2014 Report of the Arab Forum for Environment and Development

ARAB ENVIRONMENT • 7
FOOD SECURITY
CHALLENGES AND PROSPECTS

EDITED BY:
ABDUL-KARIM SADIK
MAHMOUD EL-SOLH
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المنتدى العربي للبيئة والتنمية
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AFED

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2014 Report of the Arab Forum for Environment and Development

Published with Technical Publications and Environment & Development magazine
P.O.Box 113-5474, Beirut, Lebanon

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http://www.afedonline.org

This report should be cited as follows:
AFED (2014). Arab Environment: Food Security. Annual Report of the Arab Forum for Environment and Development, 2014; A. Sadik, M. El-Solh and N. Saab (Eds.); Beirut, Lebanon. Technical Publications.
If the reference is to a specific chapter, include also number of the chapter and respective author(s).

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Editors: Abdul-Karim Sadik, Mahmoud El-Solh and Najib Saab

Graphics and Production Manager: Charbel Mahfoud
Copy Editor: Rosalyn Saab
Execution: Maguy Abou Jaoude
Printing: Chemaly & Chemaly, Beirut
Photos: *Environment & Development magazine archive - iStock photos -APN*

ISBN: 978-9953-437-52-1

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Preface

Food Security is the seventh in the series of annual reports on the state of Arab environment produced by the Arab Forum for Environment and Development (AFED). The primary aim of AFED reports is to foster the use of science in environmental policy and decision-making. This is in line with AFED's mission "to advance prudent environmental policies and action in the Arab countries based on science and awareness."

This report highlights the need for more efficient management of the agriculture and water sectors, enhancing the prospects of food security. It comes as natural addition to the sequence, after: *Arab Environment - Future Challenges* (2008), *Impact of Climate Change on Arab Countries* (2009), *Water - Sustainable Management of a Scarce Resource* (2010), *Green Economy in a Changing Arab World* (2011), *Survival Options - Ecological Footprint of Arab Countries* (2012), *and Sustainable Energy* (2013).

Food security is of great concern to Arab countries. They have been pursuing a target of higher food self-sufficiency rate, but achieving this goal remained beyond reach. With limited cultivable land and scarce water resources, Arab countries did not use their agricultural endowments effectively and efficiently. Lack of appropriate agricultural policies and practices diminished the bio-capacity of resources to regenerate their services and threatened agricultural sustainability.

The food crisis and the unprecedented spike in food prices in recent years, coupled with export restrictions imposed by some food producing countries, reignited the call to ensure reliable sources for food import-dependent countries like the Arab countries. This report attempts to address issues such as: to what extent can available agricultural resources at country and regional levels meet demand for food in the Arab world? What are the prospects for food self-sufficiency, taking into consideration the growing population and the impact of climate change on land and water resources? And, ultimately, what other options do the Arab countries have to ensure food security?

This AFED report, produced by a group of leading experts, is the result of collaborative work, in cooperation with regional and international organizations, universities and research centers. Over 200 researchers and specialists contributed to the work. Various consultation meetings were held to discuss drafts, culminating in a regional meeting hosted by the Kuwait Fund for Arab Economic Development (KFAED), where 40 experts from 14 countries and 21 institutions reviewed the drafts with the authors.

One novel feature of the report is a set of maps showing water and land resources in the Arab region, produced in cooperation with the International Center for Agricultural Research in Dry Areas (ICARDA) based on the most recent data. Beyond showing the availability of resources per country, they point out obvious routes of regional cooperation, based on the variation in natural endowment. Those maps were initially proposed by AFED senior adviser Dr. Mostafa Kamal Tolba, who thought it was essential to identify locations of water and land resources, to see where they overlap and to pinpoint potential regional cooperation spots.

Although the Arab region is a net importer of food, with dwindling natural resources and ever increasing population, this report concludes with a positive note. It asserts that the gloomy situation of food production can be reversed through a combination of measures, mainly increasing land productivity and irrigation efficiency, which are now far below the world average in most Arab countries. It is imperative to combine those measures with serious regional cooperation that explores comparative advantages, in a region characterized by stark variations in ecological footprint, natural resources and income. Achieving this, while still maintaining biodiversity and healthy environmental systems, would also require a radical shift in consumption patterns.

What this report prescribes might sound like unrealistic, and in best cases overly optimistic, in a region passing through existential turmoil. However, after conflicts and wars are over, people will still need sufficient resources to eat, drink and breathe. In order to pursue sustainable wellbeing for all residents in the region, attention should be directed to achieve more regional economic integration, and to promote inter-Arab trade free of barriers, where the free flow of goods, capital and people works to the benefit of all countries.

AFED wishes to thank all those who made this report possible, especially our institutional partners: Environment Agency – Abu Dhabi (EAD), Arab Fund for Economic and Social Development (AFESD), Kuwait Fund for Arab Economic Development (KFAED), Islamic Development Bank (IDB), Kuwait Foundation for the Advancement of Science (KFAS), International Center for Agricultural Research in Dry Areas (ICARDA), Economic and Social Commission for West Asia (UN-ESCWA), Food and Agriculture Organization (FAO), and all corporate, academic and media partners who supported this endeavor.

Special thanks are due to the co-editors, Dr. Abdul-Karim Sadik and Dr. Mahmoud El-Solh, and all authors and experts who contributed to the contents and appraised the drafts.

AFED hopes that its report on Food Security will help Arab countries adopt the right policies and commit to long-term investments, in order to secure sustainable supply of food to meet ever-growing needs.

November 2014

Najib Saab
Secretary General
Arab Forum for Environment and Development (AFED)

EXECUTIVE SUMMARY

FOOD SECURITY IN ARAB COUNTRIES

CHALLENGES AND PROSPECTS

2014 ANNUAL REPORT OF THE ARAB FORUM FOR ENVIRONMENT & DEVELOPMENT (AFED)

In their quest to enhance food self-sufficiency, Arab countries face serious challenges emanating from a backdrop of constraining factors, including aridity, limited cultivable land, scarce water resources and serious implications of climate change. Weak policies, insufficient investment in science and technology and agricultural development have contributed to the impoverished state of agricultural resources and to their inefficient use and low productivity. Population growth, rising demand for food, degradation of natural resources, and conversion of farmland to urban uses pose further challenges to the enhancement of the food security goal in the Arab region. The food deficit is underscored by a self-sufficiency ratio of about 46 percent in cereals, 37 percent in sugar, and 54 percent in fats and oil.

Food and water are inextricably linked. The Arab region faces the dilemma of water scarcity, reflected in the fact that the annual renewable water resources per capita are less than 850 m^3, compared to a world average of about 6000 m^3. This regional average masks the widely varying levels among countries, of which 13 are classified in the severely water scarce category, at less than 500 m^3 per capita. The situation is so alarming in six of these countries, with availability of renewable water less than 100 m^3 per capita, that this report has created a special "exceptionally scarce" category for them.

Water scarcity in the Arab region is accentuated by the utilization of about 85 per cent of total water withdrawals for the agriculture sector, which is characterized by low irrigation efficiency and crop productivity. Immense pressure has been exerted on the scarce water resources, including non-renewable groundwater, as reflected in the high rates of water withdrawals for agriculture, averaging about 630 percent of total renewable water resources in Gulf Cooperation Council (GCC) countries, reaching about 2,460 percent in Kuwait. 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 extract more than 20 percent of these resources. Based on this definition 19 Arab countries could be defined as water-stressed, because their current abstraction rates from their renewable water resources for agriculture greatly overshoot the defined limits.

Improving the state of food security in Arab countries through domestic production, under limited cultivable land, highly stressed and dwindling water resources, coupled with an impoverished bio-capacity of agricultural resources, is a challenging task. Nevertheless, considerable prospects do exist for enhancing the food self-sufficiency ratio through adoption of the right polices and improved agricultural technologies, and setting up an integrated food value chain capable of ensuring food security built on the pillars of availability, accessibility, utilization and stability of food.

