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The Outlook for Food Security in the Middle East and North Africa

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Abstract

Soaring food prices have triggered worldwide concern about threats to global food security. The Middle East and North Africa (MENA) region is the most food import–dependent region in the world, and net food imports are projected to rise even further in the future. Thus the MENA region is particularly vulnerable to disruptions in global grain supplies and prices. Increasing resource constraints, growing environmental pressures, and the impacts of climate change exacerbate the problem. With farmland area expected to expand only slightly in the coming decade, future increases in production must come from increases in productivity per unit of water and land and by reducing existing productivity gaps. Actual farm yields of crops in the MENA region are far below their potential.

The paper examines the case of wheat, the staple food in the MENA region, accounting for some 37% of total food supply. The region imports almost half its wheat needs at an increasing cost. The analysis shows that, although there are regional differences in the potential of different agroecologies, crop yields can be increased by the promotion and adoption of existing, "on-the-shelf" technologies available with national and international research institutes. It is clear that the full potential of rainfed farming has not been exploited as yet. However, technological change does not translate into increased production until it is widely adopted by farmers. These gains in production will be achieved only if action is taken now to develop, adapt, and promote improved technologies that incorporate soil moisture conservation, supplemental irrigation, improved soil nutrient management,

high-yielding improved varieties, and integrated pest and disease management, coupled with more suitable policy environments and institutional support to encourage the adoption of the new technologies by farmers.

Global Context

Soaring food prices have triggered worldwide concern about threats to global food security. Up until 2006, the cost of the global food basket had fallen by almost a half. By mid-2008, international food prices had skyrocketed to their highest level in 30 years. This, coupled with the global economic downturn, pushed millions more people into poverty and hunger. From July to September 2010, wheat prices surged by 60 to 80% in response to droughts and crop losses in major grain-producing countries. Rice and maize prices also rose during that period. In December 2010, the FAO Food Price Index rose above its 2008 peak. The index dropped to an 11-month low in October 2011, but food prices still remain very volatile.

The United States is currently in the midst of a severe drought, its worst in 50 years. Half of all U.S. counties have been declared disaster areas, and the international prices of maize and soybeans have risen beyond the 2007–2008 peaks. The FAO Food Price Index, which measures the monthly change in the international prices of a basket of food commodities, climbed 6% in July 2012 after 3 months of decline, mostly driven by a surge in grain and sugar prices. International wheat quotations have surged by 19% amid worsened production prospects in Russia, Kazakhstan, and Ukraine—a region that accounts for nearly a quarter of global wheat exports—and expectations of increased demand for wheat for feed because of the shortage of maize supplies. Iran's wheat harvest was also affected by a severe drought. If the region's wheat harvest is further impacted, export controls may be imposed. Thus, the Middle East and North Africa—the world's biggest cereal importers—remain vulnerable to rising wheat prices (Bänziger, 2012; FAO, 2012).

High food prices pose a major threat to food security. The impact of high prices hits the poor hardest, as they spend a higher percentage of their income on food. But the crisis also raised the specter for import-dependent countries that, whatever the price, sufficient food may not be available on the international markets to satisfy their demands. The latest OECD-FAO Agricultural Outlook (OECD 2012) anticipates that agricultural output growth will slow to an average of 1.7% annually over the next 10 years, down from a trend rate of over 2% per year in recent decades. Higher input costs, increasing resource constraints, growing environmental pressures, and the impacts of climate change will serve to dampen supply response. With farmland area expected to expand only slightly in the coming decade, additional production will need to come from increased productivity, including by reducing productivity gaps in developing countries.

The MENA Region

The increase in food prices had a major impact on the Middle East and North Africa since it is the largest food-deficit region in the world, with grain imports of about 65 million tons in 2010. In this paper, the Middle East and North Africa (MENA) region includes Algeria, Egypt, Libya, Morocco, Sudan and Tunisia in northern Africa, and Bahrain, Iran, Iraq, Jordan, Kuwait, Lebanon, Oman, Palestine, Qatar, Saudi Arabia, Syria, the United Arab Emirates, and Yemen in the Middle East (fig. 6-1).

The MENA region is the most water-scarce region in the world (fig. 6-2). Extraction rates are mostly unsustainable, and groundwater levels continue to fall. Most countries in the region will drop below the internationally

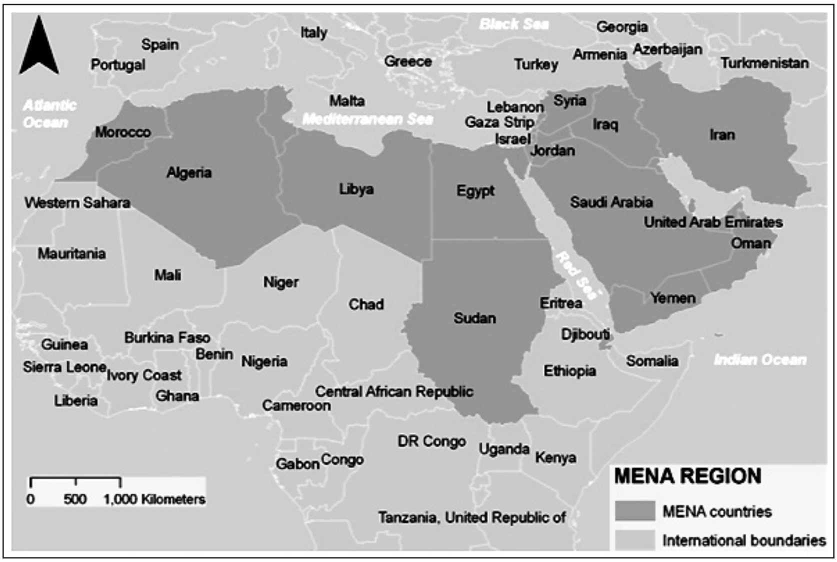

Figure 6-1. The MENA Region.

defined "water scarcity" level in the near future. Per capita water availability in the region is currently 1,100 m^3 per year, compared with a global average of 8,900 m^3 per year. Future projections suggest that this will fall to 550 m^3 by 2050 (IFAD 2009). The largest portion of available water is used for agriculture (fig. 6-3), but increasing competition from the domestic and industrial sectors is expected to reduce agriculture's share of water allocations, placing further limitations on agricultural production.

