CHAPTER 1

The State of Food Security and Agricultural Resources

Abdul-Karim Sadik

Despite endeavors to enhance the state of food security through domestic food production, Arab countries at country, sub-regional, and regional levels remain largely net importers of food, especially with respect to cereals, the main staple food commodity in the region. Heavy reliance on food imports exposes Arab countries to the vulnerability of food supply chains and volatility of food prices, as was evidenced by the conjunctural events and consequences of the 2007-2008 global food crisis.

In their pursuit to reduce reliance on food imports, Arab countries face serious challenges emanating from limited cultivable land and scarce water resources, suffering from an undermined bio-capacity to regenerate their services. Population growth and climate change compound the challenges and call for stewardship in the management and use of the available agricultural resources to ensure their sustainability.

The inextricable link between food and water limits the potential of water-stressed Arab countries to promote domestic food production. Nevertheless, the prospects for enhancing the food self-sufficiency aspect of food scarcity depend on reversing the trend in the degradation of the available agricultural resources, and in using them efficiently and productively. In this respect, such options as improving crop and water productivity and irrigation efficiency, reducing post-harvest losses, and promoting water reuse in agriculture at country level constitute priority for consideration and action. Strengthening intra-Arab cooperation on food scarcity concerns, based on comparative advantage in agricultural resources and investable capital, coupled with coordination and harmonization of agricultural policies and development strategies can pave the way for reducing the Arab region's reliance on imports. Establishing an integrated food value chain is of paramount importance to the achievement of the entire food security components comprised of availability, accessibility, stability, and utilization.

I. INTRODUCTION

Recognizing the strategic importance of securing food away from the vulnerabilities of external sources, the Arab countries have long been pursuing a food self-sufficiency goal, but the progress achieved neither kept pace with population growth, nor was it sufficient to reduce reliance on food imports.

The sudden food crisis in 2007-2008, accompanied by an unprecedented spike in food prices and ban on exports of staple food crops by some exporting countries, ignited further interest of large food importers such as the Arab countries to redouble their efforts to enhance the state of their food security through promoting domestic food production.

Renewed commitment by Arab countries to enhance food self-sufficiency is being made against a backdrop of constraining factors, including climate aridity, limited cultivable land, and scarce water resources. This is in addition to the impoverished state of agricultural resources, debilitated with inefficient use, low productivity, land degradation, soil erosion, depleted water aquifers, and polluted water resources. These consequences, largely caused by weak policies and poor agricultural practices, coupled with the predicted impact of future climate change, population growth, and rising demand for food, pose daunting challenges to food security in Arab countries. However, despite limited and degraded agricultural resources, there remains considerable potential to enhance the state of Arab food security through domestic food production.

"Food security exists when all people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life" (FAO, 1996). Following from this definition, four distinct and interrelated aspects are basic to the attainment of food security: availability, accessibility, utilization and stability.

This chapter focuses primarily on the availability aspect of food security in Arab countries, and identifies a number of options and related policy actions to improve food self-sufficiency under constraints of limited land and scarce water resources, in addition to other alternatives for ensuring the supply dimension of food security.

II. THE STATE OF FOOD SECURITY

Arab countries have been procuring their food supplies through a mix of domestic production and imports from other countries. Despite their endeavor in past decades to reduce their reliance on external sources, they remain today the largest importers of cereals, which constitute the main staple food in the Arab region.

Food self-sufficiency at country and sub-regional levels vary widely in the Arab region. At country level, it ranged between 9.9 percent in Qatar and 86.84 percent in Sudan, and at sub-regional level, the ratio ranged between 29.45 percent in the Gulf Cooperation Council (GCC) countries and 80.8 percent in the Nile Valley countries in 2011. At regional level, the self-sufficiency ratio stood at about 72 percent as shown in Table 1.

As demonstrated in Table 1, the regional food self-sufficiency ratio at 71.69 percent in 2011 did not change significantly from its level at 70.48 percent in 2005. At country level the food self-sufficiency ratio declined in all Arab countries in 2011 from its level in 2005, with the exception of Iraq, Algeria, and Somalia. This indicates that overall the Arab countries did not make progress in the past several years towards their pursued policy of enhancing food security

TABLE 1 **FOOD SELF-SUFFICIENCY RATIO IN ARAB COUNTRIES**

	Food Self-Sufficiency Ratio (%)			
Country/Sub-Region	**Total Food**		**Cereals**	
	2005	**2011**	**2005**	**2011**
Bahrain	12.96	12.81	0.00	0.00
Kuwait	28.38	21.68	3.88	2.56
Oman	45.21	34.52	1.17	9.22
Qatar	12.18	9.90	3.12	0.37
Saudi Arabia	44.52	34.49	26.75	11.15
United Arab Emirates	21.13	18.66	0.85	1.06
GCC	**37.40**	**29.45**	**20.25**	**9.12**
Yemen	51.53	31.45	22.59	10.92
GCC & Yemen	**39.74**	**29.74**	**20.54**	**9.46**
Iraq	75.34	82.84	55.51	95.42
Jordan	56.26	53.09	5.05	3.66
Lebanon	73.23	61.03	18.05	10.96
Syria	85.23	80.62	74.00	57.98
Palestine	81.55	72.26	19.69	10.00
Levant	**77.20**	**75.52**	**54.86**	**56.48**
Egypt	83.68	78.96	69.63	56.30
Sudan	91.15	86.84	75.74	70.59
Nile Valley	**85.51**	**80.80**	**70.74**	**59.09**
Algeria	53.48	70.04	29.88	31.96
Libya	44.95	43.09	10.79	7.06
Mauritania	68.49	70.03	19.17	36.04
Morocco	89.60	80.40	46.09	58.91
Tunisia	71.78	68.49	47.82	46.79
North Africa	**66.87**	**71.58**	**35.75**	**43.19**
Comoros	-	-	-	-
Djibouti	4.04	2.00	0.00	0.00
Somalia	69.17	74.26	32.89	33.00
African Horn	**64.80**	**63.52**	**28.46**	**26.70**
Arab Countries	**70.48**	**71.69**	**49.74**	**45.55**

Source: Compiled by the author based on data in AOAD, 2007 and 2012.

based on domestically produced food, especially with regard to cereals, whose self-sufficiency ratio dropped from about 50 percent in 2005 to about 46 percent in 2011 (Table 1). Regionally, the Arab countries were nearly self-sufficient in fruits and vegetables, and fish, but had a self-sufficiency ratio of 45.55 percent in cereals, 54.35 percent in oils and fats, and 36.85 percent in sugar in 2011 as indicated in Table 2.

Cereals are of special significance to food security in Arab countries, because they are the main staple food and feed for livestock. They are dealt with in more detail in the following sub-section.

TABLE 2 **FOOD SELF-SUFFICIENCY IN ARAB COUNTRIES (%)**

Food Commodity	2005	2011
Cereals	49.74	45.55
Sugar	38.47	36.85
Fats & Oils	28.12	54.35
Meat	80.80	76.19
Fruits & Vegetables	98.49	106.19
Fish	103.09	98.19
Other Commodities	77.78	82.50
Average	**70.48**	**71.69**

Source: Compiled by the author based on data in AOAD 2007 and 2012.

A. Cereals

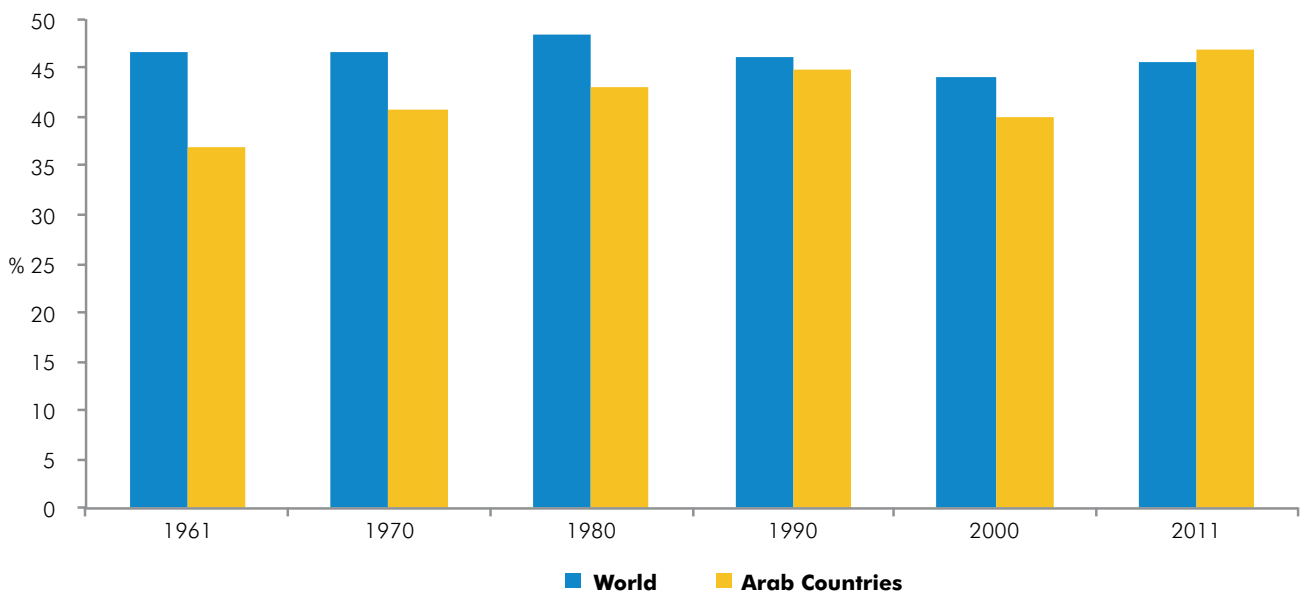
Arab countries have devoted a considerable portion of their agricultural resources to the production of cereals, in line with the importance of these commodities to food security in terms of domestic supply and cost of imports. "Cereals are still by far the world's most important sources of food, both for direct human consumption and indirectly, as inputs to livestock production. What happens in the cereal sector is therefore critical to world food supplies" (FAO, 2002b).

i. Cereal Area

The crucial role of cereals in food security is demonstrated by the share of cropland area allocated to cereal production. Throughout the past decades, the area under cereal production occupied a relatively large part of the total cropland in the world, and similarly in the Arab countries. The percentage of land under cereal production fluctuated narrowly in the world over the period 1961 and 2011, dropping from 47.3 percent in 1961 to about 45.5 percent in 2010. In comparison, the same percentage rose from about 38 percent in 1961 to about 47.5 percent in 2011 in the Arab region, as illustrated in Figure 1.

While over the past decades percentages of total cropland area devoted to cereal production differed marginally in the Arab region from similar world percentages, increase in cereal production in the world has been achieved mainly through improvement in yield, whereas average cereal productivity in Arab Countries lagged considerably behind the world average.

FIGURE 1 **SHARE OF CEREAL AREA IN TOTAL CROPLAND AREA (%)**



Source: Adapted by the author based on FAOSTAT database (FAO, 2013a).

ii. Cereal Productivity

Cereal yield in the Arab region lagged behind that of the world throughout the past decades. Its level at about 796 kg/ha in 1961 was only 59 percent of the world average at about 1,353 kg/ha, and remained at less than half the world average in 2012 as represented in Table 3.

in cereal production in the world over the period 1961-2012. However, while cereal productivity in the world grew at an average rate of about 2.48 percent over the period 1961-1990, and at an average rate of about 2.01 percent in the Arab region, the growth rate in the following period 1990-2012 declined substantially, averaging about 1.2 percent in the world and about 1.08

TABLE 3 **CEREAL PRODUCTION AND YIELD**

Arab Region	1961	1990	2012
Cereal area (1000 Ha)	18,584	26,066	25,825
Cereal yield (kg/ha)	796	1,418	1,794
Cereal production (1000 ton)	14,788	36,963	46,332
World			
Cereal area (1000 Ha)	647,997	708,197	703,197
Cereal yield (kg/ha)	1,353	2,757	3,619
Cereal production (1000 ton)	876,875	1,952,459	2,545,002

Source: Compiled by the author based on FAOSTAT database (FAO, 2013a).