Improving the self-sufficiency aspect of food security requires an all-inclusive regionally integrated approach, recognizing the interdependence of the food-water-energy nexus, and a new paradigm of agricultural sustainability, based on economic, social, and environmental considerations. Within this framework, a number of options can be identified to enhance the food self-sufficiency ratio, particularly through the efficient utilization of available agricultural resources, in addition to livestock and fisheries resources. These options include the following:

Improving Irrigation Efficiency: Producing more agricultural outputs with less water is an option of significant importance for enhancing food security in water-scarce countries. It depends on the right type of canals used to deliver water to the field, more efficient irrigation methods, such as sprinkler and drip irrigation, raised broad-bed planting and the level of farmer organization and discipline.

Average irrigation efficiency in 19 Arab countries is below 46 percent. It is estimated that raising this figure to 70 percent would save about 50 billion m^3 of water annually. With an irrigation requirement of 1,500 m^3 of water per ton of cereals, this would be enough to produce over 30 million tons, equivalent to 45 percent of cereal imports with a value of about US$11.25 billion at 2011 import prices.

Boosting Crop Productivity: Crop productivity in the Arab region is generally low, particularly that of staple cereals, averaging about 1,133 kg/ha in five major cereal producers (Algeria, Iraq, Morocco, Sudan, and Syria), compared to a world average of about 3,619 kg/ha. Ongoing research by the International Center for Agricultural Research in the Dry Areas (ICARDA) has shown considerable increases in wheat yield at demonstration fields versus farmers' fields in both irrigated and rain-fed systems in countries such as Egypt, Morocco, Sudan, Syria, and Tunisia. For example, raised-bed planting in Egypt resulted in a 30 percent increase in grain yield, 25 percent saving in irrigation water, and 72 percent in water use efficiency.

It is critically important to improve crop productivity in rain-fed areas, which constitute over 75 percent of the cultivated area in the Arab region. FAO and ICARDA refer to various forms of rain-water harvesting including in situ water conservation, flood irrigation, and storage for supplementary irrigation. Work in some developing countries has shown that yields can be increased two to three times through rain-water harvesting, compared with conventional dry farming. Increasing average rain-fed cereal yield from its current level of about 800 kg/ha to two to three times would add between 15 to 30 million tons of cereal to current annual production of about 51 million tons in the Arab region.

Improving crop yield in irrigated and rain-fed areas has a considerable potential for enhancing food self-sufficiency in the Arab region, through promoting agricultural research, technology transfer and investment in rain-fed agriculture. Application of best agricultural practices is crucial, including optimization of the use of fertilizers, pesticides and other inputs, coupled with good management of the available agricultural resources. However, the impact of climate change in the Arab region is expected to be manifested in drastic decline in crop productivity, and needs to be addressed through the adoption of effective adaptation and mitigation measures.

Improving Water Productivity: In addition to increasing irrigation efficiency, water productivity can be increased in either economic or physical terms, through the allocation of water to higher value crops or by achieving 'more crop per drop' of water, respectively. The choice of which of these options to pursue depends on whether crop value or quantity is more relevant to a country within the broader political, economic, social, and environmental context.

Water productivity can be enhanced by a combination of factors, including improved agricultural practices, such as modern irrigation methods, improved drainage, conservation agriculture or no-till farming, utilization of the available improved seed, optimizing fertilizer use, innovative crop protection techniques, and effective extension services. Such farming practices as water harvesting, supplemental and deficit irrigation, water conservation, and organic agriculture are not only conducive to raising water productivity, but they are also very important for enhancing agricultural sustainability. In addition, water productivity can be further improved by shifting consumption habits towards less water-intensive. crops of similar nutritional value.

Use of Treated Wastewater: Wastewater remains largely untapped for agricultural use in Arab countries. Only about 48 percent of municipal wastewater of about 14,310 million m^3 annually is treated, with the remaining amount discharged without treatment. The amount used for agricultural irrigation does not exceed 9 percent of the treated wastewater in countries such as Egypt, Jordan, Morocco and Tunisia, while countries use about 37 percent of treated wastewater for agriculture.

The fact that a higher percentage of treated wastewater is used for agriculture in GCC countries than in other Arab countries is prompted by the severe scarcity of freshwater resources, and the enormous pressure impacted on them through withdrawal for agriculture use, in addition to adopting improved treatment standards to ensure safe use of treated wastewater. Nevertheless, with different suitable treatment levels, wastewater can be reused as a source of non-potable water for a multitude of agricultural, industrial, and household activities, releasing pressure on freshwater resources and the environment.

Where food production is heavily dependent on rain-fed agriculture and freshwater resources are declining rapidly, the alternative of water reuse for irrigation in Arab countries should be encouraged and supported. According to FAO, by converting from rain-fed to irrigated agriculture, it is possible not only to increase yields of most crops by 100 to 400 percent, but can also allow for the growth of alternative crops with higher income and value.

Reducing Post-harvest Losses (PHL): The main causes of these losses are attributed to improper methods used in the harvesting, processing, transportation, and storage of the crops, as well as inefficient import supply chain logistics. It is estimated that the annual losses of grains in Arab countries amounted to about 6.6 million tons in 2012. In addition, loss in imported wheat in some Arab countries translates to about 3.3 million tons due to inefficient import logistics. The combined value of grain PHL and wheat import losses amount to about US$3.7 billion at 2011 import prices, which represents 40 percent of the wheat produced in all Arab countries in value terms. This is equivalent to about four months worth of wheat imports.

A reduction in cereal losses along the food supply chain cannot be overemphasized, because such losses represent a waste in food supply and other natural resources, including land, water, energy, fertilizers, pesticides and labor. This is intensified by environmental damage, including excessive greenhouse emissions from agricultural activities along the food chain.

Regional Cooperation: Cooperation among Arab countries based on comparative advantage in agricultural and financial resources is a key option for enhancing food security at the regional level. To be effective it requires an approach based on the harmonization of national agricultural strategies and policies; more investment in science and technology and agricultural development; regulations, measures and incentives conducive to the efficient use of resources; and the conservation of the productive bio-capacity of land and water resources which constitute the cornerstone for food production at the national, sub-regional, and regional levels.

Development of Livestock and Fisheries: Arab countries have considerable livestock and fisheries resources. They are almost self-sufficient in fish, but about 25 percent of meat demand is being met through imports. This percentage is expected to increase in the future driven by population, wealth and urban growth.

The productivity of the livestock sector in the Arab region is hampered by the scarcity of natural resources, in particular degradation of rangelands and insufficient sources of feed and water. Lack of support for infrastructure and services and arbitrary policies has affected the livestock sector negatively. Producing feed locally has resulted in the deterioration of non-renewable water resources, and the degradation of rangelands and feed resources, leading to loss of biodiversity, soil erosion, and consequently livestock productivity. In the face of high aridity and vast areas of marginal land, pastoralists and rain-fed livestock production systems remain the most resilient, thus policies supporting their movement and access to grazing lands are needed. More so, well integrated crop and livestock production systems at various levels provide opportunities to increase overall production, diversity, and economic sustainability of both sectors.

The fisheries sector in Arab countries has a great potential not only to meet domestic demand, but also to be exported. In 2013, fish exports amounted to 912,460 tons, with a value of about US$3 billion. However, there is potential to further growing these exports; unlocking the potential of the fisheries sector requires addressing the various problems and bottlenecks facing its development. Most importantly, there is a need for investing in the fishing industry and, among other things, enacting laws and legislation with respect to fishing in natural grounds and in fish farming activities, to ensure the sustainability of the sector and its contribution to a country's welfare. Shared governance of fisheries stocks in Arab countries is also crucial, since cross maritime borders are impacted by the health of entire watersheds.