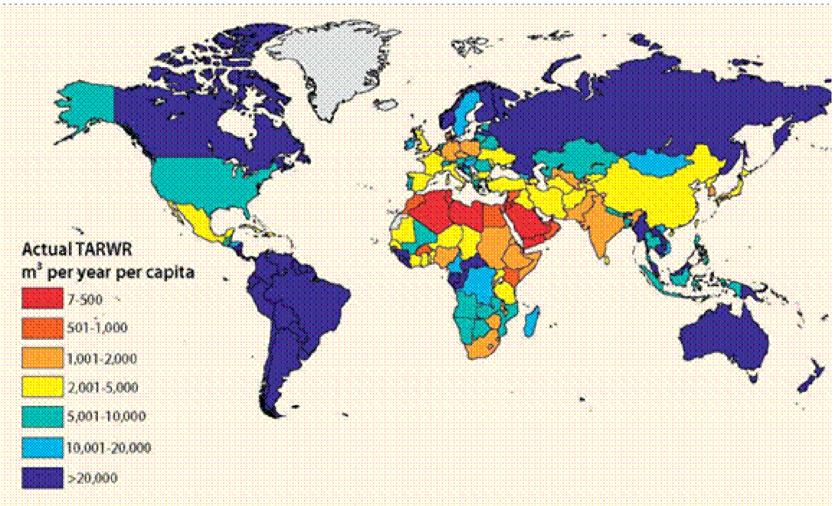

Figure 6-2. Per capita total annual renewable water resources. *Source:* FAO 2012c.

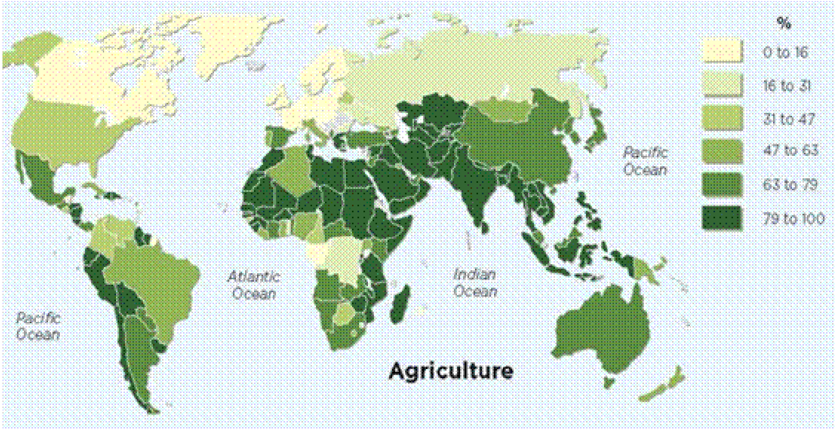

Figure 6-3. Percentage of freshwater used in agriculture. *Source:* UNESCO 2012.

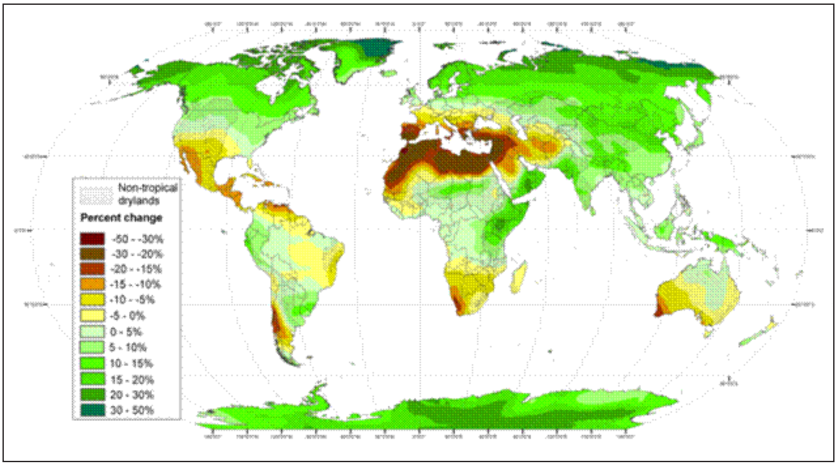

Figure 6-4. Relative change in mean annual precipitation, 1980/1999 to 2080/2099. *Source:* GIS Unit ICARDA, based on partial maps from IPCC.

These problems will be exacerbated by climate change. Projections show that North Africa, the Middle East, and the Mediterranean will be hardest hit by climate change; precipitation is projected to decrease, while temperatures will rise, having serious implications for current agricultural production systems and driving even greater pressure on limited resources (fig. 6-4). Countries with predominantly rural economies and high dependence on dryland agriculture will be most at risk, as they are highly vulnerable to shifts in seasonal climatic patterns. The rural poor will be disproportionately affected by climate change because of their greater dependence on agriculture and their lower capacity to adapt to such changes.

Food Security in the MENA Region

The recent global food crisis of 2007–2009 with soaring commodity prices and shortage of food supplies in the international markets, has raised serious food security concerns about the potential fragility of the food security situation in the region. Recent research by the International Food Policy Research Institute (IFPRI) (Breisinger et al. 2011) has classified MENA countries according to their risk of food insecurity into five categories: low, moderate, serious, alarming, or extremely alarming (fig. 6-5). Except for the oil-rich countries of the Arabian Peninsula, which constitute less than 10% of the total population of the MENA region, most countries are facing risks