As Table 3 above demonstrates, increase in cereal production in the world was driven mainly by cereal yield and not land area which increased by about 8.5 percent only from 1961 to 2012. This is in contrast to the increase in cereal production in Arab countries which was attained through expanding the area by about 39 percent over the period 1961-2012.

Growth in cereal yield, and not expansion in the area cultivated with cereals, prompted the increase

percent in the Arab region, as illustrated in Table 4 and Figure 2.

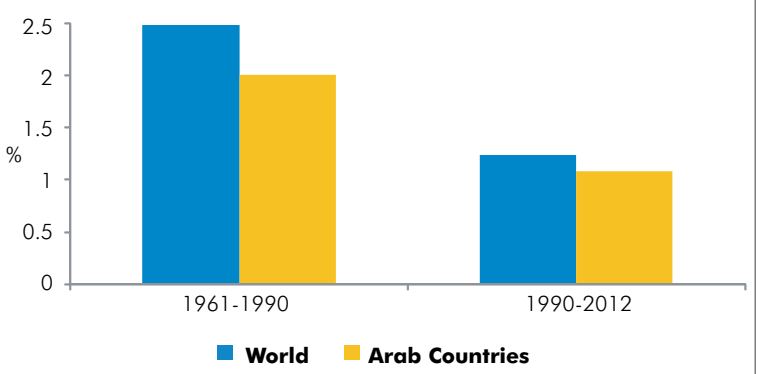
The bulk of cereal production in the Arab region is contributed by six countries – Algeria, Egypt, Iraq, Morocco, Sudan and Syria – with a share of about 88 percent of total cereal production in the Table 5 reveals some striking differences related to cereal production in Arab countries, in terms of cereal area and productivity. Sudan with a share of about 22 percent of the region's area

TABLE 4 **AVERAGE ANNUAL CEREAL PRODUCTIVITY GROWTH (%)**

Period	World	Arab Countries
1961-1970	3.00	2.59
1970-1980	2.27	1.61
1980-1990	2.74	2.28
1990-2000	1.17	0.14
2000-2012	1.40	1.86
1990-2012	1.20	1.08

Source: Compiled by author based on FAOSTAT data base (FAO, 2013a).

FIGURE 2 **AVERAGE GROWTH PER ANNUM IN CEREAL YIELD (%)**



Source: Table 4.

ENERGY-WATER-FOOD-CLIMATE NEXUS

Ibrahim Abdel Gelil

The Arab region is energy intensive, water scarce, and highly vulnerable to potential impacts of climate change. The water scarcity challenge in the region is being compounded by its multiple nexuses with various development sectors, such as water and environment, water and food, water and energy, which carry within them many cross-cutting issues of social, economic, legal, technical, political, and security nature. It is therefore important to address much more explicitly the various linkages of the food sector with other sectors like energy, water, and economic development as a whole and for professionals in all sectors to think and act beyond the boundaries of their own sector, to achieve effective and integrated resources planning and management (Zubari, 2013).

In addition, climate change is mostly driven by energy use and land use changes. Climatic variability adds further pressures such as accelerating drying of drylands, reduced glacier water storage, more frequent and intense extreme weather events (such as droughts or floods), and less reliable water supplies, as well as less reliable agricultural productivity. Worldwide, the food sector alone contributes to about a third of the global greenhouse gas emissions through energy use, land use change, methane emissions from livestock and rice cultivation, and nitrous oxide emissions from fertilized soils (Sachs J. et al., 2010).

At the same time climate change mitigation places new demands on water and land resources, such as production of biofuels, carbon sequestration and carbon capture and storage (CCS). Climate adaptation measures, such as intensified irrigation or additional water desalination, are often energy intensive. Further, increased groundwater use and water storage may require additional pumping. Thus climate policies can have impact on water, energy and food security, and adaptation action can in fact be maladaptive if not well aligned in a nexus approach and implemented by appropriately interlinked institutions (SEI, 2011). Climate change, hence, underpins the triple context of water security, food security and energy security, so there is an urgent need to understand better why this nexus requires urgent attention, especially in the Arab region, which is energy rich, water scarce, and food deficient. Based on a better understanding of the interdependence of water, energy and climate policy, this new approach identifies mutually beneficial responses and provides an informed and transparent framework for determining trade-offs and synergies that meet demand without compromising sustainability.

Jordan is a good example of such interdependence of water energy, food, and climate change. Jordan is among the most water scarce countries in the world, with about 80 percent of its food supply dependent on food imports – which also entail imports of virtual water. Climate change is projected to make the country drier, and to lead to more intense droughts and an increased demand for irrigation. Jordan lacks significant fossil fuel reserves and has no hydropower potential, but instead depends on pumping surface and groundwater to the major demand sites. Accordingly, water supply accounts for about 25 percent of Jordan's total electricity demand (Scott et al., 2003).

Groundwater resources are severely over-exploited. Most of Jordan's water is used in agriculture, while agricultural contribution to GDP and total employment does not exceed 3 percent. Besides food imports and associated virtual water, the focus of Jordan's water strategy is on large-scale supply-side infrastructure projects. However, demand-side management options have large untapped potential. These options include greater reliance on food imports (with associated virtual water imports); reducing water loss in urban systems (80 percent of Jordan's population live in cities) which approaches 50 percent of total supply; substituting freshwater use in agriculture for treated wastewater; increased energy efficiency in the water sector; and energy recovery from wastewater.

Over the past few years, new and increasingly inter-connected crises (the food, energy, and financial crises, together with extreme climate events such as drought and floods) have become evident. These crises are impacting heavily on the Arab population with different degrees, hitting the poor hardest. The nexus approach can boost resource efficiency and productivity by addressing externalities across sectors. For example, nexus thinking would address the energy intensity of desalination, or water and land demands in renewable energy production (e.g. solar energy and some hydropower schemes). The nexus approach integrates management and governance across sectors. A nexus approach can also support the transition to a Green Economy, which aims, among other things, at resource use efficiency and greater policy coherence.

The strong interdependency between energy, water and climate change makes it imperative that policy formulation becomes coordinated, particularly with respect to mitigation of adaptation to climate change effects. Traditionally, energy and water policies are developed within each sector with little coordination. Change from fossil fuel with large emissions and considerable water use towards renewable sources, with minimal emissions and water use, should be pursued. Conventional policy- and decision-making in 'silos' therefore needs to give way to an approach that reduces trade-offs and builds synergies across sectors.

This new development has created unprecedented opportunities for fundamental policy changes in various economic, institutional, technological, social and political systems. It is important to recognize that there has been weak or lack of real coordination in the Arab region in terms of policies and strategies for water, agriculture, land, energy, and addressing climate change. However, the new challenge offers real opportunities for synergies such as:

- Coordinated investments in infrastructure related to water, food and energy. Innovation to improve resource use efficiency requires investment and reductions in economic distortions. Economic instruments for stimulating investment include pricing of resources and ecosystem services, among others.
- Maximizing the beneficial uses of water and energy amongst competing demand, not only between the food and energy sectors, but also by considering the demands of other sectors such as industry, fisheries, navigation, tourism, etc.
- Applied and adaptive research to enhance adaptation to climate change in the agricultural sector and to ensure production systems resilience.
- Capacity building and sharing of experiences at national and regional levels, where professionals working on the management of water resources, the agriculture sector, and the energy sector, can work together with the common objective of achieving security. Related to this, bridging the present science-policy gap is a challenging task.
- 'No regret' adaptation actions (including using Integrated Water Resource Management, IWRM, as an adaptation tool, and up scaling decentralized renewable energy technologies) are crucial to help build resilience to the increasing number of extreme weather events.
- Integrating water, food and energy security planning at national and regional levels. Enabling conditions for horizontal and vertical policy coherence include institutional capacity building, political will, and raising awareness.

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Dr. Ibrahim Abdel Gelil, Former Director of Energy and Environment Program at the Arabian Gulf University, Bahrain.

TABLE 5 **CEREAL PRODUCTION IN SELECTED ARAB COUNTRIES (2012)**

Country/Region	Cereal Area (ha)	Percent of Cereal Area (%)	Cereal Production Ton	Percent of Production (%)	Yield (Kg/ha)
Algeria	3,062,449	11.86	5,137,455	10.05	1,678
Egypt	3,268,112	12.65	23,755,745	46.48	7,269
Iraq	2,015,790	7.81	3,513,300	6.88	1,743
Morocco	5,224,630	20.23	5,311,130	10.39	1,01
Sudan	5,631,780	21.80	2,660,000	5.20	472
Syria	2,798,610	10.84	4,599,397	9.00	1,64
Sub-total	22,001,371	85.9	44,977,027	88.0	2,044
GCC countries	309,784	1.20	1,676,811	3.28	5,413
Others	3,513,617	13.61	4,457,844	8.72	1,269
Total Arab region	25,824,772	100.00	51,111,682	100.00	1,794

Source: Compiled by the author based on FOASTAT database (FAO, 2013a).

under cereal production, contributed a mere 5.2 percent to total cereal production, while Egypt with a share of about 13 percent of the cereal area had a share of about 46.5 percent of total cereal production. Similarly, GCC countries, with a share of about 1.2 percent of the cereal area contributed a share of about 3.3 percent to cereal production in the region.

These widely disproportionate percentages between area and production are the result of the large gap in productivity, arising mainly from the mix and quantity of farming inputs (irrigation, seeds, fertilizers, pesticides, and mechanization), in addition to agricultural practices and technology. For example, irrigation in Egypt and in GCC countries covers nearly 95 percent and 100 percent of the cultivated area, respectively, while in Sudan irrigation is limited to less than 10 percent of the cultivated area (AOAD, 2012) and fertilizer use did not exceed an average of 10.8 kg/ha, over the period 2009 – 2011, compared to about 605 kg/ha in Egypt (World Bank, 2013).

Crop yields are critical to the availability dimension of food security. Growth in cereal productivity was the main pillar of the Green Revolution of the 1960s, whose adoption of improved irrigation and high-yielding varieties, coupled with the use of chemical fertilizers and pesticides boosted cereal yield and saved the plight of millions of people in Asia from starvation. However, decline in the growth rate of cereal yield raised concerns about the Green Revolution Paradigm and severely challenged its sustainability because of its externalities, including soil deterioration, groundwater depletion, and contamination. These experiences demonstrate the need for a new agricultural paradigm based on agricultural inputs and practices conducive to maintaining the bio-capacity of agricultural resources and their long-term sustainability.

B. Food Imports

Demand for food in Arab countries at country, sub-regional and regional levels has been met in large part through imports. The world food crisis in 2007-2008 associated with an unprecedented spike in food prices (Figure 3) led to more than doubling the food import bill of Arab countries. Whereas the latter imported about 86.5 million tons of main food commodities, including about 55.8 million tons of cereals, at a cost of US$24.94 billion and US$10.2 billion in 2005, respectively (AOAD, 2007), food imports by Arab countries in 2011 jumped to about 105.8 million tons, at a cost of US$55.6 billion, including about 66.8 million tons of cereals at a cost of US$25 billion (AOAD, 2012). Thus, the average cost of food imports increased from about US$288 per ton in 2005 to about US$525.4 per ton in 2011, and that of cereals rose from an average of US$183 in 2005 to US$375 per ton in 2011.

The growth in food imports at a rate of 3.39 percent per annum has outpaced population growth which averaged about 2.25 percent annually over the period 2005-2011, with wide variations in similar growth rates, ranging between 1.0 percent in Lebanon and 14.3 percent in the United Arab Emirates. A growth rate of about 1.14 percent in food imports over the population growth rate, represents the increase in demand for food imports over the same period.

