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

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Final

To be presented at the
Rosenberg International Forum on Water Policy
Aqaba, Jordan
October 1-2, 2012
Postponed
March 24-25, 2013

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This paper reviews options for confronting the increasing aridity expected in the Middle East and North Africa (MENA) as climate change progresses during the next century and 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 resident 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 1000 m^3 per year per capita. As shown in Figure 1, 15 of 21 MENA countries fall below this level, with many falling well below. While six of 21 countries have more than 1000 m3 per capita per year, three of these countries have declining TARWR levels that are likely to soon fall below 1000 m3 as their populations increase. See Table 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 from traditional sources: precipitation, surface catchment and storage and water extraction from underground aquifers will decline. Simultaneously, population growth will increase the number of water claimants. As water availability shrinks and urban demand increases, history suggests 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. The opportunities for supply enhancement are decreasing, i.e., the cost of new water supplies is rising, even if desalinization and waste water treatment can help provide additional sources for specific needs. The MENA region will benefit greatly from implementing water and economic reforms to allow market forces to play a larger role guiding resource allocation (World Bank, 2007). 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 is unlikely to offset the loss of jobs that will occur as water scarcity rises. Moreover, 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 should seek and facilitate rural to urban migration are essential if rural poverty is to be relieved. However, urban growth 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 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.

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, offer fewer and less productive jobs, the rural poor will be poorer and many will not have the resources to migrate successfully to urban areas.

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 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% (UN) and is predicted to decline only gradually. If population grows at an average rate of 1.3 percent, 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 increasingly depends on groundwater extraction, but many of the aquifers contain fossil water and enjoy little to no recharge. Thus, the MENA region is already suffering from over-extraction of groundwater aquifers and increasing aquifer water contamination due to infiltration of salts and sewage in some regions. Many MENA countries are seeking to reduce rather than increase groundwater extraction.

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 ground water. 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 (Sowers, et al., 2010).

Climate models predict a major reduction in precipitation in the MENA region, e.g., an average 10% - 25% decline by the end of the 20th 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^{o} C, with similar expectations for Syria. Suppan (2008) predicts an increase of up to 4.5C 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^{o} C increase in mean temperature. AFED (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 agriculture.

Water scarcity and agriculture

Agriculture varies in its importance across countries in the MENA region. As shown in Table 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 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 1. 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% between 1985 and 2003 (Molle and Berkhoff, 2006).

The decrease in water availability will require a reduction in area planted. The combined effect of scarcer water and higher temperatures will also decrease crop yields. Many crops in the MENA are already cultivated at the extremes of tolerance to heat and salinity and yields of these crops are expected to decrease. For example, Eid, cited in Sowers, et al., predicts a decline of 9% to 19% in crop yields for a temperature increase of 2^{o} C, which is the lower limit of temperature increase at the end of the 21st Century predicted by climate models.

Declining cropped area and yields will reduce agricultural employment. Currently, agriculture accounts for a large share of regional employment (28 percent in Egypt, 44 percent in Morocco, 50 percent in Yemen) (WDI database), though the proportion varies widely, being less than 10% in 11 countries and more than 20% in 11 countries, with 4 more than 30%. It is not unreasonable to anticipate that, as water availability declines, 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 likely to be better able to assist successfully with an attractive transition than 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 pre-existing 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 able 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/rural labor force (Ackah & 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, which reduces 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.)

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, e.g., fighting has occurred between different tribes in Yemen that appears directly related to conflict over water resources (World Bank, 2007; Christian Science Monitor, 2009). However, analysis of a broad range of case studies of environmental degradation have 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/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 as water becomes increasingly scarce. Affected communities will simply not prosper, residents will migrate, and those left behind will be tend to be poorer and increasingly marginalized unless public policy is able to offset these effects.

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. Richards (2002) asserts that one third of the urban population in Jordan and Morocco lacks adequate sewage services, and that Damietta, Egypt, which has a population of one million, has no sewerage at all. Adoption of conservation and waste water recycling can constrain urban water use.

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. Now 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 percent. However, if conservation can limit water use in the urban sector to 15 instead of 20, or if 5 units of urban waste water can be recycled for use in agriculture, water availability in agriculture would be 75, or 7 percent more. Improving the efficiency of water use in the urban sector, whether by reducing leaks in the distribution system, recycling waste water, or conserving use in the household and industrial sectors is an important consideration as water scarcity and urban use increases.

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 utilization 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 with 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 achieve greater economic efficiency, economists encourage greater reliance on “market-based” systems, e.g., letting price play a larger role in determining who receives scarce water and what the recipients do with that water. However, the introduction of water pricing systems into the MENA countries is controversial. Theoretically, a higher price of water should lead users to seek ways to use less of the more expensive resource, thus 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. But, while the higher price should lead to increased efficiency, the higher price also reduces the profits of those producers who must pay for more expensive water, assuming producers cannot fully pass on the higher costs to consumers.