Fish is not a less important source of protein intake than meat. Consuming fish should be encouraged to reduce excessive consumption of meat for economic and health reasons, as well as considering the impact of livestock production on the scarce water resources and the environment. In general, an awareness campaign is needed to encourage consumers to adapt their food consumption habits towards healthier patterns, and more conducive to the sustainability of agricultural resources.

Other Options: Despite reservations about the virtual water concept as a policy tool for addressing challenges related to the water-food nexus, it remains useful in the context of a country's specific water situation, and the overall role of agriculture in economic and social development.

The virtual water concept can be an important tool for cooperation on food security between regions based on their geographical proximity, and comparative advantage in agricultural resources. This could for instance mean expanded cooperation between Arab and African countries, where limited land and water scarcity in Arab countries can be compensated by the comparative advantage of African countries in natural and agricultural resources.

THE WAY FORWARD

While embarking on a path towards enhancing food security through promoting domestic food production, Arab countries need to adopt policies and take actions, with due consideration to the following recommendations:

a. Strengthen regional cooperation among Arab countries, based on comparative advantage in agricultural and investable capital resources, coupled with coordination and harmonization of agricultural development strategies and programs.

b. Take the necessary actions to reverse the deteriorating state of agricultural resources and maintain their bio-capacity to regenerate their services and contribution to food security.

c. Consider implementation of the available options for enhancing the self-sufficiency aspect of food security, including, among others, boosting crop and water productivity, improving water-use efficiency, reducing post-harvest and other losses, and promoting the use of treated wastewater for irrigation.

d. Allocate more investment in agricultural scientific research and development programs, supported by adequate financial resources, as well as human and institutional capacity development geared towards research for more productive and environmentally protective inputs and agricultural practices, with the aim of boosting the productivity of rain-fed and irrigated agriculture.

e. Undertake the required investments to develop the livestock and fisheries sectors, in a sustainable manner, with a view to increase production to meet local demand and promote the potential for exports.

f. Implement an awareness campaign to change consumption patterns, especially through more dependence on commodities with similar nutritional value, but which are less water-intensive.

g. Adopt an integrated approach to food security, incorporating all food value-chain components, comprising harvesting, transporting, storing, and marketing, to make food available, accessible, and utilizable with good quality at the right time and place.

h. Develop responses to cope with the threat of climate change on food security in the region through adaptation strategies, based on relevant and reliable climate forecasting models, with the adoption of improved agricultural practices and water management, conservation agriculture, diversification of crops, and selection of crops and cultivars best suited to the predicted conditions, among other adaptation and mitigation measures.

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

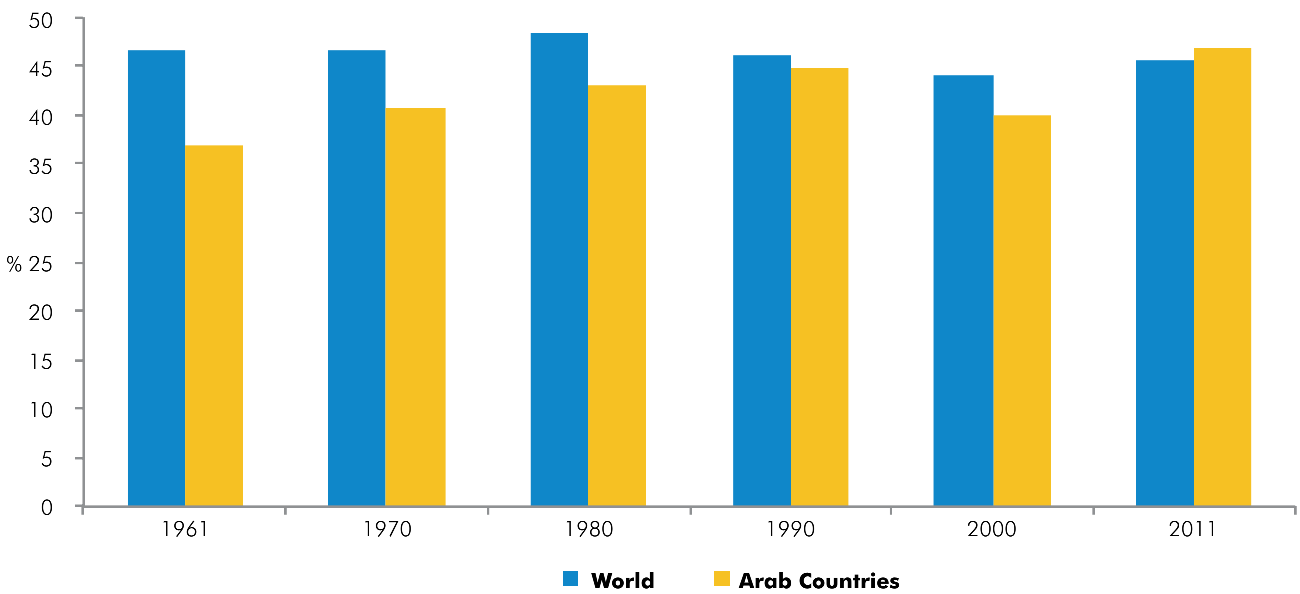
Arab countries have devoted a considerable portion of their agricultural resources to the production of cereals, in line with the importance of these commodities to food security in terms of domestic supply and cost of imports. "Cereals are still by far the world's most important sources of food, both 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).

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).

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.

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

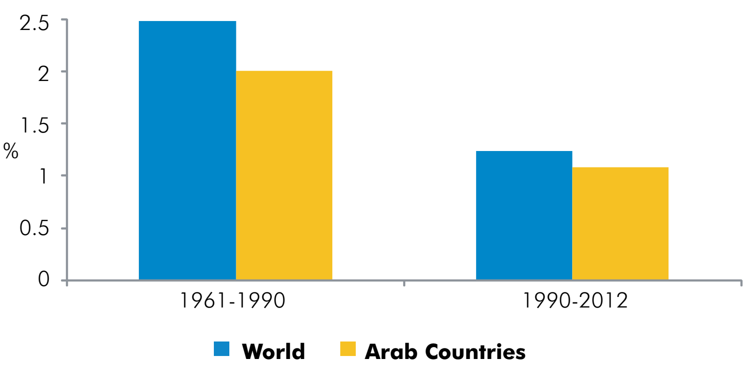
The bulk of cereal production in the Arab region is contributed by six countries – Algeria, Egypt, Iraq, Morocco, Sudan and Syria – with a share of about 88 percent of total cereal production in the region in 2012, as illustrated in Table 5. The mentioned Table reveals some striking differences related 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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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	1,017
Sudan	5,631,780	21.80	2,660,000	5.20	472
Syria	2,798,610	10.84	4,599,397	9.00	1,644
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.

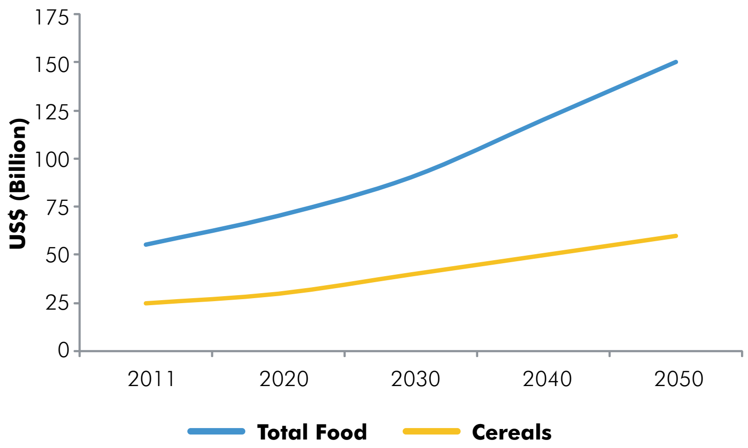
Rising cost of food imports, price fluctuations, uncertainty about the future food supplies in world markets due to, among other things, conversion of agricultural land for bio-fuel production, and impact of climate change on the productive capacity of land and water resources drive the Arab and other 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.