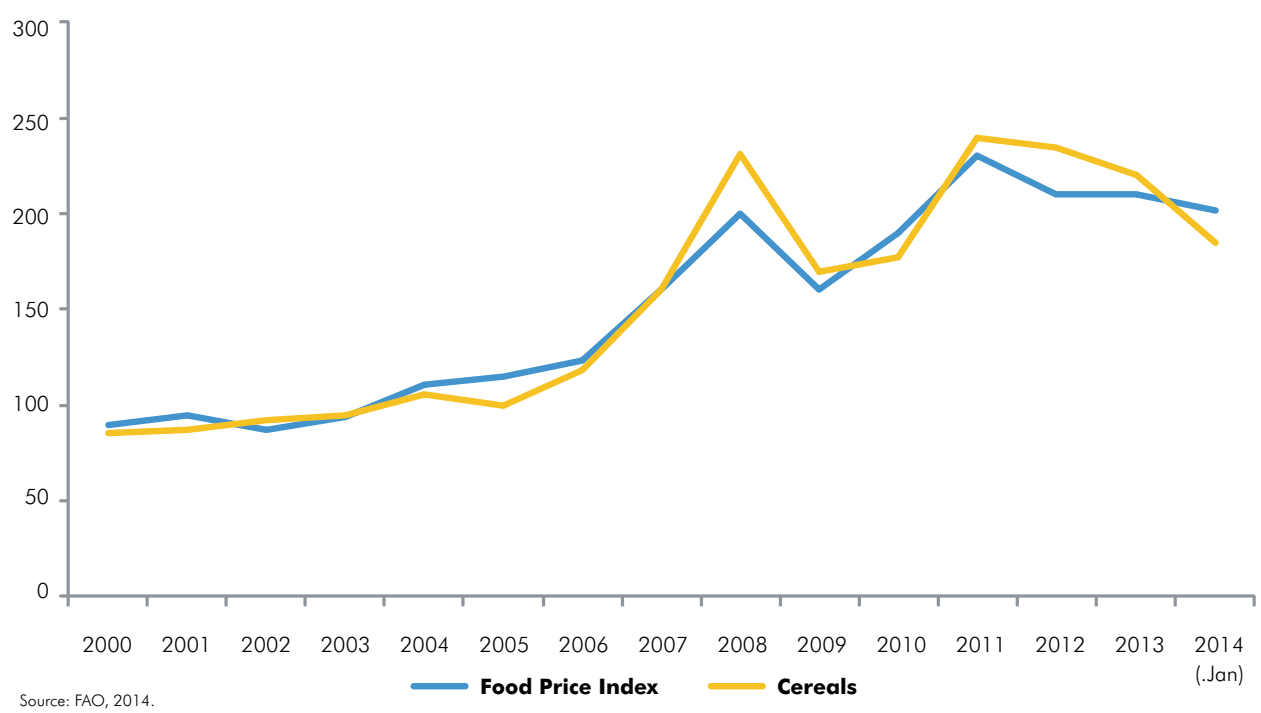
Likewise, demand for cereal imports grew at an average annual rate of about 0.80 percent over the rate of population growth. If this trend of food imports continues, in the absence of enhancing the food self-sufficiency ratio, and an Arab population of about 362 million in 2011 (AOAD, 2012), projected to reach 619 million in 2050 (UN, 2012), the future cost of food imports by Arab countries at 2011 constant prices, will shoot up from about US$56 billion in 2011 to about US$150 billion in 2050, including a cereal import bill of about US$60 billion as represented in Figure 4.

Increase in population, especially in those Arab countries with high population growth rates does not only exert immense pressure on limited agricultural resources, but it also raises their reliance on food imports.

Rising cost of food imports, price fluctuations, uncertainty about the future food supplies in world markets due to, among other things, conversion of agricultural land for bio-fuel production, and impact of climate change on the productive capacity of land and water resources drive the Arab and other food importing countries to look for options to enhance their food security, especially through reliance on domestic food production. In this respect, the question to be addressed is what the prospects are for enhancing food self-sufficiency, particularly in cereals, considering that the Arab countries give top priority to the production of staple cereals which constituted in terms of quantity and value about 63 percent and 45 percent respectively of total major food imports in 2011.

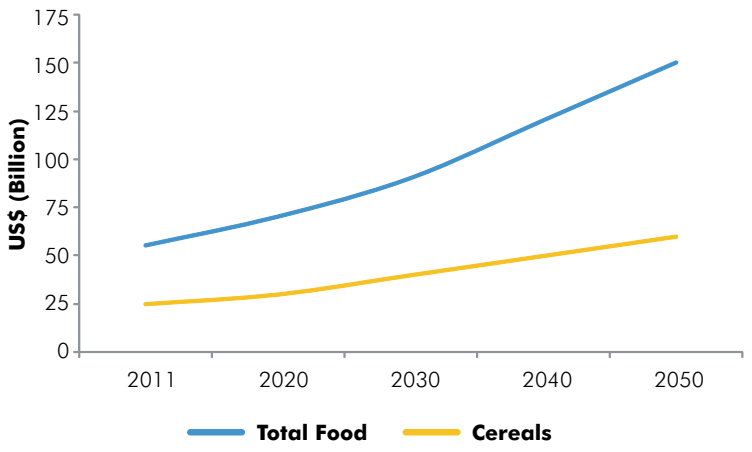
In this respect, the prospects for enhancing self-sufficiency in cereals in Arab countries depends much on the state of agricultural land and water resources, their biocapacity to regenerate their services, and agricultural sustainability at large.

FIGURE 3 **FAO FOOD PRICE INDEX (2002 - 2004 = 100)**



Source: FAO, 2014.

FIGURE 4 **PROJECTED COST OF FOOD IMPORTS IN ARAB COUNTRIES**



Source: Author's estimates.

III. THE STATE OF AGRICULTURAL RESOURCES

Situated in an arid and semi-arid region of the world the Arab countries, excluding Sudan, are endowed with limited agricultural land and scarce water resources. The availability of such resources is critical for food production, but more critical is the state of their health and biocapacity to sustain their performance over the long-term.

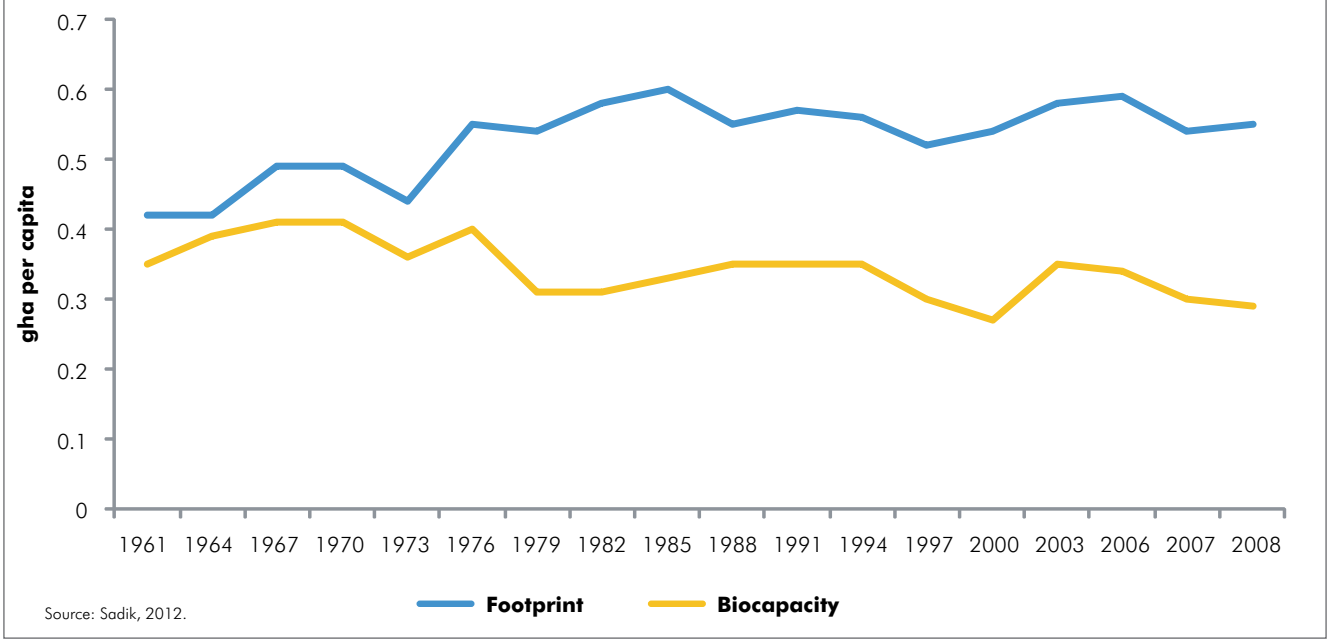
Agriculture can have a vast impact on land and water resources and on the wider environment through crop and livestock production, which are the main sources of water pollution, greenhouse gases, and biodiversity loss. In addition, agriculture threatens the basis of its sustainability through land degradation, salinization, water over-extraction, and reduction of genetic diversity in crops and livestock (FAO, 2002b).

Agriculture in the Arab countries has over the past decades been subjected to distortive policies and poor agricultural practices, leading to undermining its long-term sustainability. The capacity of land and water to regenerate their services over time has been severely constrained by disregard to their health and to the protection of ecosystems. This is often reflected in such phenomena as soil erosion, land degradation, salinization, depleted aquifers, and water pollution, which altogether loaded land and water resources with a heavy footprint.

A. State of Cropland

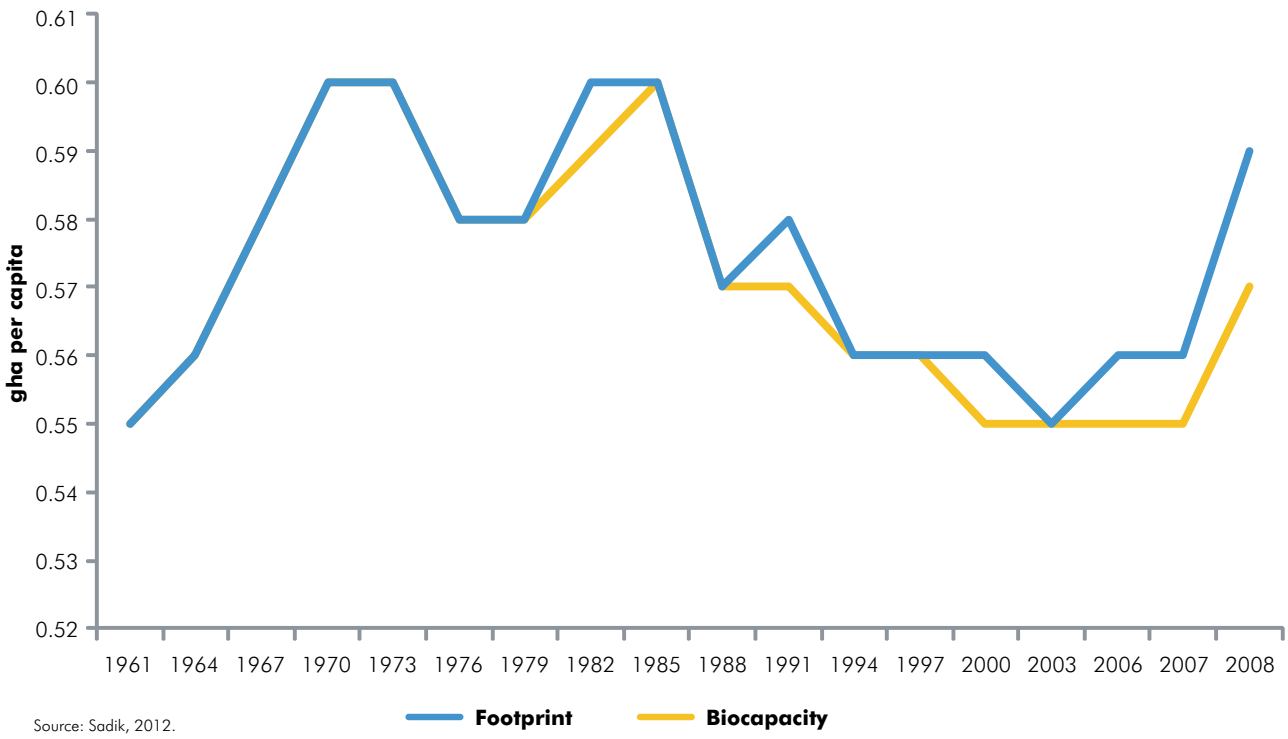
A survey prepared by the Global Footprint Network (GFN) on the Ecological Footprint of Arab countries explored resource constraints in Arab countries from the perspective of the

FIGURE 5 **CROPLAND ECOLOGIAL FOOTPRINT AND BIOCAPACITY IN ARAB COUNTRIES, (1961-2008)**



Source: Sadik, 2012.