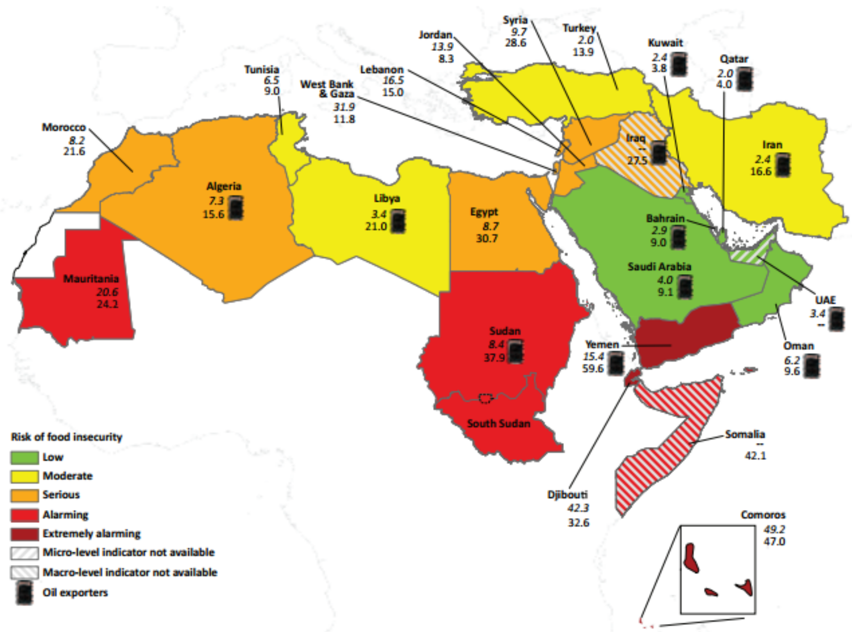

Figure 6-5. Risk of food insecurity in the Middle East and North Africa.
Source: Breisinger et al. 2012.

of food insecurity. Iran, Libya, and Tunisia exhibit moderate risk of food insecurity, whereas all other countries show serious, alarming, or extremely alarming levels of food insecurity risks. The countries at the highest levels of risk are Yemen and Sudan.

The MENA region is the most food import–dependent region in the world, and net food imports are projected to rise even further in the future. In 2000–2002, net food imports accounted for 25 to 50% of national consumption (fig. 6-6). MENA countries are very vulnerable to fluctuations in international commodity markets because they are heavily dependent on imported food. They are the largest importers of cereals in the world (fig. 6-7).

In 2010 the region imported 65.8 million tons of cereals compared with 58.8 million tons for Asia (in spite the huge difference population) and 18.0 million tons in sub-Saharan Africa. The expanding demand for cereals is expected to increase cereal net imports to 73.1 million tons by 2020. Wheat, in the form of bread and other products, is the staple food in most countries in the MENA region, and wheat imports alone will account for more than 50% of the total cereal net imports in 2020.

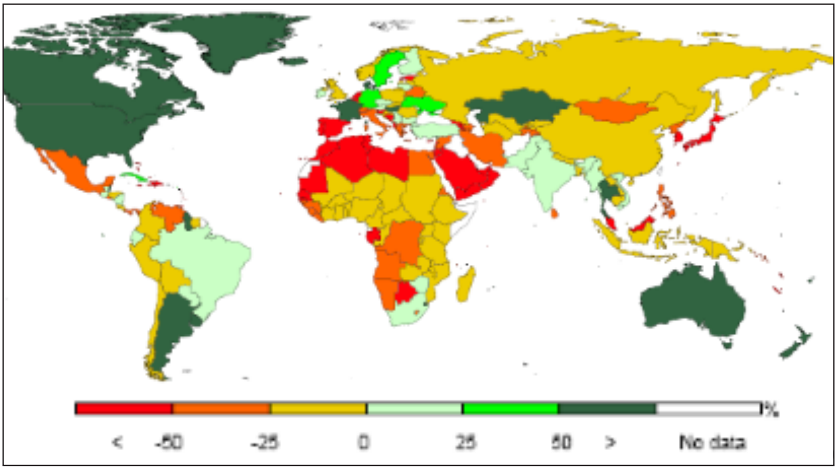

Figure 6-6. Net trade in food, 2000–2002. Net trade expressed as (exports-imports) / (calories consumed). *Source:* FAO 2004.

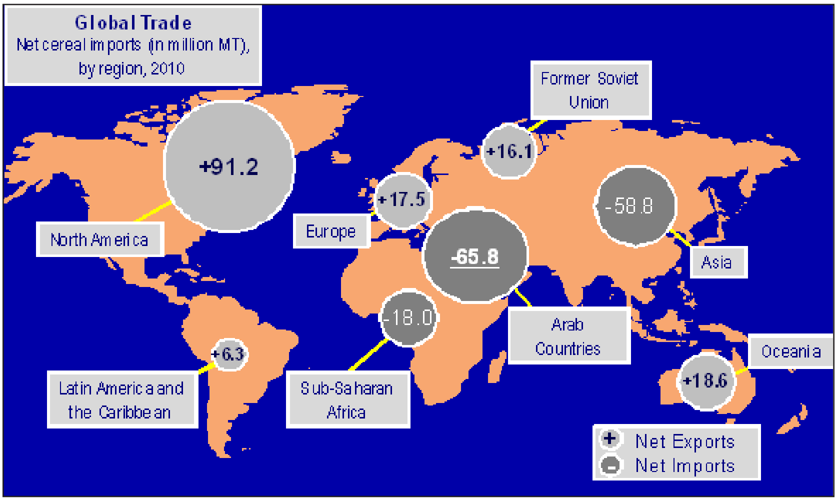

Figure 6-7. Arab countries are the largest net importers of cereal in the world (million metric tons, 2010). *Source:* Adapted from USDA 2011.

This high reliance on imported food can be attributed to both demand and supply factors. Demand factors include rising population and changing consumption patterns due to higher incomes. The MENA population has increased from 150 million in 1970 to 417 million people in 2010 and is projected to continue to grow at an annual rate of 1.7%. Shifting patterns of demand from staples to higher-value food products, combined with limited potential for land expansion, will further increase the region's food trade deficit. Supply factors include limited arable land and water resources, which constrain food production.

With limited scope for horizontal expansion, future increases in production must come from increases in productivity per unit of water and land. Following the food crisis, it became apparent that productivity gains in developing countries, and especially in the dry areas, have slowed. Actual farm yields of crops in the MENA region are far below their potential. One important and positive impact that the global food crisis has had in the region is that governments are now placing investment in agriculture high in their national priorities in an effort to ensure food self-sufficiency.