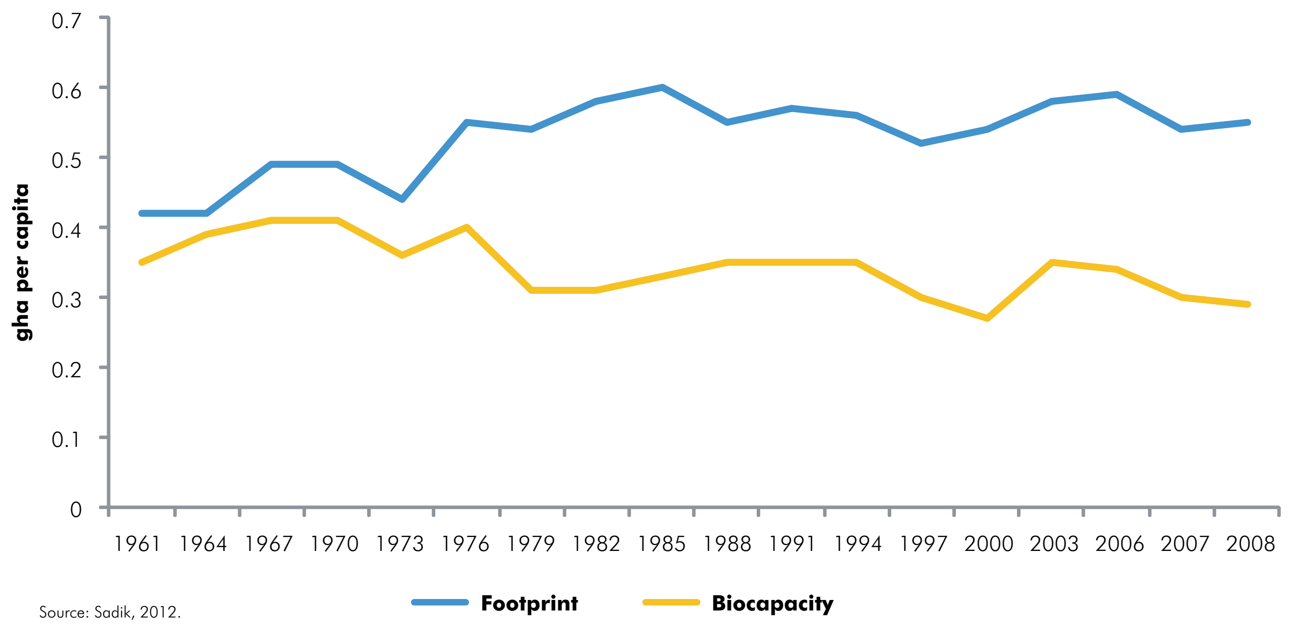
Agriculture can have a vast impact on land and water resources and on the wider environment through crop and livestock production, which are the main sources of water pollution, greenhouse gases, and biodiversity loss. In addition, agriculture threatens the basis of its sustainability through land degradation, 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

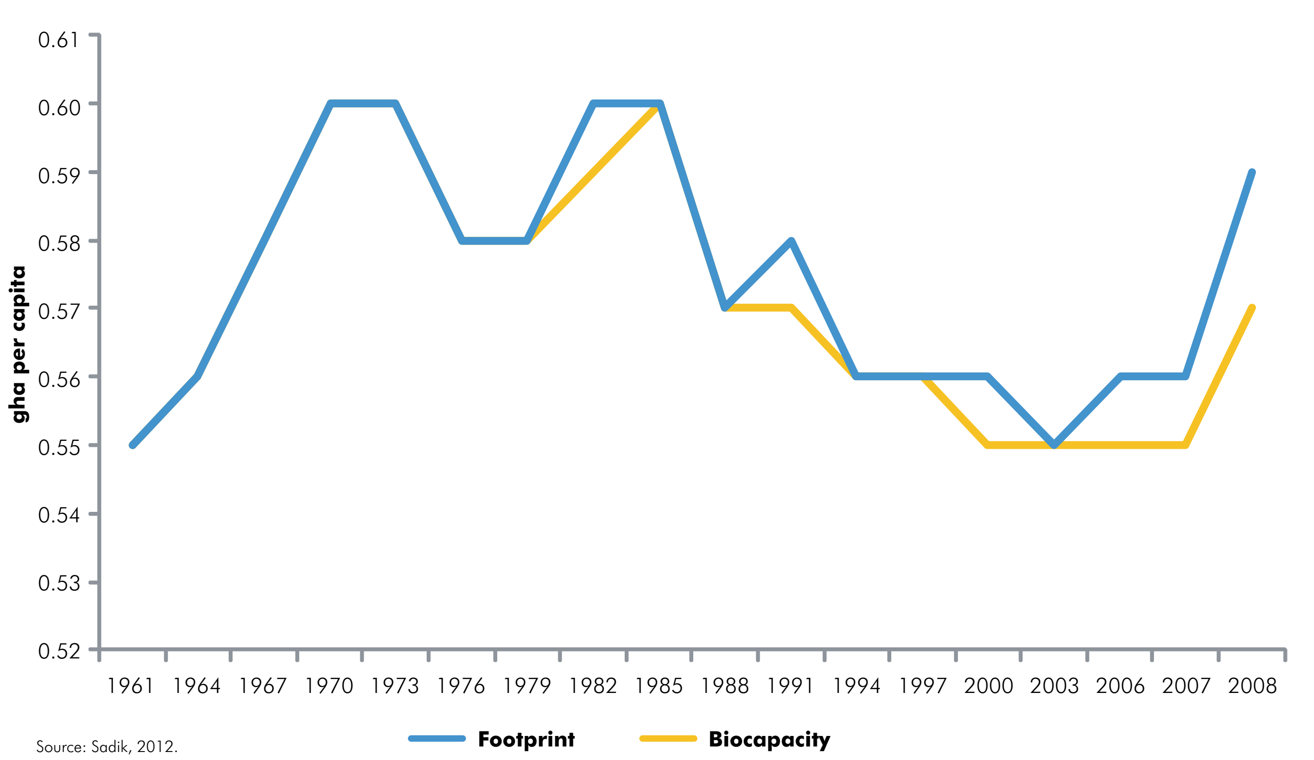
A survey prepared by the Global Footprint Network (GFN) on the Ecological Footprint of Arab countries explored resource constraints in Arab countries from the perspective of the

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 Per capita (M^3)	2040	2050
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).

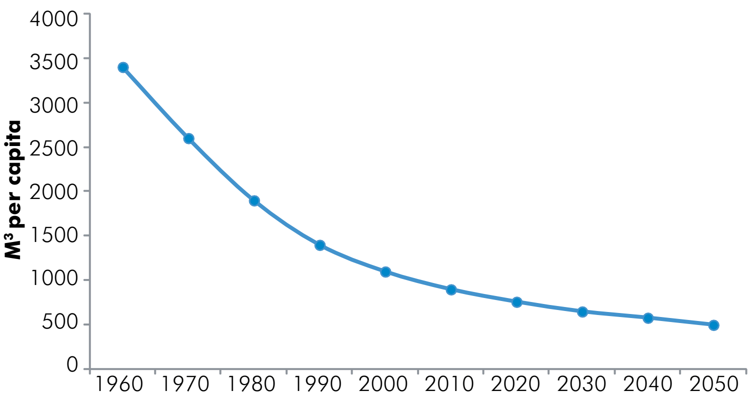
Based on this definition, most Arab countries are either in critical water condition, or are water-stressed. This is because abstraction from their renewable water resources for agriculture greatly overshoots the defined limits (Table 8).

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 M³ *	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

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

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

increase domestic agricultural investments in products with relative advantages in terms of water consumption.