FIGURE 6 **WORLD CROPLAND FOOTPRINT AND BIOCAPACITY (1961-2008)**



Source: Sadik, 2012.

regenerative capacity of nature. Nature›s capacity (biocapacity) and human demand on this capacity (footprint) are expressed in biologically productive land and sea areas with world average productivity expressed in a common unit of global hectares (gha), which allows comparisons among countries. Components of bio-productive areas include cropland, grazing land, forestland, marine and inland fishing grounds, carbon uptake land, and built-up areas (GFN/AFED, 2012).

The aforementioned survey covering the period 1961-2008 shows that since 1961 the gap between cropland bio-capacity (BC) and the Ecological Footprint (EF), representing consumption of cropland resources, has been widening as measured by globally productive areas per capita. While the gap between BC and EF was only 0.14 gha per capita in 1961, it moved with a rising trend, reaching 0.26 gha per capita in 2008 (Figure 5), compared with an almost balance between BC and EF at the world level over the same period (Figure 6). However, the gap at the Arab regional level disguised the wide variation in the gap at country level. In 2008, Bahrain, Djibouti, Jordan, Kuwait, Oman, Qatar, Saudi Arabia, and United Arab Emirates had a per capita EF several times greater than the per capita bio-capacity (Sadik, 2012).

WATER AND AGRICULTURE STRATEGY IN ABU DHABI: HOW IT CONTRIBUTES TO FOOD SECURITY

Razan Khalifa Al Mubarak

Abu Dhabi is "food secure", but due to the scarcity of natural water supplies, the paucity of fertile arable land and a population that has been growing rapidly since the 1970's, Abu Dhabi is not "food self-sufficient". Food security entails that all citizens and residents have access to enough food, both physically and economically, to meet their needs. As the world population continues to grow, and with it the demand for food and fresh water, how can the Arab world continue to be food secure and how can our domestic water and agricultural strategies contribute to food security?

Water resources in Abu Dhabi

In Abu Dhabi, there are three sources of water: groundwater which makes up 65 percent of our current supply; desalinated water which is our primary source of potable water making up around 30 percent of supply, and finally recycled water which counts for around 5 percent. Although the Emirate desalinates water, groundwater continues to be strategically important for agriculture and natural ecosystems, and is the only form of long term water storage. Eighty percent of this groundwater, or 58 percent of our total water supply, is currently used for agriculture (Environment Agency – Abu Dhabi, 2012).

However, groundwater in Abu Dhabi and much of the region is essentially a non-renewable resource. In Abu Dhabi, groundwater was laid down as long as 10,000 years ago after the last Ice Age, with around 80 percent of this water being saline and 20 percent being fresh or brackish. We refer to the fresh and brackish water as being usable. The natural recharge accounts for approximately 5 percent of the groundwater consumed on an annual basis.

As we use this water and because of our hyper arid environment and the resulting very low recharge rate, we are now seeing significant signs of depletion of our aquifers. In our most intensive agricultural areas, the groundwater levels are falling up to 5 meters per year, and as we use the fresh water, our aquifers are also becoming more saline (Environment Agency – Abu Dhabi, 2012).

A perfect storm in the water food nexus

We estimate that we have around 50 years of usable (fresh and brackish) groundwater left if we continue to use it at the current rate, but in some intensively irrigated areas the timeframe could be much shorter. If we continue down this path our groundwater aquifers will be exhausted of fresh and brackish water somewhere between 2060 and 2070, which coincides with the time that global populations are predicted to peak at around 9.5 billion, (although some researches think the population will continue to increase beyond 9.5 billion). This is not just a local challenge; according to UN Water, water availability is expected to decrease in many regions, yet water demand for agriculture alone is estimated to increase by 19 percent by 2050. The increase in global population and changing diets are estimated to lead to a 70 percent increase in demand for food by 2050. As a result, the global demand for food is likely to peak at the very time that availability of fresh water, both regionally and globally, is in serious decline.

Are we potentially looking at a "perfect storm" in the global water and food nexus?

If we are, this perfect storm will be felt acutely across the Arab region where populations are still growing rapidly, where natural fresh water is in short supply, and where food self-sufficiency is at a low level.

In addition, the predicted impact of climate change on both patterns of precipitation and crop yields adds another variable. The science is not exact and a number of predictions are emerging, but the mere fact that we are not sure how climate change may play a role suggests we should be cautious in our future planning.

If we assume that we are heading towards this perfect storm then how can we prepare for it?

Building resilience

To build resilience we need to do what we can immediately to optimise water use efficiency and minimise any wastage. This is not the final solution but will buy us time to undergo a shift in mind-set and to build real resilience in water and agricultural systems.

To build real long term resilience, water availability rather than water demand needs to be the starting point for future planning. For the majority of countries in the Arab region this will mean a reduction, and in some cases a significant reduction, in the volume of water we use. We need to determine a sustainable "water budget'" and allocate this across the different sectors within our economies taking into consideration the water,

food and energy nexus. For the Emirate of Abu Dhabi, where we do not have any surface water, this water budget should also include keeping some in storage, in the ground, to act as a buffer that we can rely on at times of real need in the future. This shift in mind-set and prioritisation of water use will involve difficult decisions and the need to identify trade-offs between one sector and another, but it seems sensible to make these decisions now while we have the opportunity to proactively plan and build a workable and sustainable solution.

Living within a "water budget"- Abu Dhabi as a case study

Depending on the definitions we use, a sustainable water budget could be made up of the desalinated water we generate today, the available recycled water and the volume of groundwater that naturally recharges (which is about 5 percent of the groundwater we consume today). Using this approach would conserve our remaining fresh and brackish groundwater to build resilience and act as a buffer for the future. This would leave us with a water budget of approximately 1,460 Mm^3 per annum. Our current use is 3,500 Mm^3 per annum, meaning today we are over using water by 60 percent.

In order to save our remaining fresh and brackish groundwater we will need to manage agricultural production with the available recycled water, the renewable element of groundwater and explore the option for increasing our utilisation of saline groundwater.

Saving groundwater makes sense not only from the water perspective but also from a food perspective. Currently Abu Dhabi's domestic food production contributes around 10 percent to our food requirements. This means that 90 percent of its food products are imported, and we will continue to be heavily reliant on imported food in the future. It is also currently cheaper to import food than it is to produce it domestically and therefore it makes sense to safeguard our water resources to enable us, if required, to increase agricultural production in the future in response to shortages in global food supply, and in case food imports become more expensive than domestic production. To enable this to happen we do not only need water to be available but we need to design a water-efficient agricultural system that can be scaled up at relatively short notice.

Desalinating more water to increase our available water budget is an option but comes with significant environmental and financial cost implications. It ties up the energy in the form of gas and some oil in the domestic market rather than being available for export, at a time when the global demand for energy will be very high. A preferred option would be to explore how we increase our water budget with less desalination by increasing the availability of recycled water and making use of saline groundwater.

The volume of desalinated water that is returned to our sewerage system to be treated and made available for reuse is very low at around 25-30 percent of all desalinated water supplied. Unlike countries in temperate regions that achieve around a 90 percent return to sewer rate, private gardens, parks and amenity plantations in Abu Dhabi are not rain-fed and they require irrigation. Because these are used for recreation or in areas where the groundwater is saline, desalinated water is often used. In order to increase the return to sewer rate we would need to rethink the volume of desalinated water allocated to irrigation as part of the trade-off discussion. We can also explore how we make greater use of saline groundwater through techniques such as biosaline agriculture. Saline groundwater is also a non-renewable resource but it is less strategically important than fresh groundwater, more limited in its potential uses, and we have four times as much saline groundwater as we do fresh and brackish groundwater.

Achieving food security

Food security in the future will be achieved through effective and fair international agreements and trade with food exporting countries, combined with the capacity to increase production domestically when food supply from food exporting countries is constrained.

These agreements and trade need to be spread across a number of countries and continents to guard against a failed harvest in one area due to challenges such as drought, flooding of large areas, disease or conflict, all of which are predicted to increase in frequency as climate change intensifies. We also need to be mindful that if there is a food shortage in a food exporting country, even if we have an agreement, countries will be prone to feed their own population before exporting.

In summary, food security in Abu Dhabi and the region is achieved, in different proportions, by a combination of domestic production and imported food. Moving forward, the demand for food and fresh water will only increase as both regional and global populations grow. We must act now through our water and agriculture strategies to optimise agricultural systems and to safeguard our water reserves to help us manage the "perfect storm" scenario should it arise in the future.

Razan Khalifa Al Mubarak, Secretary General, Environment Agency – Abu Dhabi.

TABLE 6 **ACTUAL RENEWABLE WATER RESOURCES (ARWR) PER CAPITA**

Country/Sub-Region	2011 ARWR (million M^3)	2011	2020	2030	2040	2050
		Per capita (M^3)				
Bahrain	116	83.36	76.92	70.13	65.98	64.41
Kuwait	20	6.92	5.89	4.99	4.32	3.87
Oman	1,410	482.10	428.57	391.34	376.10	377.01
Qatar	58	29.91	26.38	24.46	22.98	22.21
Saudi Arabia	2,410	83.61	71.87	62.63	57.13	53.63
United Arab Emirates	150	18.50	16.35	14.30	13.02	12.34
GCC	**4,164**	**93.38**	**78.42**	**68.70**	**62.74**	**59.14**
Yemen	2,110	82.13	65.46	51.04	41.17	34.27
GCC & Yemen	**6,274**	**89.35**	**73.52**	**61.54**	**53.34**	**47.54**
Iraq	89,831	2,666.00	2,104.56	1,625.69	1,302.84	1,077.67
Jordan	937	145.10	127.21	111.35	100.87	94.82
Lebanon	4,503	1,049.00	997.12	957.88	950.00	962.59
Occupied Palestinian Territory	837	196.00	157.42	123.91	101.70	86.05
Syria	16,810	795.50	698.12	603.40	543.64	508.61
Levant	**112,918**	**1,614.34**	**1,344.87**	**1,096.43**	**924.57**	**802.57**
Egypt	57,300	682.50	604.37	538.04	491.33	464.15
Sudan	64,510	1,411.00	1,174.64	964.91	816.00	709.20
Nile Valley	**121,810**	**939.35**	**813.54**	**702.67**	**622.50**	**568.11**
Algeria	11,670	319.80	290.44	268.43	256.54	250.85
Libya	710	108.20	100.24	91.22	84.93	80.93
Mauritania	11,410	3,147.00	2,654.72	2,194.23	1,856.49	1,610.44
Morocco	29,000	889.60	826.73	773.29	747.31	739.80
Tunisia	4,595	429.20	398.94	376.27	366.63	363.27
North Africa	**57,385**	**636.25**	**584.62**	**540.49**	**515.43**	**502.37**
Comoros	1,200	1,552.00	1,286.17	1,034.48	841.51	705.88
Djibouti	310	325.00	290.81	245.45	214.24	191.36
Somalia	14,700	1,500.00	1,201.27	898.53	678.39	520.96
African Horn	**16,210**	**1,406.26**	**1,138.66**	**863.01**	**660.50**	**514.00**
Arab Countries	**314,730**	**813.07**	**729.53**	**625.40**	**550.90**	**497.31**

Source: FAO, 2013, UN, 2012, and authors calculations.

It is interesting to note that cropland bio-capacity at the Arab regional level was maintained at about 0.30 gha per capita over 1961-2008, despite an increase of population of nearly 250 percent over the same period. This is explained by an increase of cropland bio-capacity on absolute basis, as a result of land expansion, in addition to increased productivity attributed to water use for irrigation. This pattern of stability in crop land bio-capacity in past years is not replicable in the future due to limited scope for land expansion, declining cropland area per person, and slower growth in crops yield, in addition to dwindling water resources (GFN/AFED, 2012).