As the largest net importers of cereal, the countries of the MENA region are more exposed than other countries to severe swings in agricultural commodity prices, and their vulnerability will probably be exacerbated in coming years by strong population growth, low agricultural productivity, and their dependence on global commodities markets. Two forward-looking food-balance models, the IMPACT14 model created by IFPRI and an FAO model, project that demand for food in the region will grow substantially to the year 2030 and that production will not be able to keep pace, resulting in increasing dependence on imported food. Net cereal imports vary depending on population growth and availability of land and water resources. In some countries cereal imports will double, whereas in others they will remain constant or decrease. All, with the exception of Morocco, will remain net cereal importers through 2030 and beyond (table 6-1). The primary driver of increasing net cereal imports in the model is population growth, with income growth playing a smaller role. However, yields and production in some countries have already increased between 2000 and 2010, so these projections may need adjustment. The potential for increasing production is discussed below.

Table 6-1. Projected cereal imports in selected countries in MENA 2000–2030

Sub-region and country	Projected population growth 2000–2030 (%)	Projected income growth 2000–2030 (%)	Projected increase in net cereal imports 2000–2030 (%)
ARABIAN PENINSULA			
Bahrain, Kuwait, Oman, Qatar, Saudi Arabia, UAE, Yemen	105	190	89
NEAR EAST			
Iraq	95	24	48
Jordan	74	238	61
Lebanon	30	186	52
Syria	78	189	98
NORTH AFRICA			
Algeria	47	210	18
Egypt	59	168	137
Libya	57	211	72
Morocco	45	193	–17
Sudan	66	254	na
Tunisia	29	200	4

Source: World Bank et al. 2009.

The Case of Wheat, the Staple Food in the MENA Region

Wheat is the staple food in the MENA region, accounting for some 37% of total food supply. Consumption is highest in the Maghreb countries of Algeria, Morocco, and Tunisia, with average per capita consumption of 174 kg per year in North Africa, 158 kg in the Middle East, and 166 kg for the MENA region overall, compared with the world average wheat consumption of 66 kg per capita per year. The region imports almost half its wheat needs (fig. 6-8 and table 6-2) but at an increasing cost (fig. 6-9)

Rapid increases in wheat productivity were achieved in the late 1990s through 2006; the decline in yields and production in recent years reflect a series of drought years throughout the region (fig. 6-10). While total wheat area has declined over time, yields have increased by an average annual

Table 6-2. MENA self-sufficiency in wheat (%)

CHANGE FROM	1990–1994	1995–1999	2000–2004	2005–2009	1990–2009
Algeria	33.4	34.1	27.0	29.0	**−4.4**
Bahrain	0.0	0.0	0.0	0.0	0.0
Egypt	46.4	52.1	59.0	58.0	11.6
Iran	78.8	69.8	76.1	85.7	6.9
Iraq	64.8	50.3	39.5	43.9	**−20.9**
Jordan	10.0	7.1	5.5	2.9	**−7.1**
Kuwait	0.0	0.1	0.2	0.2	0.1
Lebanon	13.3	14.5	23.1	26.2	12.9
Libya	20.4	29.5	27.0	13.6	**−6.8**
Morocco	58.7	52.4	53.4	56.4	**−2.3**
Palestine	na	na	36.3	22.3	na
Oman	0.9	0.7	0.6	0.6	**−0.3**
Qatar	0.5	0.3	0.1	0.0	**−0.5**
Saudi Arabia	150.6	111.0	99.7	87.1	**−63.5**
Sudan	72.2	63.8	23.8	30.0	**−42.2**
Syria	92.6	113.2	111.1	114.9	22.3
Tunisia	61.7	48.7	44.3	49.3	**−12.4**
UAE	2.3	0.1	0.0	0.0	**−2.3**
Yemen	12.5	12.8	7.4	7.1	**−5.4**
MENA	64.2	57.8	57.0	57.8	**−6.4**

Source: FAO 2012c.

Note: Self-sufficiency = 100*[production]/[consumption] where consumption is the sum of production and net imports.

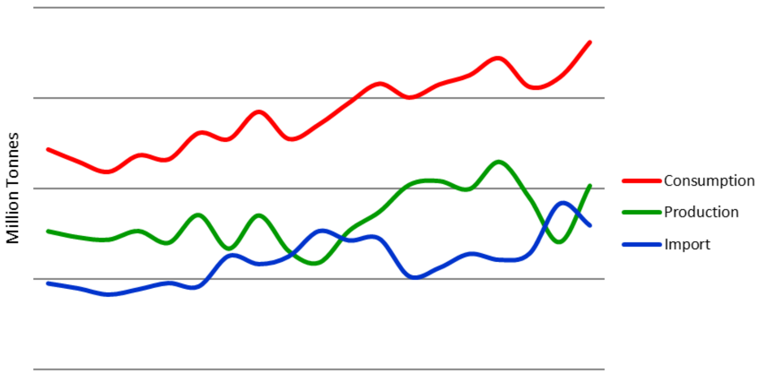

Figure 6-8. Wheat production, imports and consumption in MENA.

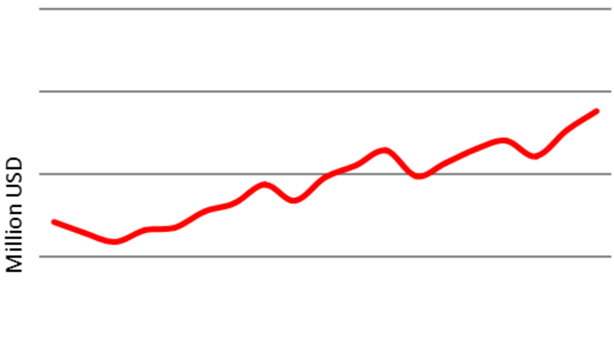

Figure 6-9. Wheat import value (USD million) in the MENA region.

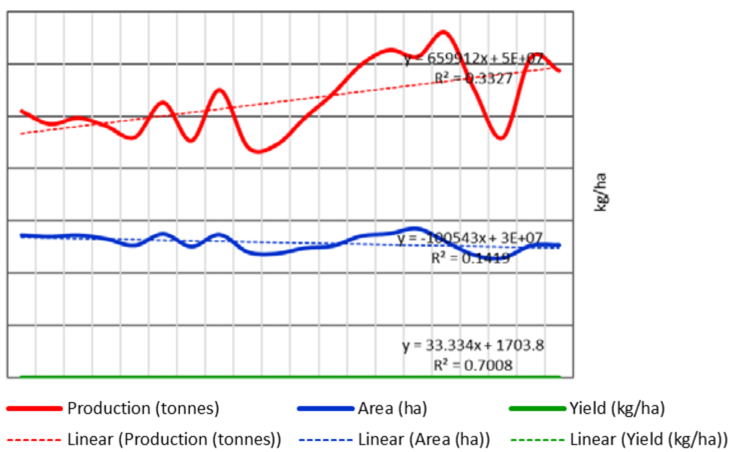

Figure 6-10. Wheat area, production and yield trends in the MENA region.

rate of 1.78%, resulting in an average annual growth in production of 1.29%. The average annual yield increase is similar to projected population growth rates in the MENA region of 1.77%. Thus, where the prospects for expanding the wheat area are limited, if production of wheat is to exceed population growth rates, yields must increase further.

