demand on the declining supply of water. A significant number of urban residents in the MENA region still do not have household access to potable water or to sanitation services. The World Bank suggests that significant progress has been made to provide drinking water and sanitation services within the region, including in rural areas, but that important gaps still remain in infrastructure coverage, with roughly 30 million people in the MENA region lacking water services and 69 million lacking basic sanitation. In addition, facilities often function well below design capability or not at all (World Bank 2007).

To provide a simple example, assume a country has 100 units of water, of which 90 units are used by agriculture and 10 units used by the urban sector. Assume that the water available decreases to 90 units as a result of climate change, while the urban sector increases its demand to 20 units. In this case, assuming urban demand is met, agriculture will have only 70 units, a decrease of 22%. However, if conservation can limit water use in the urban sector to 15 instead of 20, or if 5 units of urban wastewater can be recycled for use in agriculture, water availability in agriculture would be 75 units, or 7% more. Improving the efficiency of water use in the urban sector, whether by reducing leaks in the distribution system, recycling wastewater, or conserving use in the household and industrial sectors, is an important consideration as water scarcity and urban use increase. As we note in the upcoming section on the effect of water pricing, industrial and municipal water use is considerably more sensitive to price than is agricultural water use, so ensuring that urban water prices reflect true water cost is a particularly important tool to achieve water use efficiency (Rosegrant et. al. 2002).

Increasing the Efficiency of Agricultural Water Use

We have argued that water availability will decrease in the MENA region, a higher proportion of water will be used in urban areas, and considerably less water will be available for agricultural use. Developing additional supplies of water will be increasingly costly. MENA countries thus have strong incentive to increase water efficiency in agricultural uses, reducing losses that occur in distribution, increasing the efficiency of water use by plants, and changing the crop mix to ensure higher value produced per unit of water.

In the past, water policy in many MENA countries has emphasized providing inexpensive water to agricultural users. Countries within the MENA region are large food importers. Food security has been a political concern, and providing cheap water has been a means of subsidizing domestic food production. Providing inexpensive water also has been a means to support the incomes of poor farmers, who often produce traditional crops like wheat, and to reward or benefit a smaller number of wealthy farmers who have political influence. However, allocating water at a low price encourages wasteful use of a scarce resource and is not a sensible policy in the long run. Increasing the role of prices in the allocation of water is an important goal to achieving greater water use efficiency.

Economists encourage greater reliance on "market-based" systems, which lets price play a larger role in determining who receives scarce water and what the recipients do with that water. Theoretically, a higher price of water should lead users to seek ways to use less of the more expensive resource, leading to conservation of the scarce resource. Additionally, the higher price rations water among alternative uses, with water "flowing" to those activities in which it is most productive, e.g., using water to produce crops that produce more value added per unit of water consumes, such as vegetables instead of cereals. However, the introduction of water pricing systems into the MENA countries is controversial. While the higher price should lead to increased efficiency, the higher price also reduces the profits of farmers who must pay for more expensive water, assuming farmers cannot fully pass on the higher costs to consumers. Farmers are thus likely to resist imposition of higher water prices, making the use of water pricing an intensely political issue.

The alternative to a market system is a bureaucratic mechanism wherein authority allocates water based on established criteria. For example, the water authority could dictate that farmers in region A are to receive in a given year (t) a given amount of water liters per are of land cropped (x liters per ha) in year t–1, with no option for trading water. This simple mechanism, however, would lead to problems, two of which can be briefly noted. First, the allocation of water is fixed: farmers who could profitably use more water cannot purchase it, while farmers who receive more than they can use cannot sell it. As a result, less agricultural output will be achieved than would be possible if water could be sold from those who have too much to those that have too little. Second, water authorities are sensitive to political considerations, so that the development of allocative criteria is likely to be influenced by factors other than whether the water is used efficiently in agricultural production, and the criteria may change suddenly if political considerations change. Ultimately, water allocation may have little to do with economic efficiency or social welfare.

In fact, most water systems involve a mix of market and bureaucracy, as the two mechanisms differ in their respective strengths and weaknesses. However, the MENA region has relied heavily on bureaucratic mechanisms, and these are unlikely to perform well in the face of increasing scarcity.