B. State of Water Resources

The Arab region is the poorest region in the world in water resources, in absolute and per capita terms, mainly caused by the region's arid climate and the relatively high population growth. Water availability per capita varies widely among Arab countries, ranging between about 7 m^3 in Kuwait and 3,147 m^3 in Mauritania with a regional average of 813 m^3 in 2011 (Table 6). Actual renewable water resources (ARWR) per capita as illustrated in Table 6 were under the absolute water scarcity level of 500 m^3 in 13 countries. Water availability per person has been closely tied to population growth. Projected population growth in the Arab countries will lead to greater pressures on water resources, with a drop in regional per capita average to about 497 m^3, and a rise in the number of countries facing absolute water scarcity to 15 in 2050 (Table 6 and Figure 7).

The bulk of water withdrawals in the Arab region went to support agricultural irrigated areas of no more than 14.25 million ha (AOAD, 2012) which consume, on average, 85 percent of total water withdrawals with an average irrigation efficiency of 51 percent (Table 7), compared with a similar ratio of 72 percent in Northern Africa, 70 percent in East Asia, 67 percent in Eastern Europe, 57 percent in Northern America, and a World average of 56 percent (FAO, 2014b).

Withdrawal of freshwater for agriculture in seven countries exceeds by far their annual renewable water resources, ranging between 103 percent in Egypt and 2,460 percent in Kuwait (Table 8). These high percentages indicate the countries' heavy reliance on fossil groundwater and rapid depletion of both renewable and non-renewable water resources. In highly water-stressed countries such as those of GCC, Libya and Yemen, there are no prospects for increasing irrigated areas, or even maintaining irrigation in current areas.

According to FAO, countries are in a critical condition if they use more than 40 percent of their renewable water resources for agriculture, and could be defined as water-stressed if they abstract more than 20 percent of these resources (FAO, 2002).

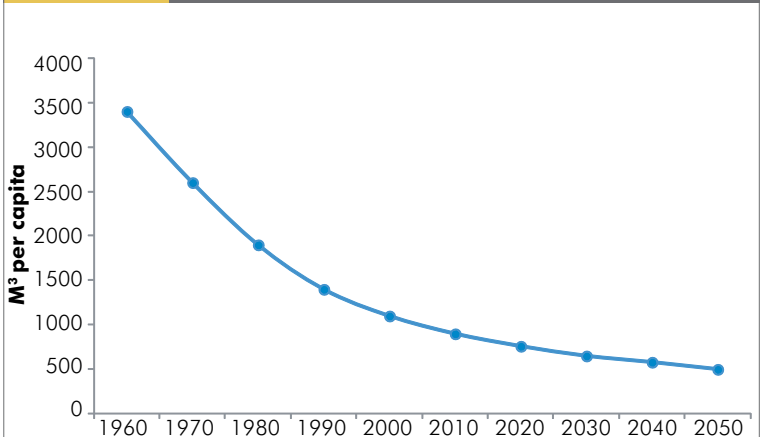
Based on this definition, most Arab countries are either in critical water condition, or are water-stressed. This is because abstraction from their renewable water resources for agriculture greatly overshoots the defined limits (Table 8).

For example intensive use of non-renewable groundwater for agriculture and depletion of aquifers in Saudi Arabia led to the reduction of the area under cereal cultivation from about 4.53 million ha in 1980 to only about 301 thousand ha in 2012 (FAO, 2013a). Consequently, the country adopted a decision in 2008 to gradually phase out all water-intensive agricultural crops by 2016 (FAO, 2014c).

IV. PROSPECTS FOR ENHANCING FOOD SECURITY

Water and food production are inextricably linked. Water scarcity, intensive use of water

FIGURE 7 **TREND IN FRESHWATER RESOURCES PER CAPITA IN ARAB COUNTRIES.**



Source: Adapted based on data in Table 6.

TABLE 7 **IRRIGATION EFFICIENCY RATIO**

Country/Sub-Region	Irrigation Water Requirement Million M^3/Yr *	Water Withdrawal Agriculture Million M^3/Yr *	Efficiency Ratio (%)
Bahrain	40	159	25.16
Kuwait	119	492	24.19
Oman	721	1,168	61.73
Qatar	76	262	29.01
Saudi Arabia	11,599	20,830	55.68
United Arab Emirates	1,815	3,312	54.80
GCC	**14,370**	**26,223**	**54.80**
Yemen	1,773	3,235	54.81
GCC & Yemen	**16,143**	**29,458**	**54.80**
Iraq	15,023	52,00	28.89
Jordan	301	611	49.26
Lebanon	529	780	67.82
Occupied Palestinian Territory	93	189	49.21
Syria	7,123	14,670	48.55
Levant	**23,069**	**68,250**	**33.80**
Egypt	45,111	59,000	76.46
Sudan	8,015	26,153	30.65
Nile Valley	**53,126**	**85,153**	**62.39**
Algeria	2,551	3,502	72.84
Libya	1,833	3,584	51.14
Mauritania	375	1,223	30.66
Morocco	5,823	11,010	52.89
Tunisia	1,552	2,165	71.69
North Africa	**12,134**	**21,484**	**56.48**
Comoros	-	-	-
Djibouti	51	85	60.00
Somalia	263	820	32.07
African Horn	**314**	**905**	**34.70**
Arab Region	**104,786**	**205,250**	**51.05**

* Year of data is different among countries, and covers the period 1990 for Iraq and 2006 for Kuwait.
Source: FAO, 2014a.

for agriculture, competition from domestic and industrial sectors on available water resources, and growth in water demand induced by population growth, in addition to rising incomes pose overwhelming challenges to food self-sufficiency in Arab countries. Nevertheless, they can still enhance their food security through implementing a number of options, supported by the adoption of right policies, practices and suitable technologies.

A. Improving Irrigation Efficiency

Improving irrigation efficiency to produce more crops with less water is an option of significant importance for enhancing food security in water-

TABLE 8 **PRESSURE ON WATER RESOURCES: WATER WITHDRAWAL AND USE IN AGRICULTURE**

Country/Sub-Region	Total Water Withdrawals Million M^3 *	Agriculture share of total withdrawals * (%)	Agriculture share of total renewable water resources (%)
Bahrain	357.4	44.54	137.20
Kuwait	913.2	53.87	2,460.00
Oman	1,321	88.42	83.43
Qatar	444	59.01	451.70
Saudi Arabia	23,670	88.00	867.91
United Arab Emirates	3,998	82.84	2,208.00
GCC	**30,703.6**	**85.41**	**629.15**
Yemen	3,565	90.74	154.00
GCC & Yemen	**34,268.6**	**85.96**	**469.53**
Iraq	66,000	78.79	57.87
Jordan	940.9	64.96	65.23
Lebanon	1,310	59.54	17.32
Occupied Palestinian Territory	418	45.22	22.58
Syria	16,760	87.53	87.32
Levant	**85,428.9**	**79.89**	**60.44**
Egypt	68,300	86.38	103.00
Sudan	27,590	94.78	40.54
Nile Valley	**95,890**	**88.80**	**69.90**
Algeria	5,723	61.19	30.01
Libya	4,326	82.85	517.00
Mauritania	1,350	90.59	10.73
Morocco	12,610	87.31	37.97
Tunisia	2,851	75.94	47.12
North Africa	**26,860**	**79.99**	**37.74**
Comoros	10	47.00	0.39
Djibouti	19	15.79	1.00
Somalia	3,298	99.48	22.32
African Horn	**3,327**	**98.85**	**20.29**
Arab countries	**245,774.5**	**84.48**	**65.97**

* Year of data is different among countries, and covers the period 1999 for Comoros and 2006 for Saudi Arabia.
Source: FAO, 2013, Table 7, and author's calculations.

scarce countries. Addressing water use efficiency could be a complicated task which requires the identification of the underlying principal factors that influence the efficiency of the components of the water delivery system, including water conveyance and water application in the field. FAO points out that conveyance efficiency is influenced by the length of canals and the soil type in which the canals are dug, and field application efficiency is mainly dependent on the irrigation method and the level of farmer discipline. Accordingly, it provides generally indicative values of the conveyance efficiency for adequately maintained earthen canals depending on soil type (sand, loam and clay) and canal length, in which case the efficiency ranges between 60 and 90 percent,

FOOD SECURITY CHOICES IN GCC STATES

Khaled Alrwis

Introduction

The world food price crisis of 2007-2008 caused an upsurge in the number of people suffering food shortage to almost one billion and, hence, an increase in a looming famine problem for 30 developing countries. The Arab countries were not insulated in the world; the crisis exacerbated the food gap by 20 billion dollars in the Arab world and threatened a further, larger increase in light of more demand and higher prices. Therefore, the issue of Arab food security became a priority in these countries. Since Arab Gulf states were keen to eschew that crisis, they developed a vision to face the food crisis by taking government procedures capable of providing prosperous living conditions for the region and its inhabitants and safeguard food security for them. The move culminated in the announcement of King Abdullah's Initiative for Saudi Agricultural Investment Abroad and Qatar's National Plan for Food Security. These initiatives sought to deal with the increase in food commodities and goods, and to create safe strategic stocks of basic food commodities such as rice, wheat, corn, soybeans and livestock. The goal was to provide food security, circumvent food crises in the future, stabilize food prices throughout the year, and limit commercial speculation of agricultural commodities.

Food Security in GCC States

Food security in Gulf Cooperation Council (GCC) states is an important strategic goal sought by their respective governments for many reasons, including supply-and-demand factors and agricultural policies. Feeling the extent of negative economic, social and developmental impacts, these states have made extraordinary efforts to decrease the food gap and provide food security. Hence, it is imperative for these states to plan a joint food security strategy for the future. The execution of such a strategy requires cooperation between the public and private sectors, diagnosis of the food security crisis and its causes, and envisioning the roles of the public and private sectors in providing food and dealing with food shortage and its social and economic impacts. Eventually, a joint Gulf food security policy should be reached.

Food Security Strategies for Arab Gulf States

Domestic Production

It is imperative for GCC states to rely increasingly on their own resources, with a focus on agricultural, livestock and fish products with relative advantages in terms of water consumption (greenhouses, poultry, fish and dates). They are urged to develop joint agricultural mechanisms and increase domestic agricultural investments in products with relative advantages in terms of water consumption.

GCC ECONOMIC FACTS IN 2014

		KSA	Kuwait	Oman	Bahrain	Qatar
Population (million)		29.0	3.8	3.1	1.2	1.8
GDP (PPP) ($ billion)		906.8	151.0	90.1	33.1	187.9
GDP (PPP)	**Growth (%)**	6.80	5.10	5.00	3.90	6.60
	5-year compound annual growth(%)	6.60	0.80	6.30	4.00	13.10
	Per capita ($)	31,275	39,889	29,166	28,744	102,211
Unemployment rate (%)		10.60	2.10	15.00	3.40	0.50
Inflation (CPI) (%)		2.90	2.90	2.90	1.20	1.90
FDI Inflow ($ billion)		12.2	1.9	1.5	891.2	326.9

GCC Imports of Food Commodities

GCC states should measure their food gap according to accurate data and statistics, while coordinating a joint GCC policy in this regard.

Food Security Investments Abroad

These investments must focus on agricultural commodities that cannot be produced domestically (wheat, barley, corn, soybeans, sugar, rice, powdered milk, green feed and red meats). Joint framework agreements are needed to regulate agricultural investments abroad, as well as the establishment of a Gulf holding company or companies that invest inside and outside of GCC states. Mechanisms are needed to expand the ownership base of existing agricultural companies in GCC states, alongside evaluations of joint GCC trends in terms of investment and the provision of credit facilities and concessional funding for Gulf investors outside the region. It is imperative to provide contributions into necessary infrastructure projects in important agricultural investment regions abroad. Special mechanisms are needed to regulate contracting with companies with investments abroad in order to purchase their products that are tied to GCC food security. Joint purchases must be preferred, while international food processing companies should be attracted to the region.