Yield Gaps

To increase food security in the developing world, two parameters are used to explore the tradeoff between production intensification and the potential for land expansion of rainfed cultivated area at the country level (Fischer and Shah 2010):

1. **Yield gap:** the amount that actual yields, from either irrigated or rainfed areas, fall short of potential yields under optimum management; and
2. **Relative land availability:** the ratio of non-forested, non-cultivated suitable land area for rainfed production relative to what is actually cultivated.

It is apparent from table 6-3 that land availability in the MENA region is very limited; thus there is no potential for horizontal expansion in agricultural productivity except in the Sudan. On the other hand, actual farm yields of crops in the MENA region are far below their potential. Bridging the yield gap through vertical expansion in productivity is almost the only way forward to enhance food security.

Table 6-3. Potential availability of land for rainfed areas in different regions of the world (1,000 ha)

	Total area	Area <6 hr	Area >6 hr
Sub-Saharan Africa	201,761	94,919	106,844
Latin America and Caribbean	123,342	93,957	29,387
Eastern Europe and Central Asia	51,136	43,734	7,400
East and South Asia	14,769	3,320	11,450
Middle East and North Africa	2,716	2,647	71
Rest of the world	52,134	24,554	27,575
Total	445,858	263,131	182,727

Source: Deininger and Byerlee 2011

Note: Data reflects potential supply of land in areas with a population density less than $25/km^2$

Most of the agricultural area in the MENA region is rainfed, and a large proportion of the region's agricultural production is based on dryland farming systems, with a variable annual rainfall in the range of 200 to 600 mm (fig. 6-11). The region has about 74 million ha of arable land, of which some 23% is sown to wheat (FAOSTAT 2012) (fig. 6-12). About 20 to 30% of the wheat area is irrigated, and the rest is grown under rainfed conditions. Productivity of wheat in rainfed areas is still low (0.8 to 2.0 t/ha) compared

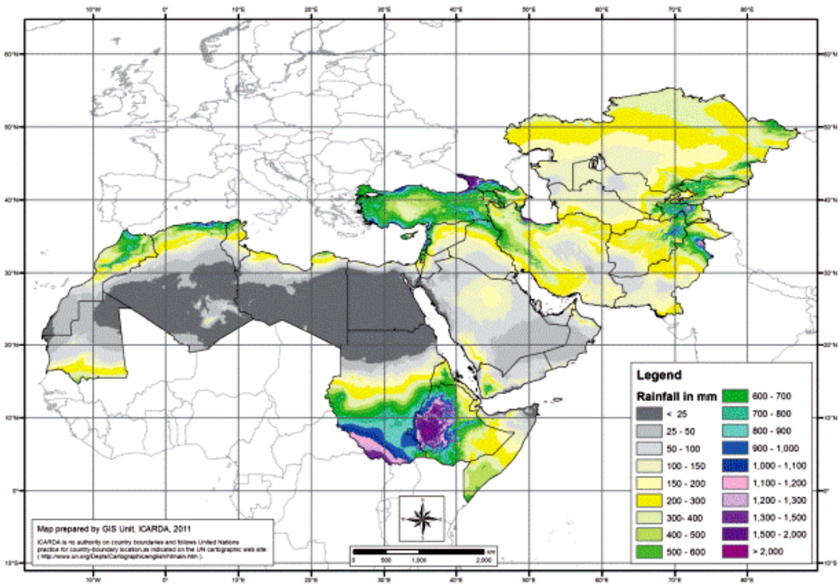

Figure 6-11. Rainfall zones of MENA region.

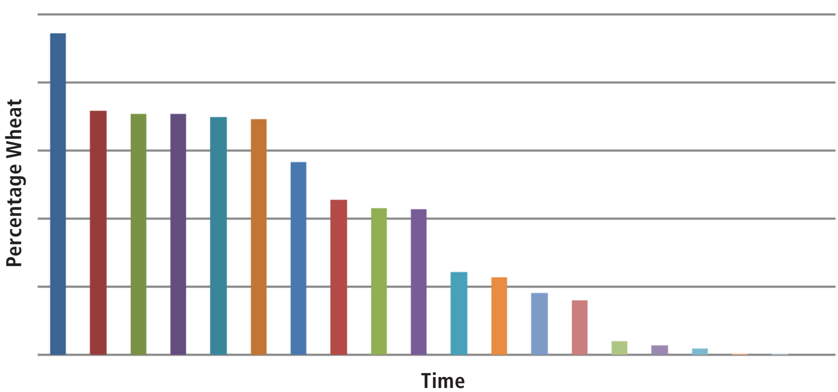

Figure 6-12. Percentage of arable area planted to wheat (average for 2006–2009).

with world averages. Rainfed production depends on low and extremely variable rainfall; therefore, productivity is low and unstable. This is further affected by frequent droughts and is likely to be exacerbated by climate change. However, higher and more stable yields have been achieved in experimental fields and in on-farm demonstrations. Analysis of potential yields and yield gaps show that the actual yields of food and other crops obtained by farmers are much below the potential yields that can be obtained with improved management. The analysis also shows that, although there are regional differences in the potential of different agroecologies, crop yields can be increased by the promotion and adoption of existing "on-the-shelf" technologies available with national and international research institutes. It is clear that the full potential of rainfed farming has not been exploited as yet.

Yield gap analysis by ICARDA (Pala et al. 2011) in key locations in Morocco and Syria, which represent major wheat production agroecologies, found that wheat yields could be substantially increased (fig. 6-13). The analysis used data obtained during the period of 1995 to 2004 on yields obtained under improved management at research stations or in on-farm demonstration trials; simulated potential yields using a cropping systems simulation model; and yields in farmers' fields in the vicinity of on-farm yield trials. The gap between yields in farmers' fields and research station yields in rainfed systems averaged 82% (fig. 6-14 and table 6-4).