The alternative to a market system is use of a bureaucratic mechanism wherein authority allocates water based on established criteria. In fact, most water systems involve a mix of market and bureaucracy, as the two mechanisms differ in their respective strengths and weaknesses, but the MENA region has relied more 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 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, farmers collectively demand more water at a zero price 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 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 got initial allocations will work consistently to hold on to what they have and, if possible, get more. Further, water holders will do all 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 will have to be made regarding who should be favored and who excluded. Unfortunately, the poor are usually squeezed out.

A market mechanism may allow small, relatively poorer farmers to ensure 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 non-market mechanisms (Richards, 2002). Nonetheless, increasing water prices can have harsh effect on the profits (incomes) of these farmers and they are unlikely to be happy about the price increases.

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 use water will not want the price of water to rise. They who receive water are clearly better off with the lower price. Numerous 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.

However, Richards notes that land values reflect the value of water in the same way that land values reflect the costs and productivity of other complementary inputs, e.g., labor, machinery, and seeds. Significant changes in the prices or in the productivity of any complementary input will affect land values, either up or down. Thus, every time governments take any major policy action, they are likely to increase or decrease farm profits and land values. However, governments cannot always take decisions that benefit farmers, or any particular set of farmers. Indeed, although political influence is a reality that must be faced, efficiency requires that the price of water, as well as the prices of other inputs and of all outputs, reflect the opportunity cost of those resources. If prices do not reflect opportunity costs, resources will be misused and output, and economic growth, will be lower.

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 (2002) presents 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 of Jordan by Rosenberg, Howitt and Lund (2008) also suggests that a 10% increase in the price of water will, over five years, reduce water consumption in agriculture by 1%. 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 increases, 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 direct some part of water allocation, some water will likely flow from poorer farmers to larger farms – and this is more likely to occur the lower is the price of water. 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 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 US, Mexico, 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.

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, i.e., 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, where each party has incentive to extract 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, some regulation and coordination is often needed.

Concern about the enforceability of contracts can stifle short term water trades, either from a fear that leasing out water today will reduce the strength of water property rights in the future, or a fear that a contract to lease in water will be abrogated when the water is most needed. Efficient water use often depends on the development of costly infrastructure, e.g., the development of canals and/or drip irrigation systems, and farmers will likely be unwilling to invest in water infrastructure if their access to water is insecure. Thus, governments must be concerned to clarify future allocations to encourage appropriate investment decisions by users. Complementary institutions must exist if the water market is to function effectively. Not only must the law be clear and consistent with desired economic and social principles, but lawyers and judges must understand the law and be able to apply it in a consistent manner. Further, if welfare improving trades are to occur, infrastructure must be available to transport the water in a timely and efficient manner from the seller to the buyer (Bauer, 2004).

It seems unlikely that the MENA countries will find it desirable to implement complete water markets in the foreseeable future because of political and institutional complications. However, allowing price to pay a larger role is highly important. Further, it will be useful to increasingly useful to 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.

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 area 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, if farmers have access to modern technology, and farmers and labor are adequately skilled and motivated. Producing horticultural crops for export will also require development of a much improved supply chain, e.g., post-harvest technologies, transportation, communications, and marketing, capable of ensuring 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 ha of cultivation than do cereals, but 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 crops 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.

Many countries in the region maintain agricultural policies that promote the intensive use of water because of concerns about social stability and rural livelihoods. Although these policies were originally designed to promote food security, they currently provide livelihoods for large portions 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 percent, removing price supports or increasing the price of agricultural inputs, including water is politically difficult. Direct income transfers or other mechanisms might be more efficient ways to transfer benefits to vulnerable populations.

Government support for wheat and other crops encourages farmers to over irrigate as well. 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; World Bank, 2006; World Bank, 2007; Pishbahar, 2001; and 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 field crops such as the cereals, e.g., where wheat produces about \$0.05 per m3, vegetables produce about \$0.50 per m3, 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 3 shows that horticulture in Morocco utilizes 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, there will be increased pressure to modernize agriculture – and also the financial incentives to carry out such modernization. Purchasers, e.g., supermarkets, now require consistent high-quality, 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.

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 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 and better capitalized farmers (who would more easily move into fruit and vegetable cultivation), while small farmers would 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, production of more may sufficiently reduce 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 of 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. Indeed, in the absence of such reforms, economic and social progress will be much slower. Nonetheless, the short run costs of reforms appear significant and careful planning is required if these 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 socio-economic 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 over drafting 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 are overwhelmingly dependent on agriculture as an economic driver and for cultural orientation will suffer greatly unless major reforms are implemented and specific counter measures 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. Equally important, 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 through block water grants with lower initial prices for base allocations – 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 too to forecast the expected rise in prices 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 stimulate more efficient industrial growth, thus absorbing more people who must migrate from agriculture. The economic reform must include adjustment in the exchange rate to an equilibrium level, and in tariffs/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 significant possibility that reforms will reduce the welfare of poor farmers and some agricultural workers, even as they benefit wealthier farms with greater access to land, capital, technology and with 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.