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:

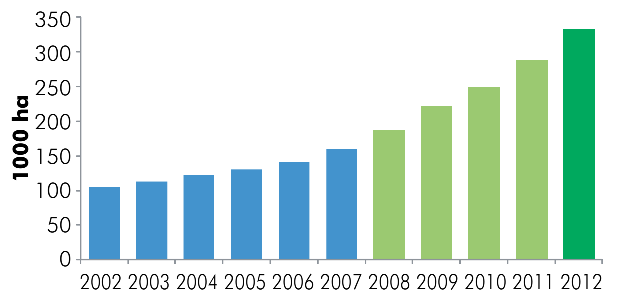
The National Irrigation Water Saving Program

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 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.

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



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.

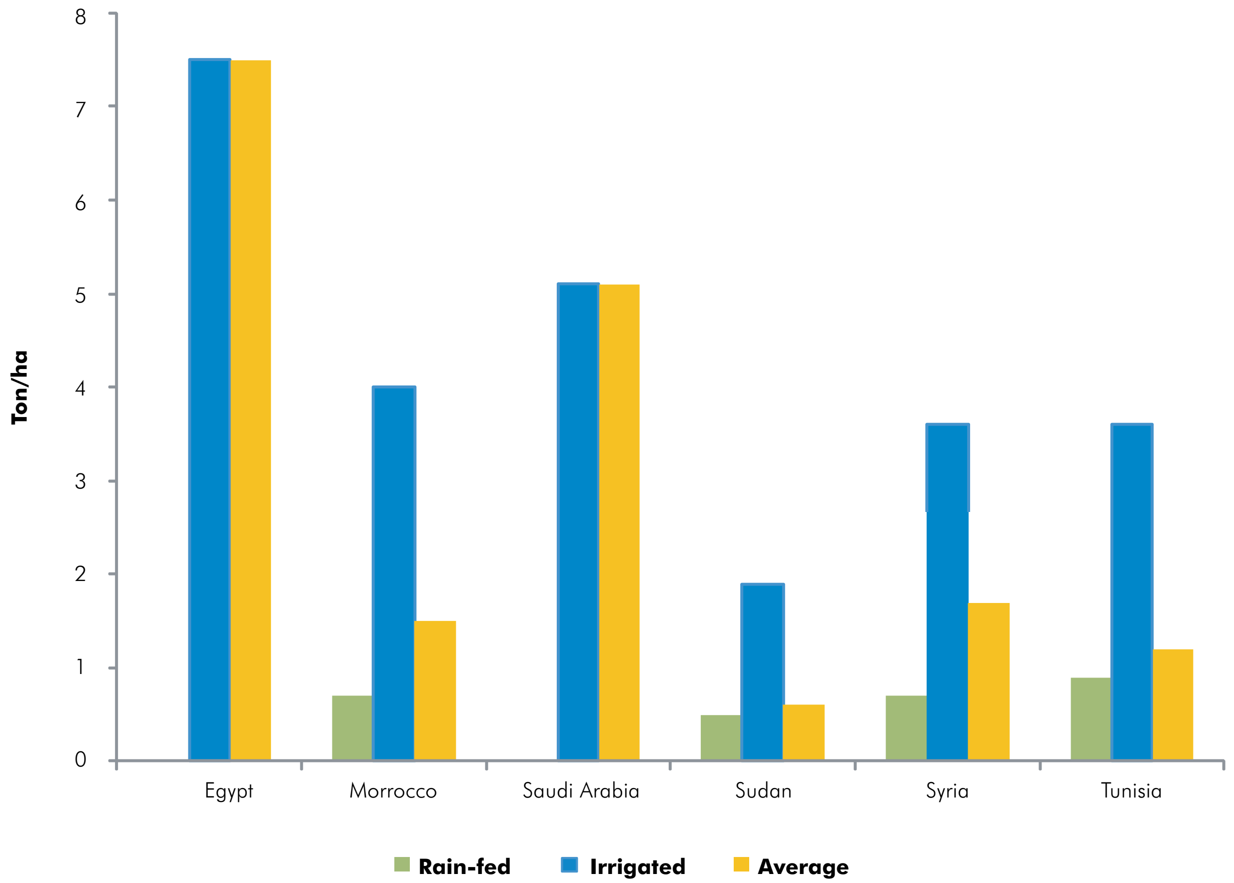
Agricultural Insurance

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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CHAPTER 2

The Role of Science and Technology in Enhancing Food Security

Mahmoud El-Solh

The Arab region is the largest cereal importer in the world with widening gaps in demand and production, making the region increasingly vulnerable to global upheavals and rising food market prices. There is a dire need for change in the countries' approach to food security. Today, the advances made in agricultural research and technology development can turn around the trend and can put Arab countries on track toward self-sufficiency, even with scarce natural resources.

The region's diverse agro-ecosystems will require a two-pronged approach to enhance productivity: sustainably intensifying the production in areas where relatively greater access to water provides an opportunity and building resilience in marginal lands where farmers are vulnerable to droughts – an occurrence becoming more frequent with climate change. In either approach, sustainable agricultural development must be the guiding force to ensure the scarce natural resources can sustain long-term food production. This calls for an integrated approach to increasing productivity – improving crops and livestock, promoting natural resource management, and developing enabling policies and institutional capacity.

Over the last three decades, ICARDA's research partnerships with the National Agriculture Research Systems (NARS) in several dryland countries have led to several improved and innovative technologies that can transform productivity. For example, developed wheat cultivars that are higher yielding as well as tolerant to droughts, salinity and pests are offering a potent opportunity for Arab countries to dramatically increase their food production. Substantial gains can also be attained from a suite of technologies validated for improving water productivity, and crop-livestock integration strategies proven to enhance resilience and incomes for resource-poor farmers in the marginal lands.

The case of Syria, which moved from wheat importing to wheat exporting status benefiting from improved crop varieties in tandem with water management technologies and enabling policies, is clearly demonstrative of the role science and technology can play when applied in an integrated approach.

There exist, however, large gaps that are deterring sustainable progress in Arab countries that must be bridged in order to unleash the full potential of science and technology in the region. These include:

- Investing in science and technology
- Enabling policy environment
- Investment in agricultural development
- Sustainable intensification of wheat production systems – a key role player in food security
- Extension and effective technology transfer mechanisms
- Capacity development and institutional support
- Innovative partnerships, particularly between public and private sectors

Unlocking the Productivity in Arab Countries

A sampling of ready-to-implement technologies

- Developed durum wheat cultivars: Delivering ~130 percent higher yield over landrace and 40 percent over popular improved variety in Egypt
- Heat-tolerant wheat cultivars: Bringing wheat production to South of Khartoum in Sudan where high temperatures once prevented its cultivation
- Raisedbed machines innovated for fragmented lands: Saving an average of 24 percent irrigation water, along with increasing wheat yields by ~34 percent for smallholders in Egypt and now scaling out to other countries such as Iraq, Sudan, Nigeria and Morocco.
- Soilless farming technology packages: Increasing water productivity and yields of cash crops by 50 percent, now being nationally incentivized for greater adoption by farmers in Oman, Emirates, Qatar and Bahrain

I. INTRODUCTION

The global challenges of food security and high food prices, particularly of major cereal crops, have serious impacts in Arab countries considering the region is the largest cereal importer in the world. Despite the population of Asia being much larger than that of the Arab countries, in 2010 the latter imported 65.8 million tons of cereal crops while Asia imported 58.8 million tons. . The region's growing dependence on food imports is estimated to reach US$115 billion by 2020, a trend that will make the countries increasingly vulnerable to global food price fluctuations, not to mention the lagging development in rural parts where crops and livestock are the mainstay of incomes for households.

The extreme fragility of food security in Arab countries, coupled with their rapidly growing populations, highlights the dire need in the region to focus on agriculture development. Supporting innovative research will arm the countries with the tools and capacity needed to increase their productivity and sustainably develop their rural economy. Today, the advances made in agricultural research and technology development can help unlock the potential of production systems in dry areas even with scarce natural resources – making it entirely possible for Arab countries to significantly increase their food self-sufficiency.