To explore this issue, consider a simple system where a large number of farmers demand water for their farms but the price of water is set at zero. In figure 8-2, the demand curve for water intersects the horizontal axis at Q_D, showing the collective amount of water farmers want to use when the price is zero. The amount of water that is available, Q_S, is well to the left of Q_D. Thus, at a zero price, farmers collectively demand more water than is supplied. The implicit shadow price of the available water is P*, which is much greater than zero. As the scarce water is valuable, everyone wants

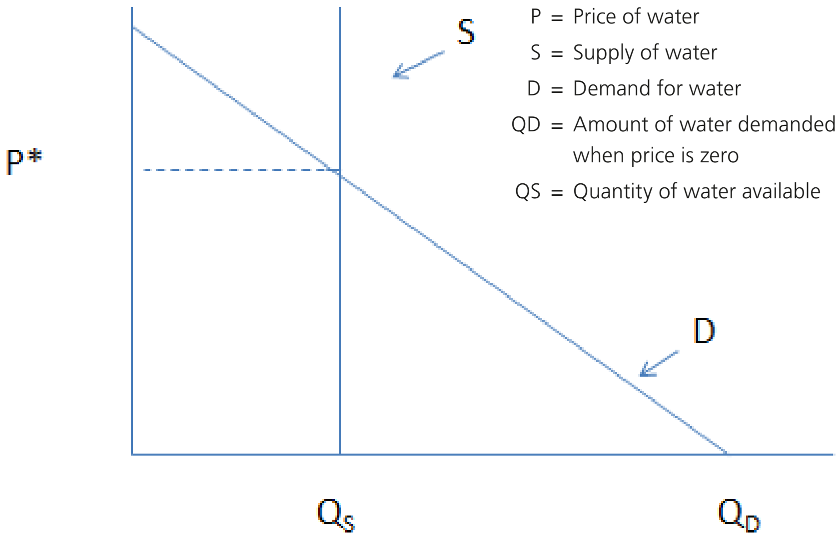

Figure 8-2. A model of a water market with P = 0.

more water when the price is zero. However, if price is playing no role in water allocation, the only mechanism available is bureaucratic authority. The national water agency or some designate must allocate water.

What do we know about allocation by bureaucratic authority? A bureaucracy will establish rules, but these rules will be subject to interpretation and adjustment. Wealthy and poor farmers will compete for the available water using as much influence as they can muster, both individually and in association. Generally speaking, those who are better politically and institutionally connected will get more water. Those who were lucky to receive initial allocations will work consistently to hold on to what they have and, if possible, get more. Further, water holders will do everything possible to frustrate water reforms that would reduce the value of their allocation. As water is worth much more than it costs, water users will be prepared to "pay" a great deal to ensure their allocation is preserved, and this eagerness often leads to bribery and corruption, or simply to wasteful rent seeking. If the water supply declines, decisions have to be made regarding who should be favored and who excluded. Unfortunately, the poor are usually squeezed out.

A market mechanism theoretically allocates water among potential users efficiently, allowing water to move from users whose water use generates little economic value added to those with higher value added. This mechanism may allow small, relatively poorer farmers to achieve access to water. Poorer farmers would generally prefer to receive water, even if at a cost, rather than to be excluded, directly or indirectly by nonmarket mechanisms (Richards 2002). Nonetheless, increasing water prices can have harsh effect on the profits (incomes) of farmers, including small farmers, and they are unlikely to be happy about being asked to pay for water.

Traditional practice in many MENA countries has been to allocate water to agricultural users in a fixed block at a very low price. The low price, which is well below the "shadow" value of water, is an implicit subsidy to users. Regardless of water's current price, farmers who today receive water will not want the price of water to rise. Those who receive water are clearly better off with the lower price. A number of scholars, e.g., Sowers et al. (2010), suggest that it is "impractical to directly price agricultural water for small-scale users in most countries of the MENA for both political and economic reasons." One argument is political infeasibility, i.e., a belief that users have sufficient political influence to make it infeasible for governments to raise the price. They argue, citing Richards (2002) that when the price of water is low, profits are higher and the higher stream of profits is capitalized in land values. Sowers et al. argue that farmers will fight harder to avoid an increase in water prices because it will reduce the price of the land in addition to reducing their annual profits.