Moreover, still more 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 socio-economic 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.

The challenges are great and governments would be well advised to begin planning and implementing policies that will allow an effective transition to occur. 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.

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

Table 1.

Overall statistics **2008-2012**	**Total economically active population (1000 inhab)**			**Human Development Index (HDI)**		
Algeria	14968	E	2010	0.70	E	2011
Bahrain	627	E	2010	0.81	E	2011
Djibouti	385	E	2010	0.43	E	2011
Egypt	26383	E	2010	0.64	E	2011
Iran (Islamic Republic of)	30278	E	2010	0.71	E	2011
Iraq	7929	E	2010	0.57	E	2011
Israel	2987	E	2010	0.89	E	2011
Jordan	1803	E	2010	0.70	E	2011
Kuwait	1385	E	2010	0.76	E	2011
Lebanon	1551	E	2010	0.74	E	2011
Libya	2334	E	2010	0.76	E	2011
Morocco	11798	E	2010	0.58	E	2011
Occupied Palestinian Territory	1380	E	2010	0.64	E	2011
Oman	1100	E	2010	0.71	E	2011
Qatar	1140	E	2010	0.83	E	2011
Saudi Arabia	10087	E	2010	0.77	E	2011
Sudan and South Sudan	13825	E	2010	0.41	E	2011
Syrian Arab Republic	6689	E	2010	0.63	E	2011
Tunisia	3917	E	2010	0.70	E	2011
Turkey	24847	E	2010	0.70	E	2011
United Arab Emirates	4741	E	2010	0.85	E	2011
Yemen	5958	E	2010	0.46	E	2011

Table 2. **Share of agriculture** 2008-2012	Percentage of total country area cultivated (%)			Total economically active population in agriculture (1000 inhab)			Share of agric. (%)	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

Table 3. **Water withdrawal** 2008-2012	**National Rainfall Index (NRI) (mm/yr)**			**Dependency ratio (%)**			**Fresh groundwater withdrawal (10^9 m3/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
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

Table 4.

Total Actual Renewable Water Resources 2008-2012	**TARWR (10^9 m3/yr)**			**TARWR per capita (m3/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	1859	K	2010	
Iraq	75.61	I	2010	2387	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	1065	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	1481	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	2936	K	2010	
United Arab Emirates	0.15		2010	20	K	2010	20
Yemen	2.10	I	2010	87	K	2010	120