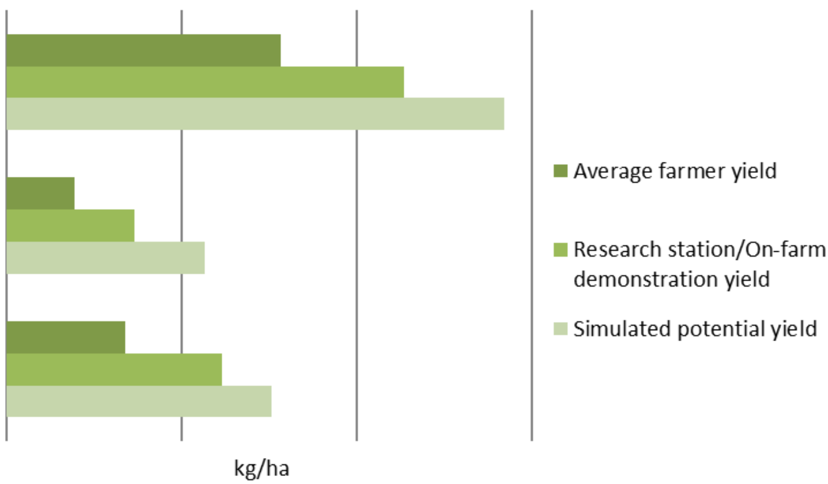

Figure 6-13. Yield gaps in Morocco and Syria: Mean yields for 1995–2004.

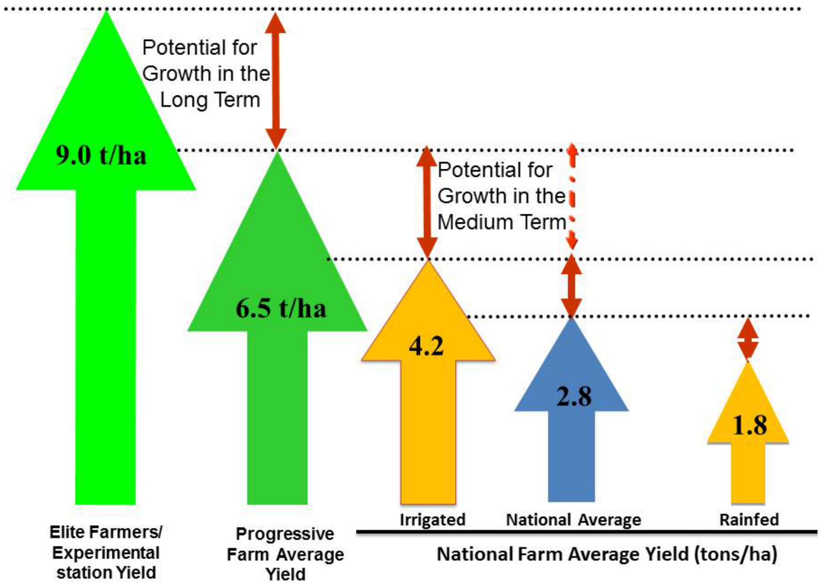

Figure 6-14. Yield gaps involving elite and progressive farms compared to national average, rainfed, and irrigated wheat crop in Syria.

Table 6-4: Yield gap analysis for Morocco and Syria

MEANS OF 1995–2004	Morocco Settat-Berrechid (rainfed)	Morocco Tadla (irrigated)	Syria (rainfed)
Rainfall (mm)	327	285	372
Average farmer yield (kg/ha)	1,163	4,685	2,020
Research station/on-farm demonstration yield (kg/ha)	2,190	6,800	3,675
Simulated potential yield (kg/ha)	3,390	8,510	4,540
GAP ANALYSIS			
Gap 1 (kg/ha)	1,028	2,115	1,655
Gap 2 (kg/ha)	2,228	3,825	2,520
Gap 1 (%)	88%	45%	82%
Gap 2 (%)	192%	82%	125%

Notes:

Gap 1 = difference between average farmers' yield and research station or on-farm demonstration yield.

Gap 2 = difference between average farmers' yield and simulated potential yield.

Thus, there is a large potential for increasing wheat production in the MENA region. Improved management practices along with improved varieties and supplemental irrigation can close the wide gaps between farmers' current yields and those achieved in research stations and on-farm demonstration trials.

The Case of Syria

In Syria, beside the apparent clear yield gaps between research and on-farm demonstration yields and farmers' yields, there is also a clear gap between the yields achieved by progressive farmers and those achieved by the average farmer (see fig. 6-14).

A collaborative program between the Ministry of Agriculture and Agrarian Reform and ICARDA in Syria has tackled the yield gaps in wheat. The program involved breeding for improved germplasm (with yield stability and drought and disease resistance/tolerance), supplemental irrigation, and research on improved crop management (agronomy, fertilization, and mechanization). The improved varieties and management practices were tested under farmers' conditions over multiple years and locations.

Figure 6-15 shows the impact of the adoption by farmers of improved wheat technologies. Wheat production was significantly increased (linear production trend), and Syria became more or less self-sufficient in wheat. The increased production resulted from the combined use of improved technologies and not from an expansion in area, which remained more or less constant (see the linear area trend). Production still varies with annual rainfall, but the graph also shows the higher responsiveness of improved wheat varieties to rainfall compared with the earlier period of 1977–90. The main technical reasons behind this impact include improved varieties, which contributed one-third of the increase in productivity, while supplemental irrigation and inputs (fertilizer, herbicides, etc.), each contributed one-third. All of this was supported by the government's enabling policy environment.