Effects of Higher Water Prices

Will higher prices achieve water savings? How will users respond to higher prices in the short run and in the long run? Rosegrant et al. (2002) present evidence from multiple studies suggesting that the price elasticity of water use in agriculture is about –0.09 in the MENA region, indicating that higher prices will induce water savings. A study by Rosenberg, Howitt, and Lund (2008) found a similar price responsiveness in Jordan, where a 10% increase in the price of water was estimated to reduce water consumption in agriculture by 1% over five years. There may also be thresholds for changes in water prices, with little or no change up to some level and significant changes for price increases above that threshold. Rosenberg et al. show that larger increases in water prices could be fully justified by efficiency concerns and would also produce much larger gains in water conservation and efficiency. Given that water prices are so low, prices in many countries of the MENA region might double and still remain low relative to their shadow prices. If so, fairly modest absolute increases in water prices might lead to important water savings on a national scale.

If water prices must increase, how can farm income be cushioned, particularly the incomes of poor farmers? One approach that has been suggested is to charge farmers a low price for a volume of water that is somewhat smaller than what they have previously used and then allow farmers to purchase a limited additional amount at a new, higher price. This approach largely protects farmers' incomes, while causing them to face a higher price for water used at the margin. The higher incremental price should encourage them to use the last units of water more efficiently. Further, farmers also might be allowed to "sell" some of their water back to the water authority at the higher price, making any returned water available for reallocation.

Wealthier farmers having larger and more profitable farms might be charged a higher price for the base allocation of water, as there is no income distribution justification for allowing them to pay a low price. Moreover, larger farmers may find it more profitable than poorer farmers to purchase additional water. Thus, if agricultural water is priced and the market is allowed to determine some part of overall water allocation, some water will likely flow from poorer farmers to larger farms—and this is more likely to occur as the price of water decreases. This is a powerful reason for substantially increasing the price of water for larger, wealthier farmers. However, the price of water ought not to exceed its opportunity cost to any farmer.

Even where users do not hold formal water rights, users are likely to view the allocation of a block of water at a low price as the granting of a quasi-property right over the water. Once granted, it can be increasingly difficult to change that allocation in the future. Thus, governments should be clear in their announcements if they plan to continue to change the water allocation and/or the price of the water allocated in the future. Announcing plans makes it easier for opponents of policies to lobby against them, but transparent policies are generally easier to defend and create greater certainty among users.

We have emphasized the importance of introducing a greater role for water prices within systems that are largely bureaucratically determined. It is worth mentioning that some countries have water systems in which markets play a larger role. For example, in part of the United States, Australia, and Chile, water is partly or largely a private good that can be freely traded in markets. Theoretically, the price of water will adjust to supply and demand, with a higher price simultaneously encouraging water development and conservation, while ensuring that water flows from lower- to higher-value uses. Equally important, a water market allows this process to work through the actions of many individual water sellers and consumers, who, making their own welfare-improving decisions, allow for a more efficient aggregate water allocation, which increases overall welfare.

Water markets have generally produced more efficient water allocations than have bureaucratic systems. Nonetheless, water markets are difficult to implement and do not fully escape the need for regulation (bureaucratic authority). Water use can create strong externalities, which means that one person's use affect's another person's use through non-market channels. When externalities exist, reliance on the private market does not produce fully efficient results. If the externalities are small, the market may still provide a better result than can be achieved by a water users association or government intervention. If the externalities are large, some type of collective action is likely to be better. These externalities include the case where multiple users extract water from a common aquifer and each party has incentive to extract water more rapidly than is collectively efficient. Similarly, because of return flows, changes in water use by some users may significantly affect the water rights owned by others downstream. There is also the difficulty of understanding the effect of groundwater extraction on water availability and water quality, and studies of these effects are unlikely to be carried out by private users who individually extract only a small portion of the water. Finally, environmental water uses are unlikely to receive attention within a market system unless water is specifically set aside by government decision. Thus, even when greater reliance on water markets is sought, regulation and coordination is needed.

Therefore, implementing a comprehensive water market might not be the optimal solution for MENA countries, but allowing price to pay a larger role in water allocation is highly important. Further, it will be useful to increasingly involve farmers in water management as a means of educating them regarding the importance of water management and the collective need to use water more efficiently and to achieve their input, as users, in the design and management of water systems (see Tutwiler 2009).