E - External data

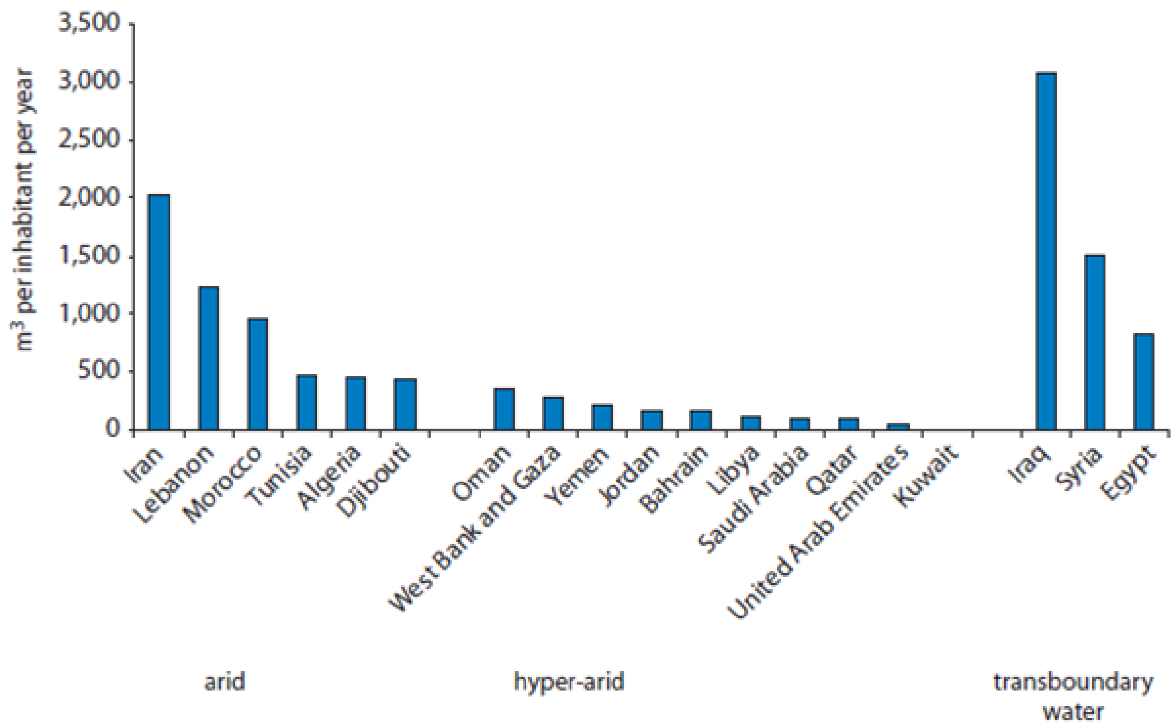
I - AQUASTAT estimate

K - Aggregate data

L - Modelled data

Figure 1.

Total Actual Renewable Water Resources per Capita in MENA



Source: FAO AQUASTAT.

Taken from World Bank (2007, Chapter 3)

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

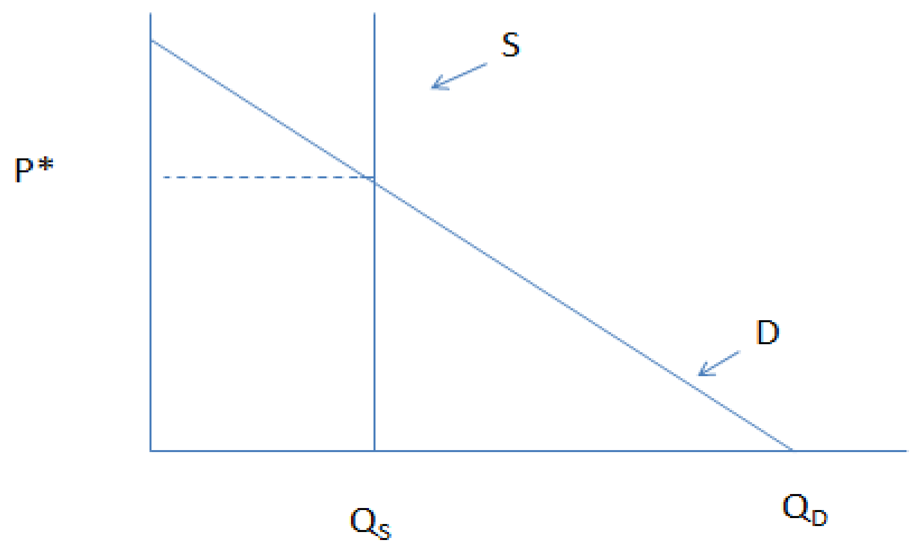
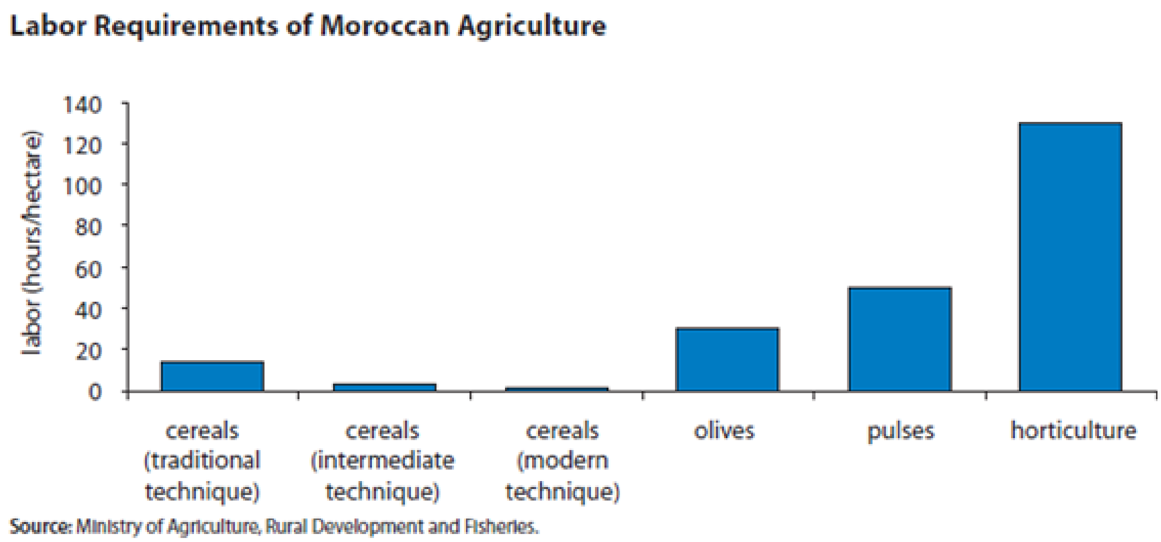


Figure 3.



Taken from World Bank (2007, Chapter 3)

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