The strategy adopted in Syrian agriculture can serve as a model for development elsewhere and demonstrates that increases in staple food crop production are possible. The MENA region currently has a population of about 400 million, with an annual deficit of some 30 million tons of wheat, which is met by imports. By 2020, the population is expected to

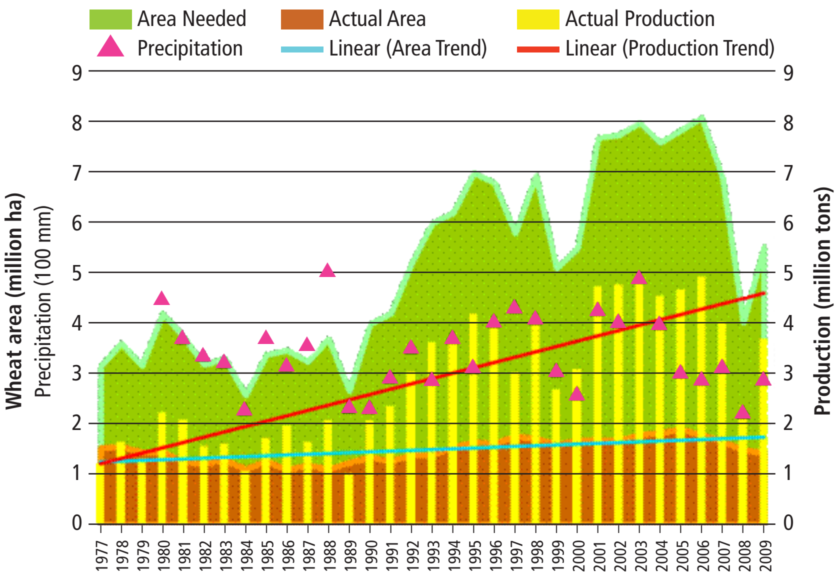

Figure 6-15. Adoption and impact of improved wheat production technologies in Syria.

reach almost 500 million, at an annual growth rate of 1.77%. Production of wheat needs to be kept above this rate of population growth if it is to meet the increasing demand. Land and water resources are already limited, so most of the increase in food production will have to come from increased productivity per unit area and per unit water. Assuming the same average per capita consumption of 166 kg per year, and the same wheat area, average wheat yields would have to increase by almost 1 ton, or 45%, in the 10 years to 2020 in order to meet demand without increasing imports above their 2007–9 current level (table 6-5). This is an average annual increase in yield of 3.15%.

Is such an increase achievable? The example of yield gaps above shows that such an increase is potentially achievable, being well within the difference between average farmers' yields and research station yields. However, technological change does not translate into increased production until it is widely adopted by farmers. Some individual countries may be able to achieve these gains, but only if action is taken now to develop, adapt, and promote improved technologies that incorporate soil moisture conservation, supplemental irrigation, improved soil nutrient management, high-yielding improved varieties, and integrated pest and disease management,

Table 6-5. Estimated average annual increase in yields required to meet the demand for wheat in 2020 without increasing imports

	Average 2007–2009	2020
Population	400,149	493,927
Kg/ha consumption	166.10	166.10
Consumption	66,465,209	82,041,774
Imports fixed at 2007-2009 level	31,436,022	31,436,022
Area fixed at 2007-2009 level	15,756,248	15,756,248
Production	34,886,552	50,605,752
Yield (kg/ha	2,214	
Yield required to maintain consumption (kg/ha)		3,212
Required yield increase		998
Average annual increase (%)		3.15%

coupled with more suitable policy environments and institutional support to encourage the adoption of the new technologies by farmers.

It should also be noted that these are the yield increases needed to simply maintain the current trade position of the MENA region; it will not reduce imports or achieve self-sufficiency in the region. Achieving self-sufficiency and reducing imports to zero would require average yields to be increased by almost 3 tons within 10 years, an unrealistic prospect. Many countries of the MENA region will therefore continue to be reliant on imports and the international market to meet their populations' demand for wheat. The global food crisis and ongoing instability in international food markets have raised questions about the reliability of international markets as suppliers of affordable food and have prompted many food-importing countries to pursue strategies focused on increasing self-sufficiency in staple foods as a way of becoming less reliant on food imports.

Enhancing Food Security in Arab Countries

The results of the first 2 years of a project on the Enhancing Food Security Project in Arab Countries clearly indicate that there is clearly potential to increase food security in Arab countries. The project, which involves Egypt, Jordan, Morocco, Syria, Tunisia, Sudan, and Yemen, is supported by the Arab Fund for Economic and Social Development (AFESD), the Kuwaiti Fund for Economic Development (KFEAD), and the Islamic Development Bank (IsDB). The goal of the project is to contribute to achieving food security and agricultural sector growth with a focus on wheat-based production systems in the Arab countries under the challenging scenarios of climate change, the global economic crisis (increased food prices), and increasing population.

The project aims at increasing wheat production following an integrated, multidisciplinary research approach and technology transfer in whole provinces involving researchers, farmers' participation in planning, field days, farmers' fields schools, extension staff, and policymakers.

In the 2010–2011 season, production of wheat in Sharkia Province in Egypt was increased by 20%, with water savings of 20%, as result of improved wheat varieties, raised-bed plantation, and improved agronomic practices under irrigated conditions. In Tunisia, average wheat yields were increased by 12 to 20% as a result of adopting improved varieties under rainfed conditions in Janduoba Province; under irrigated conditions in Kairouan Province, yields were increased by 20 to 40%. In Syria, the wheat yields increased by 10 to 22% under drought conditions, while under supplemental irrigation, these increases were 20 to 40%.

Direct Investment in Foreign Agriculture: Is Land Acquisition a Viable Strategy?

The global food crisis and inflation in food prices in 2008 exposed the vulnerability of import-dependent countries to a volatile international market and raised the prospect of food insecurity for countries in the MENA region without much farmland, such as those in the Arabian Peninsula (Kuwait, Qatar, Saudi Arabia, and the United Arab Emirates). Investment in foreign agricultural land is seen as one way to reduce the amount of food that these countries need to import at world prices. An increasing number of countries are engaging in foreign direct investment to ensure their national food security by buying or leasing land in other countries (a so-called "land grab"). The investor country acquires land and guaranteed access to the food produced on it, while the recipient country gets an infusion of investment into its agricultural sector. Other possible benefits include the creation of jobs in rural areas and the development of rural infrastructure leading to economic development. The scale and terms of these investments and arrangements vary widely; some have no direct land acquisition but involve securing food supplies through contract farming and investment in rural and agricultural infrastructure, including irrigation systems and roads. However, for this to truly be a win-win arrangement, such investments should protect the recipient country's citizens from expropriation of their land, labor abuses, and loss of their own food security. Land investments can displace small-holder farmers or impact on the local food production in the target countries, especially if these countries face food security challenges of their own. FAO is now encouraging investors to support joint ventures with local farmers in poor nations rather than lease or buy land outright.