Agricultural and Economy-Wide Transformation

Wheat has long been the largest crop in terms of area and water use in the MENA region. However, the MENA region has a comparative advantage in higher-value crops such as fruits, vegetables, nuts, and olives, provided these can be produced to meet the high quality standards of European countries. Similarly, horticultural products can and will be produced only if farmers receive high prices for horticultural products and access to modern technology, and if farmers and labor are adequately skilled and motivated. Producing horticultural crops for export will also require development of a much-improved supply chain. This includes postharvest technologies, transportation, and communications, but also marketing, contributing to ensure product condition and its timely arrival to market. While more difficult to produce, horticultural crops would allow farmers to produce substantially higher value added with their resources, which will become increasingly important as the amount of water available is shrinking. Horticultural products use more water per hectare of cultivation than do cereals, but they are also more labor intensive, offering opportunity to employ more labor and generate more income, both on and off the farm, than do current crops. Thus, the switch to horticultural crops is likely to lead to a still further decrease in acreage planted than would be caused by the decrease in water availability, but it should also increase total agricultural output and employment relative to the alternative. Altering the cropping mix and upgrading management and labor skills are important steps if the MENA countries are to maintain agriculture as a competitive and dynamic sector.

The World Bank has recently argued that water reforms and economic reforms must be carried out simultaneously in the MENA region. Economic reforms are fundamental if water reforms are to be effective. The argument is persuasive. Water reform will encourage farmers to use water efficiently from a national perspective only if farmers face appropriate prices for inputs and outputs. Without economic reforms that would remove major existing economic distortions in international trade, energy pricing, real estate, credit, and other areas, farmers will not have the motivation to shift water use from low-value to high-value crops. Cropping choices play a key role in water use, and cropping choice is much more affected by crop prices than by water prices (World Bank 2007). Producer subsidies for wheat, which are closely related to food concerns, ensure that large amounts of water are used for low-value crops. This limits the water available for other crops that are considerably more valuable.

For example, many countries in the region maintain agricultural policies that encourage the use of water for cereal production. Although these policies were originally designed to promote food security and support the incomes of relatively poor farmers, they also encourage inefficient use of water. The MENA region does not generally have a comparative advantage in extensive cereal production. However, cereal production provides a livelihood today for a large proportion of the agricultural workforce in several countries. Because 70% of the region's poor people live in rural areas, and current unemployment rates in many MENA countries are around 15%, removing price supports for grains and/or increasing the price of agricultural inputs, including water, will be politically difficult. However, direct income transfers or other mechanisms should be more efficient ways to transfer benefits to vulnerable populations than the use of water subsidies. Furthermore, government support for wheat and other crops also encourages farmers to over-irrigate. Subsidized credit for agricultural investment encourages investment in boreholes, which encourages over-drafting of aquifers, while subsidized energy reduces the price of pumping groundwater, making it profitable to pump even from great depth.

Previous studies (World Bank 2001; Shetty 2006.; World Bank 2007; Pishbahar 2001; Muaz 2004) have found that MENA countries have a comparative advantage in a wide range of fruits, nuts, and vegetables, as well as cotton and potatoes. Such advantage occurs partly because their harvest occurs in different months than the countries to which they would export. The World Bank estimates that fruit and vegetables offer higher returns to land and water than do field crops such as cereals. Wheat produces about \$0.05 per m^3, while vegetables produce about \$0.50 per m^3, or 10 times as much. High-value export crops also generate more employment than do traditional crops such as cereals, which have low labor requirements, particularly when modern farming techniques are applied. Figure 8-3 shows that horticulture in Morocco uses nine times more labor than does traditional cereal farming (World Bank 2007).