A Joint Emergency Plan for dealing with Food Shortages in GCC States

To stabilize food supply, it is imperative for GCC states to have a joint emergency plan capable of dealing with the possibility of food shortages in emergencies and unsuitable weather and environmental conditions in these states. The plan should include the creation of strategic reserve stocks. However, the administration and creation of strategic stocks requires the establishment of a higher agency with an organizational and legal framework; both the public (the ministries of agriculture, trade, industry and finance and investment bodies) and the private sectors should participate in this agency, while a research administration should be attached to the agency to prepare strategic stock studies, estimates of surpluses and deficits, readings of foreign markets, plans for import sources, and appraisals of the costs of imports needed for the creation of strategic stocks. Special measures should be taken in order to create the strategic stock from imports and agricultural investments abroad. Requirements also include constructing storage capacities for the most important strategic commodities, making available suitable equipment and stores, and encouraging major Gulf merchants and importers to participate in recycling and refurbishing the strategic stock. It is possible to take advantage of available storage capacities in Gulf ports, especially in Kuwait and the United Arab Emirates, while GCC states can play a key role in encouraging re-export and transit of various commodities they import and making the most of their advantageous position between Asia and Africa.

GCC states should fire up their joint food agricultural production program agreed upon in the GCC. The program provides for making material and institutional support available for the private sector in order for it to enhance its investments and investment efficiency in producing agricultural inputs and agricultural marketing and processing. It also supports the provision of stabilizing conditions by giving a larger role to existing GCC funding and agricultural production companies in establishing agricultural projects in member states (projects involving processing, marketing, transportation and making available agricultural, livestock, poultry and fish production requirements). Furthermore, the program involves the creation of standardized specifications of agricultural, livestock and fish products.

GCC Food Security Mechanism

1- Planning a joint GCC food security strategy with the participation of involved governmental and societal bodies.
2- Contributing to monitoring GCC food security's development on personal, household, regional and world levels and creating an information database for involved research and executive bodies.
3- Studying overlaps and intersections between macroeconomic development and food security while taking into consideration the impact of economic reform programs on production, consumption, exports, imports, labor, surpluses in foreign currencies, etc. by using the partial equilibrium model.
4- Monitoring supply-demand developments in terms of the most important agricultural commodities and calculating the periods of adequate production, imports' coverage of domestic consumption, the amount of surplus and deficit in domestic consumption, and the development of self-sufficiency's percentage for the most important

agricultural commodities between 1990 and 2012, and its expected percentage by 2035.

5- Contributing to the estimate of the strategic stock administration's current and expected scope, position and methods in terms of the most important food commodities, and estimating the cost of imports needed for creating and recycling these stocks by 2035.
6- Studying national, regional and world food security aspects and other nations' experiences in food security policies and mechanisms and comparing them with their GCC parallels.
7- Studying relations between food security and water security/efficiency in exploiting water resources.
8- Studying the food aspects of high GCC consumption modes, both current and expected by 2035.
9- Studying the effects of pricing, marketing and financing agricultural policies on developing food security.
10- Studying current subsidy and aid policies and proposing social safety nets to support poor groups that are most targeted in food security targets.
11- Studying the anticipated impacts of climate change on the productivity of various agricultural activities and consequently on household and national food security.
12- Studying the prospects of developing agricultural social solidarity systems, early warning systems and other systems of risk administration in order to develop food security.
13- Measuring instability coefficients in factors influencing production, consumption, exports and imports in terms of the most important food agricultural commodities, as well as income variations among GCC states.
14- Studying overlaps among food security, poverty, rural development and the policies and mechanisms that are needed to protect targeted groups.
15- Supporting and encouraging cooperation among GCC states and specialized international organizations, bodies and centers, such as the Food and Agriculture Organization (FAO), the International Fund for Agricultural Development (IFAD), the Arab Organization for Agricultural Development (AOAD), the International Center for Agricultural Research in the Dry Areas (ICARDA), the Arab Center for the Studies of Arid Zones and Arid Lands (ACSAD), and the Consultative Group on International Agricultural Research (CGIAR).

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while the indicative value for the conveyance of lined canals is independent of canals length and averages 95 percent (FAO,1989).

As regards the field application efficiency the indicative values reported by FAO stand at 60 percent, 75 percent, and 90 percent as per irrigation methods classified as surface irrigation (border, furrow, basin) sprinkler, and drip irrigation, respectively (FAO, 1989). Thus, notwithstanding the difficulty of formulating universally applicable solutions to water efficiency it is often possible to derive benefits through making the right decisions regarding irrigation practices, including selection of crop type, irrigation scheduling, irrigation methods, and source of water for irrigation (AFED, 2010).

More importantly, improving irrigation efficiency, coupled with best farming practices and the application of an optional mix of agricultural inputs, not only produce a crop with less water, but more of it, as a result of improving both the irrigation efficiency and water productivity.

Given that water is not the only factor in the production of crops, but also other inputs as well as the energy consumption associated with water delivery and other processes in food production, the benefits of water use efficiency and water productivity can be far more than water savings per se. Other benefits include reduction of energy costs, lower cost of crop production, less greenhouse emissions, and more price competitive crops.

Therefore, the interdependencies between water, energy and food security form a nexus that advocates a coherent policy approach across different sectors to ensure the efficient use of the scarce resources devoted to food production.

With the exception of Egypt, Algeria, and Tunisia, irrigation efficiency in all other Arab countries is below 70 percent, and agriculture consumes about 140,580 million m^3 (Table 7), to irrigate an area of about 9.32 million ha. (AOAD, 2012). In these countries, irrigation consumes an average of about 15,084 m^3 per ha, with irrigation efficiency of about 46 percent.

Raising irrigation efficiency to 70 percent in these countries would save about 50 billion m^3 of water, enough to produce over 30 million tons of cereals, equivalent to 45 percent of cereal imports with a value of about US$11.25 billion at 2011 import prices.

B. Boosting Crop Productivity

Crop productivity in the Arab region is generally low, particularly that of staple cereals whose productivity lagged behind the world average over the last five decades, reaching about 2,044 kg/ha, compared to a world average of 3,619 kg/ha in 2012 (Table 5).

Excluding Egypt in which cereal productivity is way above the world average at 7,269 kg/ha, all other Arab countries stand to greatly enhance their cereal self-sufficiency through boosting cereal yield. If only five major cereal producers other than Egypt (Iraq, Algeria, Morocco, Sudan and Syria) in which cereal yield averaged 1,132.8 kg/ha in 2012 were able to boost cereal yield to the world average, their combined cereal production would rise from the current level of about 21 million tons to about 68 million tons in the future, or an increase of about 47 million tons over current production.

On-going research by the International Center for Agricultural Research in the Dry Areas (ICARDA) supported by funding from four Arab national and regional development institutions, namely; the Arab Fund for Economic and Social Development (AFESD), Kuwait Fund for Arab Economic Development (KFAED), Islamic Development Bank (IDB), and OPEC Fund for International Development (OFID) shows encouraging results on wheat production in some Arab countries. The completed first phase (2011-2012) season showed considerable increase at demonstration fields versus farmers' fields in both irrigated and rain-fed wheat systems. Average increase ranged between 11 percent in Morocco and 58 percent in Sudan in irrigated systems, and between 20 percent in rain-fed systems in Syria and 30 percent in Tunisia. Raised bed planting in Egypt resulted in 30 percent increase in grain yield, 25 percent saving in irrigation water, and 72 percent in water use efficiency (Solh, 2013).

These results provide strong evidence of the importance of agricultural research to food self-sufficiency in Arab countries. If ICARDA's results on wheat yield are disseminated to farmers on a large scale, with the introduction of farming practices as applied in demonstration fields, the prospects for increasing production in wheat producing Arab countries are very promising. Scarce water resources in the region limit expansion of irrigated systems and call for further development of rain-fed systems.

C. Improving Rain-fed Crop Productivity

Rain-fed agriculture still supplies some 60 percent of the world's food, and improving its productivity would make a significant impact on global food production (FAO, 2002b). Rain-fed agriculture in the Arab region is practiced on nearly 75 percent of the cultivated area (AOAD, 2012). Productivity of such crops as cereals in rain-fed land is very low compared to that in irrigated areas as illustrated in Figure 8 in six Arab countries.

In Morocco, Sudan, Syria, and Tunisia, rain-fed cereal productivity ranges between 0.5 ton/ha in Sudan and 0.9 ton/ha in Tunisia. On the other hand, irrigated cereal yield ranges between 1.9 ton/ha in Sudan and 7.5 ton/ha in Egypt. Cereal production in most Arab countries is largely dependent on rain-fed systems. Improving rain-fed cereal yield is of paramount significance to enhancing self-sufficiency in cereals.

FAO points out that the potential to improve yields depends strongly on rainfall patterns, yet in dry areas, rainwater harvesting can both reduce risk and increase yields. It refers to various forms of rainwater harvesting including in situ water conservation, flood irrigation, and storage for supplementary irrigation. Work in some developing countries, including Sudan has shown that yields can be increased two to three times through rainwater harvesting, as compared with conventional dry farming (FAO, 2002).

FAO's AQUASTAT database shows that the latest value of the cereal irrigated area in Arab countries amounted to about 7.5 million ha (FAO, 2013). The total area cultivated with cereals amounted to about 25.8 million ha in 2012 (Table 5). It can be deduced that about 18.3 million ha are under rain-fed cereal production, with an average

THE GREEN MOROCCO PLAN: AN INNOVATIVE STRATEGY OF AGRICULTURAL DEVELOPMENT

Mohamed Badraoui

In Morocco, agriculture is a strategic sector, economically and socially. It plays major roles in terms of food security and nutrition, supply for agro-industry, employment, integration into the international markets, stabilization of populations in rural areas, and sustainable development.

Main Features of Agriculture in Morocco

Food supply in Morocco, which is a major component of food security, depends mainly on rainfall. Agricultural production is challenged by extreme large inter-annual variation in rainfall. Irrigation is provided only for 16 percent of croplands, leading to little flexibility for weather risk mitigation and crop improvement. Long term average rainfall in Morocco is around 365 mm, varying from a minimum of 198 mm recorded in 1994-1995, to a maximum of 610 mm recorded in the 2009-2010 season. Also, rainfall distribution between seasons is skewed, since most of the seasons display under average precipitation. Most of the rainfall in Morocco is received between the months of October and April, which is a short period for crop growth and development.

In Morocco, as in most of the Mediterranean countries, the cereal production system (cereals/food legumes) is predominant. In arid areas, the cereal/fallow sub-system is dominant, with very little room for spring crops. Olive tree plantations cover an area of about 980,000 ha, or nearly 65 percent of the national tree orchard.

The correlation between Gross Domestic Product (GDP) and agricultural GDP (AGDP) is very high. AGDP contributed to 18 percent of the GDP on average for the period of 1980-2010 (in current prices), with extremes of 23.3 percent in 1991 and 13.3 percent in 2000. However, contribution of AGDP to GDP has been declining since the early 1990s, from 16 percent on average over the period 2000-2010. Agriculture (including fisheries) is the first economic sector providing employment (38 percent of national employment and 75 percent of employment in rural areas). The agricultural sector also contributes to reducing the rural exodus and to socio-political stability. Winter cereals (soft wheat, durum wheat and barley) contribute nearly half (47 percent on average) of agricultural added value since they cover most of agricultural lands (5.1 million hectares in average). Livestock is the second contributor to AGDP (31 percent), but is closely linked to the cereal system. During dry seasons, the contribution of livestock to AGDP increases compared to other activities (38 percent in 1981 and 39 percent in 1995 and 42 percent in 2000), attesting the role of livestock in the climate risk management system of farmers.

AGDP (excluding fisheries) is highly dependent on the weather. Due to the economic importance of the agricultural sector, any rainfall deficit or excess immediately affects the entire economy. Weather also impacts cereal imports, since the import/production ratio can range from 10 percent (in 1994-1995, following the good season of 1993-1994) to 244 percent (in 2000-2001, following the dry season of 1999-2000).