II. STATUS OF AGRICULTURAL RESEARCH IN THE ARAB COUNTRIES

The most comprehensive review of the status of agricultural research in the Arab countries was published in 1999 (Casa et al., 1999). Since then, the Agriculture Sciences and Technology's Indicators initiative conducted further analyses and published briefs for Sudan in 2003 (Beintema and Faki, 2003), Mauritania in 2004 (Stads et al., 2004), Morocco and Tunisia in 2005 (Stads and Kissi, 2005) and Jordan and Syria in 2006 (Beintema et al., 2006).

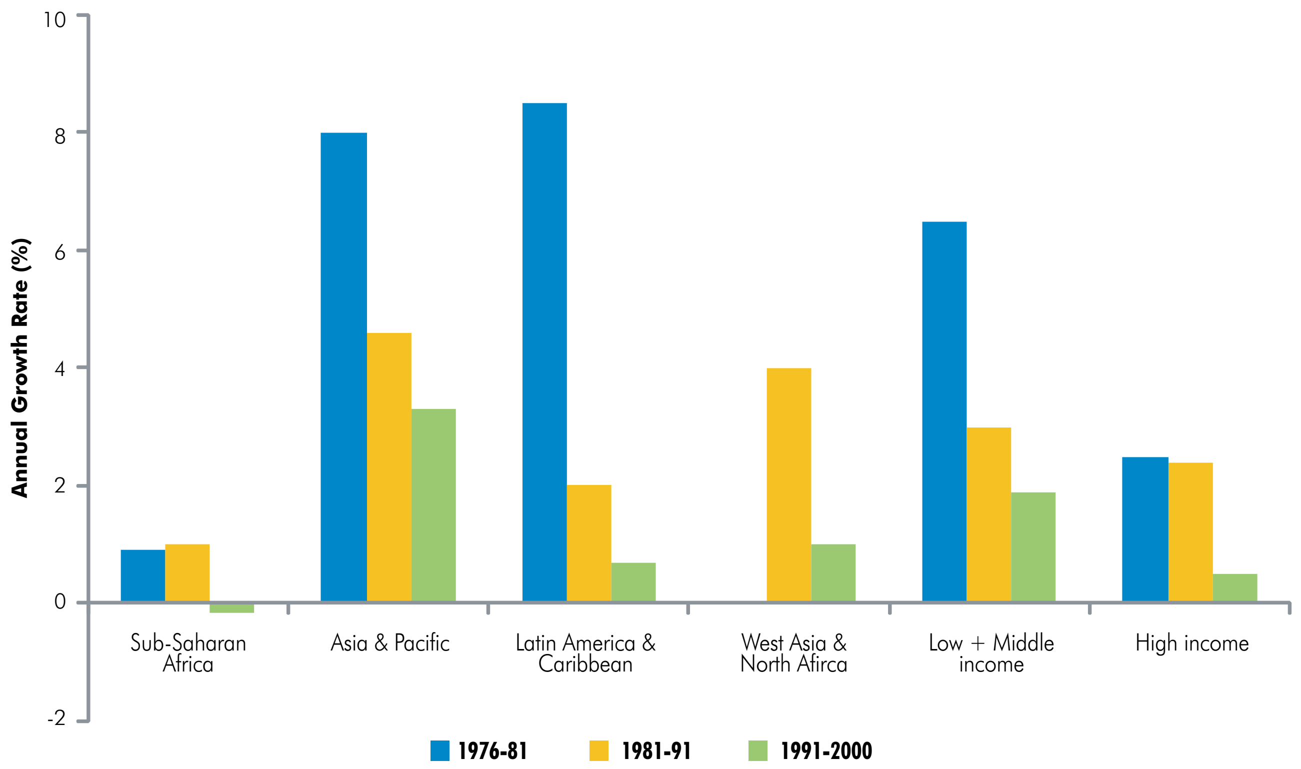
The 1999 review compiled key data on the state of economy and agriculture in the West Asia and North Africa countries, and stressed the strategic potential role of agricultural research in solving the difficult food challenges facing these countries in the long and the short term. It also reviewed the national agricultural research systems (NARS) in 13 Arab countries: Bahrain, Algeria, Egypt, Iraq, Jordan, Lebanon, Libya, Morocco, Sudan, Syria, Tunisia, the United Arab Emirates and Yemen (See list of the main agricultural research institutions in the Arab countries).

The review brought out the diversity of the NARS profiles in terms of structure, resources, research activities, and productivity, which in turn reflected the diversity of the countries themselves. Still, some characteristics were found to be common across the NARS. Except for Morocco and some of the Gulf countries, investment in agricultural research for development has slid back (Figure 1) and the following findings from the review still hold true:

- In comparison with other regions of the world, Arab countries have one of the lowest public expenditures in agricultural research and development (Table 1).

- Most of the NARS were established soon after independence, so they have had a significant time to grow and evolve. In the 1970s and 1980s, many NARS in the Arab countries experienced rapid growth and made significant contributions to knowledge. However, some of the gains achieved in countries like Lebanon, Algeria, Sudan, Iraq, Egypt and

FIGURE 1 GROWTH RATES IN PUBLIC AGRICULTURAL RESEARCH EXPENDITURE, 1981-2000



Syria were lost from the unstable political and institutional changes that occurred in recent years, which affected their performance.

- NARS in Arab countries continue to have poor advantage in attracting and retaining top quality researchers as opposed to research universities, where career opportunity and salary scales are more competitive. The advanced research institutions (ARI), for the most part, still receive less funds and resources compared to faculties of agriculture.

- The relatively low allocation of human, financial and physical resources is a major issue for many NARS. Many countries do not have the capacity to deploy permanent scientific and technical staff in the regions where they are needed the most such as the less favorable agro-ecological zones and less productive farming systems. This affects the performance of the NARS in meeting food security and results in unbalanced research activities and poor relations with development

TABLE 1 TOTAL PUBLIC AGRICULTURAL R&D SPENDING FOR LOW- AND MIDDLE-INCOME COUNTRIES BY REGION, 2000

Low- and middle-income countries by region and countries	Public agricultural R&D spending (million 2005 dollars)		Percentage share of global total	
(number of countries)	U.S. dollars	PPP* dollars	U.S. dollars	PPP* dollars
Sub-Saharan Africa (45)	561	1,239	3	5
China	795	1,891	4	8
India	433	1,301	2	6
Asia-Pacific (26)	1,848	4,758	10	20
Brazil	674	1,209	4	5
Latin America and the Caribbean (25)	1,435	2,710	8	12
West Asia and North Africa (12)	**613**	**1,412**	**3**	**6**

*PPP: Purchasing power parity.
(Source for Figure 1 and Table 1: Beintema and Stads, 2008).

organizations located in those regions. While there have been improvements and more NARS are engaged in activities far away from the center, the change has been slow. It is expected that as political and economic decentralization processes continue, a greater balance in regional development is likely to emerge. However, decentralization is contingent on political stability and in both political and financial commitment to the research-for-development process.

- Insufficient financial resources for operation and capital costs are considered the most limiting factors to research efficiency. Organizational restructuring to address staff redundancy and improve the quality of both scientists and support staff can potentially enhance research productivity.

- Lack of monitoring and assessment and limited international and regional scientific cooperation are further constraining the efficacy of NARS. Most ARIs are aware of these weaknesses and have been working hard to progressively overcome them by enhancing human capacity, preparing and taking action on national strategic plans, and building partnerships within and outside the Arab world.

- With regards to linking public and private development organizations, improvements are underway but greater focus is needed from NARS toward activities that could reinforce these partnerships, such as training of senior staff and leads, and temporary deputation of researchers to private organizations. Also, rethinking research approaches could help produce more innovative science and build a better understanding of farmers' needs, such as research on farming systems and integrated rural development.