If the MENA countries are to move into the production of higher-value horticultural products, farmers must have incentives to modernize agriculture, including the financial incentives to carry out such modernization. Purchasers of agricultural output, such as supermarkets, now require

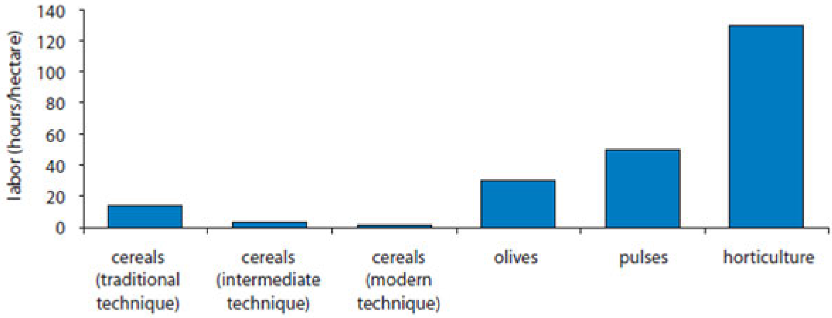

Figure 8-3. Labor requirements of Moroccan agriculture.
Source: World Bank 2007.

consistent, high-quality products and reliable, timely delivery based on longer-term contracts (Shepherd 2005; Codron et al. 2004). It will be difficult for smaller, less-well-capitalized, and less-skilled producers to satisfy these requirements, placing still greater pressure for land and enterprise concentration. These will create difficult dilemmas for governments.

Several economic studies have concluded that progressive trade liberalization should significantly affect agriculture in the MENA region (Lofgren et al. 1997; Radwan and Reiffers 2003; Roe et al. 2005 as cited in World Bank 2007). As indicated above, trade liberalization should raise the domestic prices and exports of fruits and vegetables while lowering cereal prices and increasing cereal imports. However, this process would be politically complicated, as the liberalization process would benefit consumers (who would consume cheaper imported wheat) and larger, more modern, better-capitalized farmers (who would more easily move into fruit and vegetable cultivation), while small farmers might lose, as they currently produce much of the wheat and are expected to have greater difficulty moving into the technologically more complex and more capital-intensive fruit and vegetable cultivation). The impact on farm labor is difficult to determine. As fruit and vegetable cultivation is more labor and skill intensive, one would anticipate that rural employment would increase. However, as fruit and vegetables are also more water intensive, and as water availability will decline sharply, output may sufficiently reduce the area planted to counteract this effect, reducing total labor use.

If employment declines even if economic reform occurs and if total water availability decreases as a result of climate change and the need to reduce aquifer over-drafting, rural communities could face declining employment opportunities in even the best economic scenarios. Income might increase, but the higher incomes might be earned by larger farmers, more-skilled agricultural workers, and urban entrepreneurs and workers engaged in activities such as input supply, transport, marketing, and finance. Smaller rural communities might contract and wither, with larger towns becoming poles of attraction. In these larger towns and smaller cities, the growing population and rising level of commerce and services might create thriving communities, even as the water availability declines. However, it appears this scenario could materialize only under certain conditions.

If reforms lead to downward pressure on the incomes of poor small farmers and agricultural workers, and if the countervailing growth in urban industrial employment is relatively slow, great pressure will arise to reduce or reverse the reforms. Some will call for the subsidization of water and the reimplementation of protection for production of wheat. If modern, exporting horticultural producers can provide an offsetting influence, the policies may largely survive, but they will be more likely to do so if the government can develop support policies for farmers and workers who suffer. In the longer run, reforms will raise income and employment in the MENA region. Note again, however, that the MENA countries face a growing, severe crisis as a result of declining water availability. Although the reforms we suggest may not fully solve the crisis in rural areas, these areas are likely to be far better off if the reforms are implemented well than if they are not. In the absence of such reforms, economic and social progress will be definitively slower. Nonetheless, the short run costs of reforms appear significant, and careful planning is required if these reforms are to be successful.

Conclusions

This paper analyzes the effects of growing aridity on agriculture, farmers, and rural communities in the MENA region. To do so, we have attempted to place these effects within a broader context. We argue that economic and water reforms will permit more-efficient use of scarce water, shift agriculture toward higher-value crops, increase rural income and employment, and increase the national rate of economic growth. These reforms are especially crucial determinants of rural welfare. However, these sector- and economy-wide policies are insufficient to achieve rural prosperity given the major impact that the decline in water for agriculture will have. Specific policies to increase human capital in rural areas and increase the socioeconomic viability of selected rural communities will also be crucial elements of a successful policy agenda.