Toward Long-Term Food Security

Managing future food security at the national level requires strategic choices among a mix of domestic investments in agriculture and food stocks and international market arrangements. With limited arable land and water resources, there is limited scope for horizontal expansion in agricultural production; future increases must come from increases in productivity per unit of water and land. Against this background, the question is, what can make a difference in efforts to improve food production under land and water scarcity?

- An enabling policy environment and strong political will are critical. Policies are needed that support sustainable productivity growth in agriculture. Governments need to ensure that farmers have sustained access to quality seeds, fertilizers and tools as well as technical assistance, training, and credit; they also need to invest in rural infrastructure such as roads, irrigation systems, storage and market facilities. Reducing post harvest food losses could also contribute significantly to improving domestic supplies. Encouraging better agronomic practices; creating the right commercial, technical, and regulatory environment; and strengthening the agriculture innovation system (e.g. research, education, and extension) are essential steps.

- The dry areas must give greater priority to and investment in enhancing water productivity for sustainable agricultural and rural development, particularly in the vulnerable rainfed areas. Water is the fastest-depleting resource in the region, and managing the resource more effectively ("getting more crop-per-drop") and addressing impending issues of climate change is critical in the future.
- Advances in science and technology are crucial in overcoming or adapting to the challenges facing dry areas. An integrated approach is needed that addresses both agricultural productivity and the better management of the natural resources on which that productivity depends.
- Above all, greater investments are needed in agricultural research capacity development and institutional support. Strengthening the agriculture innovation system (research, education, and extension) is essential. Far greater investment is needed in developing a new generation of national scientists and technicians that will carry these efforts into the future.

The Role of ICARDA

With 35 years of applied research experience in the region, the International Center for Agricultural Research in the Dry Areas (ICARDA) is uniquely placed to provide the assistance needed in addressing the twin challenges of improving food crop production and conserving the natural resource base on which agricultural production depends. Collaborative research by ICARDA and its partners has contributed to significant gains in food security in dry areas. Ensuring food security in the future will require a long-term, multipartner, multisector strategy to deal with the challenges facing dry areas. ICARDA's research is directed toward improving food security and helping farmers adapt to climate change in dry areas.

Conservation and Use of Genetic Diversity

Researchers are using genetic diversity—germplasm from diverse sources—to develop improved, adapted crop varieties that can offer higher yields and simultaneously cope with climate change through better resistance to environmental constraints. The MENA region contains tremendous diversity, both in cultivated landraces and wild species. These provide an invaluable resource for identifying new sources of resistance to temperatures, drought, diseases, and insect pests, as well as other adaptive traits.

Crop Improvement

ICARDA's mandate includes the improvement of wheat (the staple food crop in the MENA region), barley (a major livestock feed in the MENA region), and food legumes (chickpea, lentil, and fava bean), which are an important source of protein, especially for the urban and rural poor who cannot afford animal protein. ICARDA uses both conventional plant breeding and biotechnology to develop improved germplasm adapted to changing production systems with high yield potential and enhanced resistance to specific stresses. These, combined with improved crop management and integrated pest management (IPM) practices, are pivotal in ensuring food security and increasing agroecosystem resilience in the face of climate change.

Over the last 35 years, 880 improved varieties of wheat, barley, chickpea, lentil, fava bean, and forage crops developed by national research programs in collaboration with ICARDA have been released. About 86% were released in developing countries and 14% in industrialized countries. The estimated net benefit from these varieties is $850 million per year.

Improving Water Productivity

Water is the most critical limiting factor in dry areas. Irrigation accounts for 80 to 90% of water consumption in the MENA region. Thus, small improvements in on-farm water use efficiency can substantially improve water availability. Technologies and policy and institutional innovations are needed to improve water management in agriculture, increase productivity, and reduce production costs.

Climate change will exacerbate water scarcity in dry areas, many of which are already reaching critical levels of scarcity. Scientific innovation has led to several approaches for more effective management of water in agriculture. ICARDA's research focuses on increasing water productivity (the amount of crop or biomass produced per unit of water used) both at the farm and basin levels. ICARDA has also been studying the use of alternative water resources. For example, marginal-quality water and treated wastewater have been found useful for growing cotton, forages and trees. Conjunctive or blended use of drainage water with regular irrigation can optimize yields while conserving freshwater.

Diversification and Intensification of Production Systems

To cope with climate change, farmers will need to diversify their farming systems in order to improve ecosystem resilience, reduce risk, and simultaneously create new income opportunities. System diversification includes diversification of crop rotations, for instance by promoting the inclusion of legume crops in cereal systems, which also contributes to maintaining soil fertility, and also diversification into higher-value crops such as dryland fruit trees, protected (greenhouse) agriculture, and herbal, medicinal, and aromatic plants.

Reducing Production and Energy Costs

The fundamental driver of agricultural technology adoption by farmers is an increased return to their investment, either by increasing production or reducing costs. Conservation agriculture achieves both. It combines minimum soil disturbance (zero tillage), stubble retention, crop rotation, and early sowing of crops. It offers multiple benefits: savings in time, fuel, and machinery costs for land preparation; better soil structure; better soil moisture conservation; higher yield potential; and reduced soil erosion. While the practice has been widely adopted in other dryland areas (Australia, Latin America), a major bottleneck in the MENA region has been the lack of affordable planting equipment. This has now been resolved with the development of locally fabricated, low-cost zero-till seeders developed with local manufacturers and tested by farmers in Syria and Iraq. In the 2010–11 season, these machines were used by 400 farmers to plant almost 20,000 ha of zero-till crops, and the equipment and associated practices are being scaled out to other countries.

Capacity Development

In order for national research programs to meet the challenges of increasing agricultural production, they need a cadre of qualified researchers trained in the new and emerging research approaches needed to address the specific problems encountered by each country. Evidence shows that the MENA countries in general are facing a "skills gap"—an acute shortage of agricultural researchers. The Young Agricultural Scientists Program established at ICARDA is designed to bridge this skills gap by strengthening national research capacities and encouraging graduate careers in agricultural research.

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