Productivity of major crops is improving in irrigated areas as a consequence of increasing the use of inputs. However, in rainfed areas productivity is still evolving erratically, concurrently with weather conditions. The ratio between yields of major crops and cumulated rainfall during the cropping season shows that, so far, efforts have had limited significant impacts on rainfed productivity in the medium term, despite significant yield improvement at the research level. In fact, improvement of rainfed crop productivity is difficult, and requires deep measures to adapt to irregular and dry climate, mainly through technological transfer of efficient technologies already available in Morocco, training of farmers, and development of agro-meteorological services.

Reducing Agricultural Weather Related Risks

The provisions of preparedness and response to weather risks, taken by the Moroccan government, aimed at reducing vulnerability to drought and buffer crop productivity. These provisions are structural (dams, irrigation systems, land use planning, etc.), and non-structural (adaptation measures, drought insurance, solidarity funds). They can be summarized as:

- Development of water storage infrastructure and distribution of irrigation water;
- Upstream protection of water resources;
- Expansion of irrigated areas;
- Improvement of the efficiency of irrigation water use;
- Improvement of agricultural yields, through improvement of agricultural inputs (certified seeds and fertilizers);
- Optimization of land resources;

- Mobilization of non-conventional water;
- Adaptation to climate change through the use of water economy technologies;
- Agricultural insurance against climatic hazards.

Green Moroccan Plan

The Green Moroccan Plan (GMP), launched in 2008, is the governmental strategy which aims to stimulate the agricultural sector. It intends to reform agriculture and promote its integration in the international market, and heighten sustainable growth. The implementation of the GMP is based on two pillars and several cross cutting programs. The first pillar concerns the highly productive, intensive and market connected agriculture, and the second pillar concerns the strengthening of small holder farmers by promoting intensification of crops where appropriate, and the reconversion to more adapted crops with respect to ecological conditions and markets demand. The cross-cutting programs deal with water economy, land tenure, farmers organization, market access, free trade agreements in which Morocco is involved, and investment mobilization. In total, the GMP is made of 1500 projects requiring more than 10 billion USD for implementation until 2020.

Selected programs implemented by the GMP to improve productivity and food security under climate change are presented below:

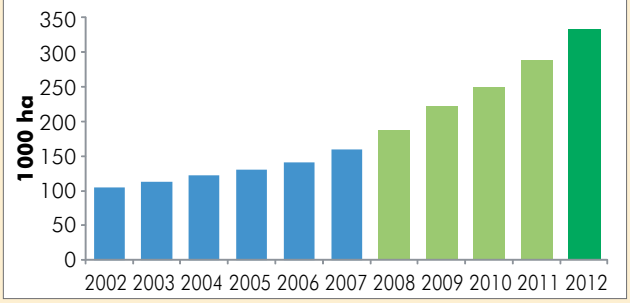
The National Irrigation Water Saving Program

The National Irrigation Water Saving Program (PNEEI) is considered to be one of the main programs of the GMP, since still 77 percent of irrigated areas are surface irrigated (MAPM, 2012). The PNEEI aims at saving water irrigation through the conversion of surface irrigation to drip irrigation on nearly 550,000 ha towards 2020, with an investment of 4.5 billion USD. Up to 2012, 333,000 hectares have already been converted (MAPM, 2012) (Figure). It is expected that after completion of this program, Morocco will have 700,000 ha under the drip irrigation system. To promote water economy, the government is subsidizing the equipment of farms by drip irrigation and procurement of seeds and plants of adapted crops.

Integration of Climate Change Measures in the GMP

Climate change will lead to decreasing agricultural yields for major crops and increasing variability of agricultural production. The GMP has launched many projects for adaptation to climate change. The project "Integrating

TREND OF AREAS UNDER DRIP IRRIGATION IN MOROCCO (MAPM, 2012)



Climate Change in the implementation of the 'Plan Maroc Vert'"(PICCPMV) is an ongoing project (2011-2015), aimed at promoting adaptation to climate change in five regions of Morocco. The main technologies being adopted at large scale are the conservation agriculture system based on no till, the use of certified seeds of productive varieties tolerant to drought, and the adoption of crop rotation by farmers using pulses and/or oil seed crops after cereals. This program concerns 900 small farmers in these regions and was presented as a success story at the Conference of the Parties (COP 18) in Doha.

Reconversion of Cereals to Fruit Tree Program

The objective of this program is to convert 1.1 million ha of land cultivated by cereals in non-suitable areas to fruit trees, especially olive trees. Land suitability maps are used to select those areas to be reconverted. The program is implemented in arid and sloppy land to promote more soil and water conservation. Under this program small holder farmers are being organized into cooperatives and groups of economic interest to promote their connection and entry to the market and get the maximum from the added value of their products.

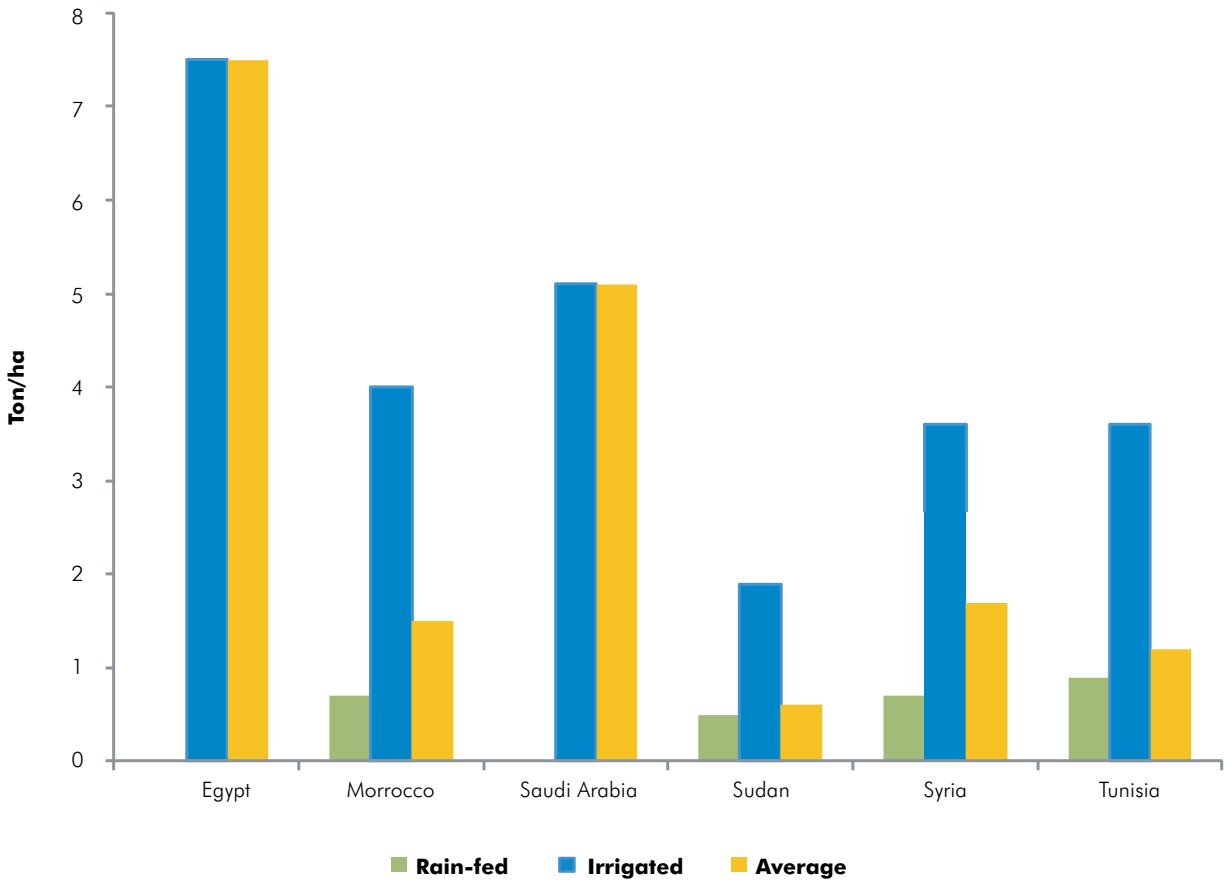
Agricultural Insurance

The "Climate casualty insurance" program, launched in 2011 by the Ministry of agriculture, came to replace the drought insurance program launched in 1996. It aims at protecting small farmers to climatic risks, in particular:

- Reducing weather risks to agriculture;
- Promoting access to finance;
- Promoting investment and increasing crop productivity;
- Contributing to the development of modern agriculture with high added value ;
- Promoting solidarity and smallholder agriculture.

Prof. Mohamed Badraoui, Director General of the Institut National de la Recherche Agronomique (INRA), Morocco.

FIGURE 8 **PRODUCTIVITY OF RAIN-FED AND IRRIGATED CEREAL IN SELECTED ARAB COUNTRIES**



Source: GSLAS et al., 2011.

yield of about 0.8 ton/ha. Improving rain-fed cereal productivity in the Arab region two to three times has the potential of increasing cereal production by about 15 to 30 million tons, or an average of about 23 million tons. This is an increase of about 45 percent in current cereal production of about 51 million tons (Table 5). These rough calculations representing an order of magnitude are indicative of the considerable potential for enhancing cereal self-sufficiency through research and investment in rain-fed agriculture, the application of best agricultural practices, and good management of the available agricultural resources.

D. Improving Water Productivity

Maximizing the productivity of water used for food production, especially in water-scarce countries, is an option of significant importance to enhancing food security. Water productivity measures the conversion of water into either the quantity of the crop produced per cubic meter of water (kg/m^3), or the monetary value of the crop produced per cubic meter of water (\$/M^3). Thus, water productivity is measured either in physical or economic terms.

Economic water productivity considers allocation of water to higher value crops, whereas, physical water productivity disregards crop value and focuses on 'more crop per drop'. The choice between those two water productivity indicators is country specific. It depends on whether crop quantity or crop value is more relevant to a country within the broader political, economic, social, and environmental aspects of food security.

Improving crop yields is a key option for

enhancing self-sufficiency in such staple food as cereals. However, it is important to note that maximizing crop water productivity requires complementing and reinforcing water with a composite of factors, such as the adoption of efficient and modern irrigation schemes, coupled with best farming practices and improved inputs conducive to agricultural sustainability. "There are various kinds of improved agricultural practices, such as drip and sprinkler irrigation, no-till farming and improved drainage, utilization of the best available germplasm or other seed development, optimizing fertilizer use, innovative crop protection technologies and extension services" (FutureWater, 2011).

Moreover, farming practices such as water harvesting, deficit irrigation, water conservation, and organic agriculture are not only conducive to raising water productivity, but they are also significantly important for agricultural sustainability

E. Reducing Post-Harvest Losses

A significant amount of food produced in the world for human consumption is lost or wasted throughout the food supply chain. It is estimated that roughly about one-third of the edible components of food produced for human consumption, equivalent to about 1.3 billion tons per year is lost or wasted globally (FAO, 2011). Growth in population, higher pressure on limited land and water resources, rising demand for food, and the spike in food prices prompted by the recent food crisis triggered greater attention at global, regional and national levels to issues concerning food security, focusing, among other things, on post-harvest losses in food production.

Post-harvest losses (PHL) occur across all food products, with varying quantities and values, but their impact on food security can be much greater in food-deficit countries and major consumers of such food commodities as cereals. The latter constitute the main staple food in the Arab region, the largest importer of cereals in the world.

It is estimated that the annual losses of grains in Arab countries represent about 13 percent of the total regional cereal production (Al-Zadjali, 2013). This percentage translates into a loss of about 6.6 million tons of cereal production, which amounted to about 51 million tons in the Arab region in 2012 (Table 5).

In addition, loss in imported wheat in some Arab countries can be as high as 5 percent (World Bank and FAO, 2012). An average loss of imported wheat in Arab countries would translate to about 3.3 million tons, with a value of about US$1 billion. The combined loss value of cereals PHL and imported wheat amount to about US$3.5 billion in 2011 import prices.