The inadequate NARS infrastructure and low investments in agricultural development are compromising the food security in Arab countries increasingly more as regional trends and challenges indicate a worsening scenario in times to come with growing populations, declining per capita water resources, degraded natural resources and the vagaries of climate change (presented in Chapter 1).

The following sections shed light on the vital role science and technology can play to turn the situation around and enhance food security in the Arab region.

III. STRATEGIES AND APPROACHES TO ENHANCE AGRICULTURAL PRODUCTIVITY

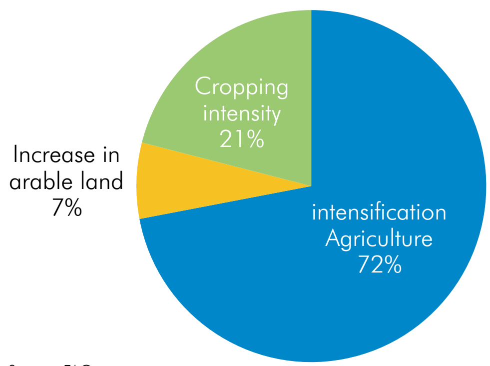
A. Tailoring the approach based on agro-ecologies

The scope of increasing agricultural productivity on any farming land is inherently linked to the agro-ecosystem of the area. In the case of the Arab region, the drylands can be broadly grouped into two different types of agro-ecosystems. While there are parts of countries that lend themselves to relatively favorable farming conditions, there exist vast tracts of marginal lands in the Arab region that are tending towards severe land degradation and desertification, a condition that is threatening the livelihoods of millions of poor farmers dependent on the land. Varying largely in their natural resources, these two agro-ecosystems will require different approaches to increasing agricultural productivity in response to their available potential:

1. High yield potential with relatively favorable conditions

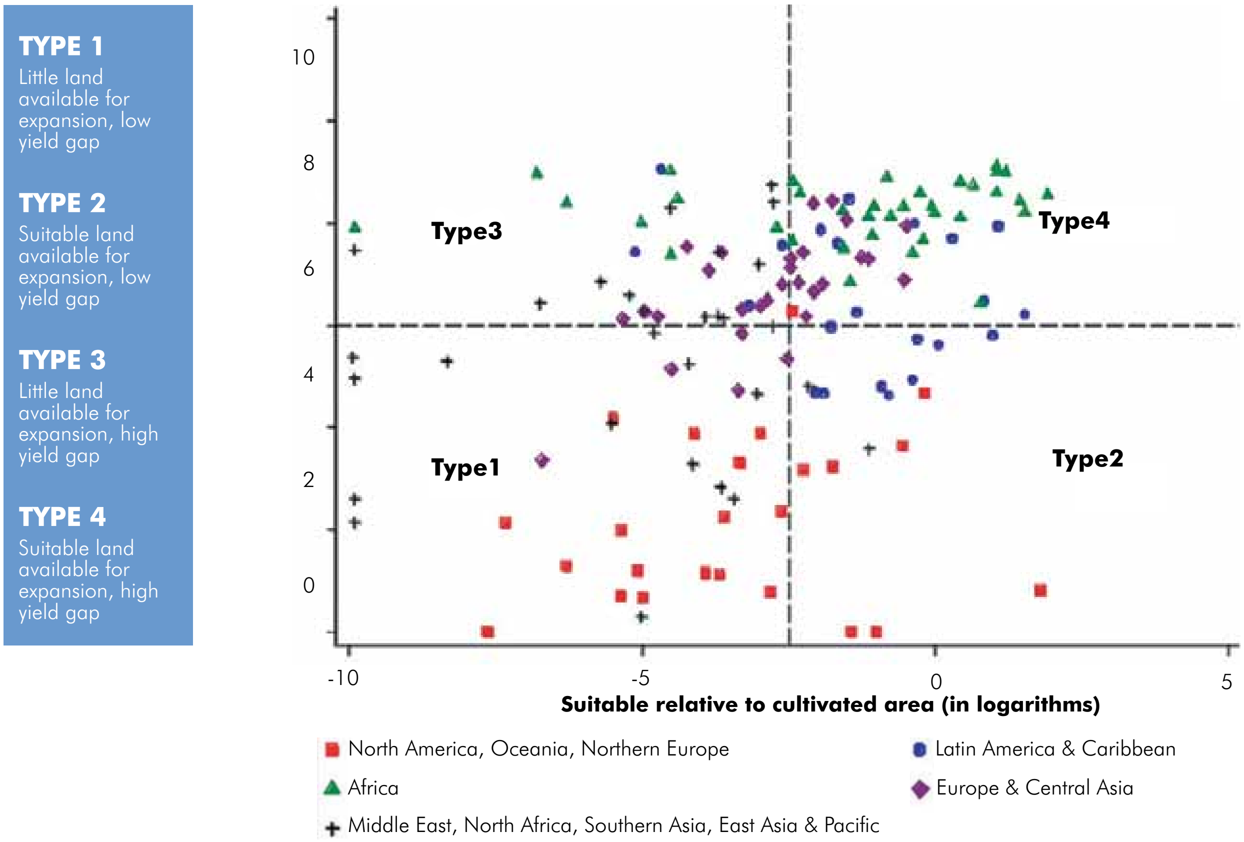
Places with relatively higher rainfall and/or irrigation water availability offer significant opportunity to increase productivity and thus will benefit from a strategy of developing options to sustainably intensify the production systems.

FIGURE 2 SOURCES OF INCREASE IN FOOD PRODUCTION



Source: FAO.

FIGURE 3 **YIELD GAPS AND RELATIVE LAND AVAILABILITY FOR DIFFERENT COUNTRIES OF THE WORLD**



Source: Authors based on Fisher and Shah 2010.

According to the FAO, there are three main pathways to increase crop production: agricultural intensification, expansion of arable land, and increasing cropping intensity (Figure 2). The agricultural intensification entails increasing productivity by bridging any existing yield gap – the gap between potential yields under optimum management and the actual yields reaped on farms. The opportunity in relative land availability can be estimated by reviewing the ratio of non-forested, non-cultivated suitable land area for rainfed production relative to what is actually cultivated. Increasing the cropping intensity involves amplifying the frequency that crops are harvested from a given area. Considering the scarce natural resources characteristic of Arab countries, intensive cropping is not a favorable option.

Yield gaps and relative land availability greatly vary for countries around the world, which can be broadly grouped into four categories (Figure 3). Arab countries fall in the "Type 3" category – limited land and high yield gap. Increasing arable land is a limited option for Arab countries as studies show the Middle East and North Africa region have an estimated 2,716 thousand