Climate change will contribute to growing aridity in the MENA region. Declining precipitation and rising temperatures will combine with the need to reduce or cease overdrafting of aquifers to significantly reduce water availability in most countries during coming decades. Population growth will further reduce water per capita. The urban industrial sector will grow, and rising incomes will lead to higher water demand. With less water availability and higher urban demand, agriculture—always the residual user—will receive less water.

As water availability declines, agricultural production and employment will also decline, and rural communities that overwhelmingly depend on agriculture as an economic driver and for cultural orientation will suffer greatly unless major reforms are implemented and specific countermeasures are taken. The welfare of rural residents is quite vulnerable. It is essential that water and broader economic reforms be implemented.

Economic reforms must be designed to remove subsidies for low-value crops like wheat and allow higher prices for high-value crops like fruits, vegetables, and nuts. Reforms are also needed to allow farmers access to modern technology at competitive prices. Water reforms must be implemented to induce gradual changes in water use efficiency at the farm level. The water reforms must include some price mechanisms to encourage greater water efficiency by users. These price mechanisms can be tailored, e.g., by providing block water grants that have a low initial prices for a base allocation and higher prices for incremental water use. This approach can ease the income effect on farmers of rising prices, while forcing farmers to face higher prices for incremental water use. It makes sense for water prices to rise over time, allowing for adjustment and also taking account of growing scarcity. However, it would be useful to publicly forecast the rise in prices to the level that the government intends to implement in order to achieve greater certainty in expectations. Thus, future water prices might be specified similarly to the way countries have published future foreign exchange rates, i.e., a crawling peg.

Broader economic reforms will also stimulate more-efficient industrial growth, thus absorbing more people who must migrate from agriculture.

The economic reforms must include adjustment in the exchange rate to an equilibrium level and adjustment in tariffs and quotas to bring input and output price ratios into alignment with border prices. These reforms should increase the rate of economic growth and overall employment, though some studies suggest that they may not increase agricultural employment. Worse, there is the possibility that reforms will reduce the welfare of poor farmers and some agricultural workers as they benefit wealthier farms with greater access to land, capital, technology, and a greater ability to respond effectively to changing market conditions. Thus, while it appears that reforms are a crucial aspect of the region's ability to effectively meet the challenge of declining water availability while still prospering, the reforms will not be easy to implement. To ensure that policies are well designed, it will be useful to involve rural leaders and residents in the planning and implementation of policies. Involving farmers in the implementation of water reforms will also be especially important.

Moreover, still more action will be needed to relieve the expected severe pressure on small farmers and rural communities. Without other policy elements, many people in rural areas will remain impoverished. Given the macro context described, considerable investment will be needed in rural communities to facilitate agricultural development and counterbalance the harsher socioeconomic effects of transition by improving other aspects of rural life. Emphasis is needed on education, health care, finance, communications, transportation, and cultural opportunities that will support thriving rural communities, facilitate agricultural modernization, and allow successful rural-to-urban migration. These investments will improve welfare while also improving labor productivity and rural residents' ability to migrate successfully. Because resources are limited, it will make sense to concentrate investments and services in larger rural towns, where the return to investments will be higher. Such communities can serve as poles of attraction for people migrating from nearby smaller communities. This process, if successful, will allow more migrants to maintain their occupations and their connection with friends, family, and place. Agricultural modernization, when combined with the development of complementary commerce and services, can also contribute to improving the quality of life in these rural communities.

Water is becoming increasingly scarce within the MENA region. Population growth, a need to reduce the use of underground water sources that

Selected Water-Related Statistics for the MENA (FAO-Aquastat 2010, except for AFED predictions)

Table 8-3. Water withdrawal 2008–2012

	National Rainfall Index (NRI) (mm/yr)			Dependency ratio (%)			Fresh groundwater withdrawal (10^9 m^3/yr)			Share of agricultural water from total withdrawal (%)		
Algeria	242	E	1998	4	I	2010				64	L	2000
Bahrain				97		2010	0.24		2003	45		2003
Djibouti	107	E	1999	0	I	2010	0.02	I	2000	16		2000
Egypt	107	E	2002	97		2010	7.04		2000	86		2000
Iran (Islamic Republic of)	207	E	2000	7		2010	53.10		2004	92		2004
Iraq	225	E	1998	53	I	2010				79		2000
Israel	392	E	2001	58	I	2010				58		2004
Jordan	149	E	2001	27	I	2010	0.55		2005	65		2005
Kuwait	67	E	1999	100		2010	0.42		2002	54		2002
Lebanon	558	E	2000	1		2010	0.70		2005	60		2005
Libya	141	E	2000	0	I	2010	4.31		2000	83		2000
Morocco	288	E	2000	0	I	2010	3.17		2000	87		2000
Occupied Palestinian Territory				3	I	2010				45		2005