The main causes of these losses can be attributed to the improper methods of harvesting, processing, transportation, and storage of the crops, as well as due to inefficient import supply chain logistics. Given the importance of cereals to food security in the Arab region, a reduction in cereal losses along the food supply chain cannot be overemphasized, because these losses represent not only a waste in food supply and other natural resources, including land, water, energy, fertilizers, pesticides, and labor, but also can cause damage to the environment, arising from greenhouse gas emissions.

The recent food crisis prompted new interest in effective actions against PHL, because the investment required to reduce PHL is relatively modest, compared with the return on that investment which rises rapidly in response to increases in the price of the commodity (World Bank et.al,2011a).

The widening food gap in Arab countries under conditions of land and water constraints calls for greater attention to the reduction of food losses throughout the food supply chain, for incorporation in an integrated approach for the full realization of the agricultural potential.

F. Water Reuse

Wastewater is increasingly becoming a source for use in agriculture worldwide (World Bank, 2010). Wastewater reuse in water-stressed countries such as the Arab countries holds the potential to reduce water scarcity and expand the irrigated area for food production. However, unless wastewater is treated to suitable levels, its use for agriculture poses serious risks to public health and the environment.

Municipal wastewater (domestic and industrial) produced in the Arab region amounts to about 14,310 million m^3, of which about 6,872 million m^3 are treated (FAO, 2013), representing 48 percent of the total production, with the remaining amount discharged without treatment. A modest amount of treated wastewater is used for agriculture in the Arab countries. For example, Egypt, Jordan, Morocco, and Tunisia) use only about 9 percent of treated wastewater for irrigation. The six GCC countries use 1.4 million m^3 per day of treated wastewater for agriculture (World Bank, 2010), amounting to 511 million m^3/ per year which constitutes almost 37.3 percent of the total treated wastewater of about 1,370 million m^3 per year (FAO, 2013).

The higher percentage of treated wastewater used for agriculture in GCC countries than in other Arab counties is prompted by the severe scarcity of freshwater resources, and the enormous pressure impacted on them through withdrawal for agricultural use, in addition to adopting improved treatment standards to ensure safe use of treated wastewater.

In general, despite the high pressure imposed by irrigation on freshwater resources in most Arab countries, yet the potential of wastewater remains largely untapped for agricultural use. The availability of water for irrigation, among other things, reduces demand for reclaimed water. When farmers have to choose between reclaimed water and the freshwater alternative, they consistently prefer the latter in spite of higher costs. Their choice is driven by social stigma and restrictions on water reuse in crop production (World Bank et al. 2011).

In the Arab region where food production is heavily dependent on rain-fed agriculture, scarce freshwater resources are declining rapidly, the alternative of water reuse for irrigation should be encouraged and supported to take advantage of its benefits. "Converting from rain-fed to irrigated agriculture can increase yields of most crops by 100 to 400 percent and can permit the growth of different crops with higher income value" (FAO, 2010).

The limited reuse of wastewater in general and for agriculture, in particular, in the Arab region can be attributed to economic, health, institutional and environmental issues. Promoting water reuse requires adhering to guidelines and adopting strategies conducive to sustainable safe wastewater reuse, supported by a management approach to raise public awareness, establish confidence, and new altitudes towards water reuse. It is reported that countries including Tunisia, Jordan, and Gulf States which have made significant strides with water reuse, their fully-fledged local or state regulations have been supported by national guidelines and the setting of basic conditions of wastewater treatment and safe reuse (World Bank, et al. 2011).

G. Virtual Water

The concept of virtual water refers to the embedded water in the production of agricultural products. It postulates an option for water-scarce countries to counter food security issues by importing water-intensive food products, and using their limited internal water resources for the production of high-value and less water-intensive commodities. It is basically an economic thesis that does not address the broader political, social and environmental aspects of food security.

In this regard, the virtual water concept as a policy tool for addressing the water-food nexus overlooks the reality that the world market is not a level playing field. It neither recognizes the relevant concerns over international trade policies in agricultural products, nor the impact of the policy on agricultural development and the livelihoods of the farming communities in food importing countries.

Nevertheless, despite the cited reservations regarding the virtual water concept, it remains useful in the context of a country's water situation, and the overall role of agriculture in economic and social development.

H. Adapting To Climate Change

Food production in the Arab region is constrained by limited land and scarce water resources. It is likely to be further compromised by climate change which is predicted to invariably affect regions and countries across the globe, albeit with varying degrees. "It is no longer a question of whether or not climate change is happening.

The question now is how climate change will manifest itself regionally and locally and what can be done about it" (Tolba and Saab, 2009).

The impact of climate change on food security in the Arab region, in particular, is predicted to manifest itself mainly through its effect on land and water resources. Those countries in the Arab world which are already experiencing water stress are likely to face further declines in agricultural yields which adversely affect rural incomes and food security (Verner, 2013).

Crop productivity is key to enhancing food supply in Arab countries. Preliminary estimates of climate change impact on crop yields have already been reported in some studies. For example, it is predicted that in Egypt climate change will cause a reduction in the productivity (ton/acre) of rice by 11 percent, barely by 18 percent, corn by 19 percent, and wheat by 18 percent by 2030, compared to the base year 2006 (AOAD, 2010). Furthermore, warnings have been issued of the dangerous impact of climate change on the mostly rain-fed agriculture in Arab countries, as rain-fed crop yields are expected to fluctuate increasingly over time with a declining trend, decreasing by an overall average of 20 percent in Arab counties and by almost 40 percent in Algeria and Morocco (World Bank et al. 2009).

Agriculture productivity, especially in rain-fed areas is vital to increasing food production in the Arab region, climate change can be a serious drawback in an already precarious state of agricultural resources. The daunting challenge for Arab countries is how to produce more food from existing cropland and water resources, in a changing climate.

The linkage between climate change and food security needs to be recognized and addressed as agriculture is predicated to be seriously threatened by a changing climate. Obviously, Arab countries need to implement mitigation and adaptation polices and measures based on validated country weather data and relevant prediction models.

I. Intra-Regional Cooperation

Varying land and water resources endowments in the Arab region provide an important

alternative to enhance food security based on exploiting the existing comparative advantage in food production. Arab countries have over the past decades expressed their willingness to promote Arab cooperation to advance regional food security.

Nevertheless, AOAD points out that over the past decades agricultural economic policies were designed at country level in the Arab region, while narrowly taking into consideration the Pan-Arab dimension. With the exception of the Gulf Cooperation Council (GCC) coordination of Arab economic and agricultural policies were minimal. Experience proved that Arab agriculture suffered heavy damages due to lack of coordination policies in respect of production and exploitation of land and water resources, in addition to weak coordination of trade policies (AOAD and LAS, 2007).

To be effective, intra-regional cooperation in food security requires an approach based on the harmonization of national agricultural strategies and policies, implementation of agricultural practices, regulations, measures and incentives conducive to the efficient use of resources with special attention to the improvement of the management of shared regional water resources. Conservation of the productive bio-capacity of land and water resources is a pre-requisite for agricultural sustainability which is the cornerstone for food production at the national, sub-regional, and regional levels.

While availability of food is only one pillar of food security, facilitation of intra-regional agricultural trade through reduction or elimination of trade barriers, improved marketing information, and provision of infrastructure for communication and transport are of critical importance for accessibility to food.

J. Inter-Regional Cooperation

As large importers of food, especially in cereal staples, the Arab and African regions possess common grounds for an effective cooperation to enhance food security. Prospects for reducing the gap in their food security lie in their geographical proximity and complementarity of their comparative advantages. The African region is endowed with relatively abundant land and water resources which remain mostly untapped. Arable land in use in 1997/99 (228 million ha) in Sub-Saharan Africa averaged only 22 percent of land potential, with a balance of 803 million ha of arable land. The irrigated area averaged 5 million ha over the same period, equivalent to 2 percent of the arable area in use, and an irrigation water withdrawal of 2 percent of total renewable water resources, amounting to 3,450 billion m^3 (FAO, 2002a).

On the other side, expansion of arable land in the Arab region is limited to less than 3 million ha (Solh, 2013), and the scarce natural water resources are currently overstressed by irrigation which consumes 66 percent of the said resources (Table 8). Recognizing their agricultural resources constraints, and exposure of their food security to vulnerability of future food supplies and food prices in world markets, some Arab countries with investable capital were prompted to outsource food production abroad, in countries endowed with abundant land and water resources, including in the African region. It is reported that Bahrain, Egypt, Jordan, Kuwait, Libya, Qatar, Saudi Arabia, and United Arab Emirates have already acquired land in other Arab or non-Arab countries in both the Arab and African regions. The land area acquired by these countries amounted to 7.462 million ha to be used for the production of various crops, with cereals (wheat, rice, and maize) accounting for a major share of the acquired area (UNEP, 2011).

V. CONCLUSION AND RECOMMENDATIONS

Arab countries have been targeting food self-sufficiency over the past several decades, but currently their food security remains heavily dependent on external sources. As the world's largest importers of cereals, the main staple food in Arab countries, the food crisis in 2007-2008 and its associated repercussions reignited interest in Arab food security, with top priority given to domestic production.

In their endeavor to enhance food self-sufficiency, Arab countries confront serious challenges due to limited land and scarce water resources, burdened by a heavy footprint which undermined their bio-capacity to regenerate their services and maintain agricultural sustainability.

Notwithstanding the limited and impoverished state of agricultural resources, there remain considerable prospects for enhancing food self-sufficiency through a number of options within an all-inclusive approach conducive to agricultural sustainability, in addition to considering further alternatives in the context of the broader food security perspective. With no-size-fits-all approach, a set of recommendations, borne of the need to foster stewardship and informed policy and decision-making in the quest to ensure food security are described hereunder as follows:

a. Adoption of policies, farming practices, and adapted technologies within a framework of laws, rules and regulations conducive to the efficient and sustainable utilization of land and water resources to ensure regenerating their ecological, economic, social, and environmental services.

b. Adoption of a holistic and integrated approach to food-water-energy nexus to derive maximum benefits from its intertwined linkages.

c. Saving water by increasing irrigation efficiency through rehabilitation and timely maintenance of water transport systems, and the use of modern methods for farm irrigation.

d. Boosting crop productivity in irrigated and rain-fed systems, especially cereals, is key to enhancing food self-sufficiency and call for providing adequate funding for agricultural research institutions and organizations to intensify their research for developing high-yielding, salt-resistant, and drought-tolerant crop varieties.

e. Improving water productivity by producing more crop with less water requires knowledge-based farming practices, farmer discipline on farm water-saving methods and incentives, including appropriate pricing for water irrigation.

f. Encouraging safe wastewater reuse through suitable treatment for irrigation, supported by a management approach and national guidelines to raise public awareness, establish confidence and new attitudes towards water reuse and its economic, social, and environmental benefits.

g. Giving greater attention to the reduction of crop post-harvest losses throughout the food supply chain, as well as to losses due to inefficient import supply chain logistics. Adequate infrastructure, proper facilities and efficient logistics are needed to preserve the quality and quality of food products.

h. Reducing the impact of a changing climate on food supply calls for the need to implement mitigation and adaptation policies and measures based on validated weather data and relevant prediction models.

i. Acquiring food through the 'virtual water' concept requires thorough evaluation of its political, economic, social, and environmental implications, especially its impact on domestic agriculture and the role it plays in the development of the national economy.

j. Strengthening Arab intra-regional cooperation in food security requires harmonization and coordination of national agricultural strategies and policies, with special attention to the management of land and water resources and their efficient utilization.

k. Enhancing food accessibility at regional level requires the facilitation of intra-regional trade in agricultural products through reduction or elimination of trade barriers, improved marketing information, and the provision of infrastructure for communication and transport.

l. Promoting south-south cooperation in food security concerns, such as between the Arab and African countries is an option that merits high consideration due to the geographical proximity of the Arab and African regions, and their comparative advantages in agricultural resources and investable capital.

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