	National Rainfall Index (NRI) (mm/yr)			Dependency ratio (%)			Fresh groundwater withdrawal (10^9 m^3/yr)			Share of agricultural water from total withdrawal (%)		
Oman	23	E	1998	0	I	2010	1.21		2003	88		2003
Qatar	36	E	1998	3		2010	0.22		2005	59		2005
Saudi Arabia	129	E	2001	0	I	2010	21.37		2006	88	E	2006
Sudan and South Sudan	741	E	2002	77	I	2010				97	L	2000
Syrian Arab Republic	376	E	2000	72		2010				88	I	2005
Tunisia	326	E	1998	9		2010	1.90		2001	76	I	2001
Turkey	615	E	2002	1		2010	11.61	I	2006	74		2003
United Arab Emirates	52	E	2002	0		2010	2.80		2006	83	I	2005
Yemen	233	E	2000	0	I	2010	2.40		2000	91		2005

Note:

E = External data

I = AQUASTAT estimate

L = Modeled data

Table 8-4. Overall statistics 2008–2012

	Total economically active population (1,000 inhab)			Human Development Index (HDI)		
Algeria	14,968	E	2010	0.70	E	2011
Bahrain	627	E	2010	0.81	E	2011
Djibouti	385	E	2010	0.43	E	2011
Egypt	26,383	E	2010	0.64	E	2011
Iran (Islamic Republic of)	30,278	E	2010	0.71	E	2011
Iraq	7,929	E	2010	0.57	E	2011
Israel	2,987	E	2010	0.89	E	2011
Jordan	1,803	E	2010	0.70	E	2011
Kuwait	1,385	E	2010	0.76	E	2011
Lebanon	1,551	E	2010	0.74	E	2011
Libya	2,334	E	2010	0.76	E	2011
Morocco	11,798	E	2010	0.58	E	2011
Occupied Palestinian Territory	1,380	E	2010	0.64	E	2011
Oman	1,100	E	2010	0.71	E	2011
Qatar	1,140	E	2010	0.83	E	2011
Saudi Arabia	10,087	E	2010	0.77	E	2011
Sudan and South Sudan	13,825	E	2010	0.41	E	2011
Syrian Arab Republic	6,689	E	2010	0.63	E	2011
Tunisia	3,917	E	2010	0.70	E	2011
Turkey	24,847	E	2010	0.70	E	2011
United Arab Emirates	4,741	E	2010	0.85	E	2011
Yemen	5,958	E	2010	0.46	E	2011

Note:

E = External data

are already overdrafted, and climate change will combine to dramatically reduce per-capita water availability during this century. This scarcity will eventually have particularly severe impact on agriculture, including rural communities primarily dependent upon it. We encourage MENA countries to consider reforms that can achieve greater efficiency in the use of water, as these reforms should allow more rapid economic growth, higher employment, and reduced poverty over the longer run. In particular, these reforms should contribute to agricultural modernization and rising productivity, employment, and output relative to the situation of no change in policy.

Why are these reforms not being enacted if they have potential for considerable national benefit? Without question, these reforms will be politically difficult to implement in most, if not all, MENA countries. The reforms are likely to cause significant changes in the economic welfare and political influence of different societal groups and thus will encounter considerable resistance. Implementing the reforms could heighten political tension and even threaten the viability of government administrations. We recognize these problems, which will differ from country to country in nature and in magnitude. Nonetheless, water scarcity is going to increase, and countries that do not deal with the problem efficiently will encounter continuing economic, social, and political problems of increasing severity. We argue that it is better to recognize the inevitability of the problem now and begin to craft policies to deal with it in an effective manner.

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