TABLE 2 **POTENTIAL AVAILABILITY OF LAND FOR RAINFED CULTIVATION IN DIFFERENT REGIONS (1000 HA)**

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

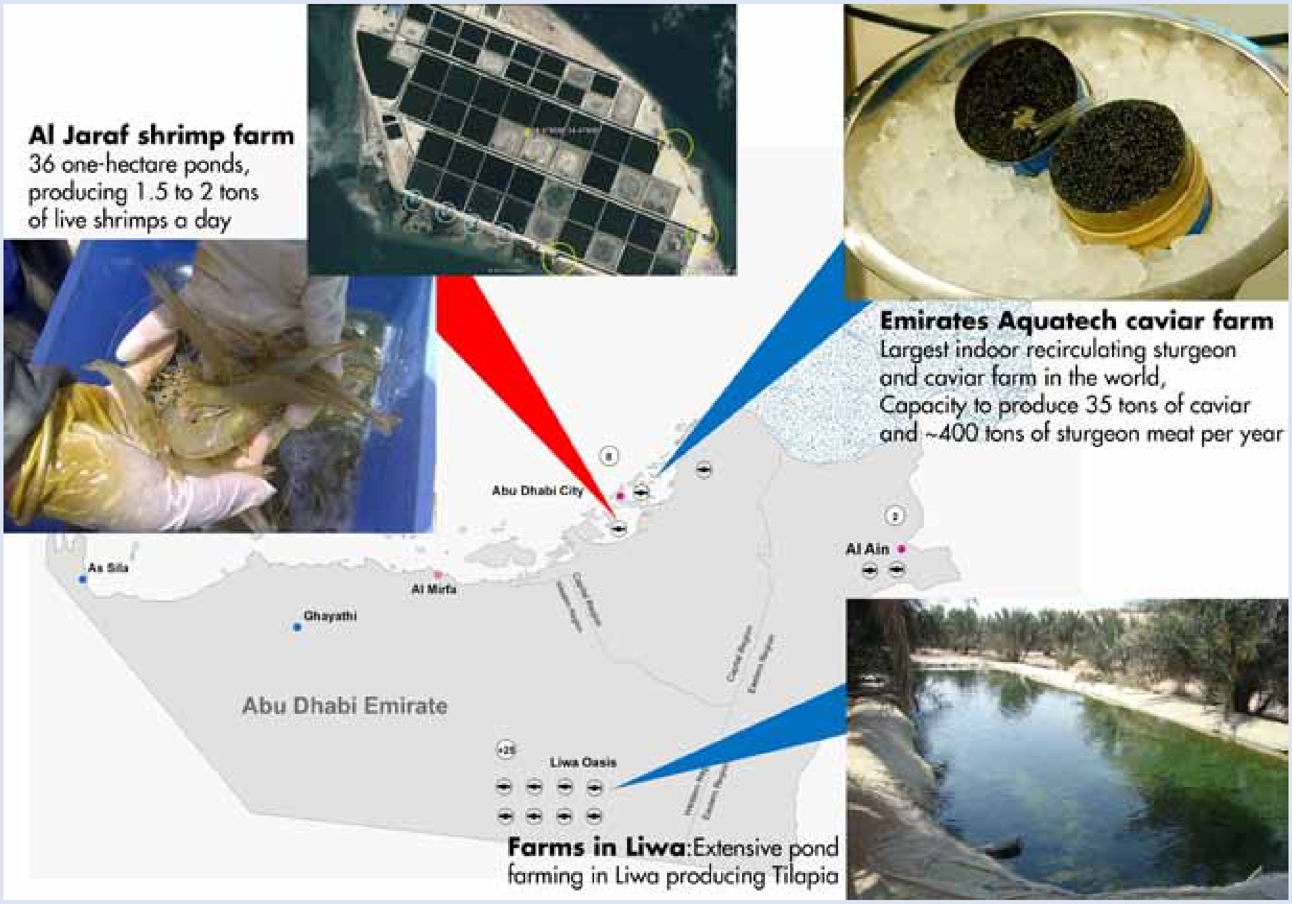
Notes:
-Data reflects potential supply of land in areas with a population density less than 25/km2.
- Last two columns display share of land based on travel time to market.

SUPPORTING SUSTAINABLE AQUACULTURE DEVELOPMENT IN ABU DHABI

Ayesha Al Blooshi and Mohamed Al Marzooqi

Over the next 20 to 30 years, global food production will change considerably from what we know today - and fisheries will not be an exception. The demand from more numerous, more prosperous and more sophisticated consumers already exceeds traditional supplies of many foods. As a result, nations are being challenged to develop new and innovative ways to enhance the world's food supply for both underdeveloped and commercial markets. In the fisheries sector, this challenge will be particularly pressing as natural stocks diminish in the face of overexploitation, pollution and climate change.

Aquaculture, the farming of aquatic organisms including fish, molluscs, crustaceans and aquatic plants, is the fastest growing food production sector in the world. Today, more than 50 percent of seafood for human consumption is derived from aquaculture. By 2020, the United Nations Food & agriculture Organization predicts that global aquaculture output will contribute more than 62 percent of the global seafood supply, reflecting extraordinary potential in the industry. World-wide, concerns over the state of wild fish stocks have driven the development of aquaculture technologies to produce alternative sources of fish protein. Aquaculture technologies range from simple backyard operations, to net-cages floating in the ocean, to highly sophisticated capital-intensive water recirculation systems. At first glance, Abu Dhabi would appear to have few natural opportunities to develop a robust aquaculture sector given its desert topography and arid climate. There are, however, some successful farms in operation and research is underway for production of other local, highly-desired species such as hamour (orange-spotted grouper). Today, there are approximately 30 aquaculture operations in Abu Dhabi. About 25 farms are located in the Liwa Oasis area of the Western region, two farms are in Al Ain plus there are eight farms in the vicinity of Abu



Dhabi and suburbs (of these is Emirates Aquatech, the largest sturgeon and caviar farm in the world and al Jarraf Fisheries shrimp farm). Species produced include tilapia, shrimp, sea bream and sturgeon meat and caviar. Most of the aquaculture facilities are small scale mainly producing tilapia in lined ponds. This practice is not encouraged since ponds tend to leak and evaporation can be excessive resulting in less-than-ideal use of precious groundwater resources.

Aquaculture development is in the interest of the Emirate of Abu Dhabi and the United Arab Emirates at large where studies indicate that overfishing and destruction of fish habitat have resulted in alarming declines in fish and other marine species. Of all the species that have been assessed by EAD, the hamour is the most heavily impacted by fishing. It is amongst the most sought after species of fish locally, having an iconic significance throughout the region. Exploitation rates have been estimated to be 6-7 times in excess of sustainable levels. Furthermore, abundance surveys conducted in 2002 showed that the groupers in general had been depleted to 13 percent of the abundance recorded in 1978. As the human population of Abu Dhabi has increased over the years, fisheries expanded to try and meet the rising demand for fresh fish. The age structure of the population of hamour is clearly 'truncated' with few very large and old individuals, and over capitalization in the fishery (too many fishing boats) has resulted in a condition termed 'recruitment overfishing' where the removal of fish is so high, the reproductive capacity of the population is impaired. Sustainable aquaculture which has a benign, if not positive, net impact on the environment, presents an opportunity to relieve pressures on declining wild populations and give them a chance to recover by providing fisherman with alternative livelihoods and the public with a locally-produced, safe, reliable and wholesome source of seafood (i.e. protein).

On the other hand, well-managed restocking initiatives introducing hatchery-produced fish fingerlings (juvenile fish) of overexploited local species back into the wild can replenish overexploited fisheries resources. Sustainable aquaculture technologies can also be used to preserve biodiversity by raising threatened and endangered species. In addition, some types of aquaculture, such as pearl aquaculture (or those involving filter feeding species), require sites at sea with good water quality. In effect, the existence of these farms at these locations ends up protecting these pristine areas and further enhancing the water quality in the area.

The government of Abu Dhabi recognizes the opportunities that sustainable aquaculture presents to support a diversified economy, contribute to food security and assist in the conservation of endangered fisheries populations. Efforts to advance the aquaculture sector in Abu Dhabi must be built around the three fundamental factors for responsible sustainable development; namely economic prosperity, environmental protection and social well-being. Genuine sustainable development necessitates that all three factors be reflected equitably since initiatives built on only one or two of the factors cannot and will not deliver the benefits associated with sustainable development.
Good management in government is typically built around five principal factors:

i. Forward planning and policy guidance to establish a desired future state of affairs;
ii. Procedures and processes to enable a sector to develop and be managed in accordance with the policy objectives;
iii. Monitoring to collect pertinent information that will enable governments to determine whether the policy objectives are being achieved and to facilitate adaptive management;
iv. Enforcement mechanisms to entice and/or mandate operators to comply with all requirements; and
v. Goal-oriented results to enable an assessment of whether the policy objectives have been successfully attained.

In this regard, the Environment Agency – Abu Dhabi has recently completed an initiative to create enabling conditions for aquaculture development in the Emirate of Abu Dhabi by

- Enhancing aquaculture legislation and legal framework
- Reducing the burden on aquaculture investors through enhanced coordination between local competent authorities
- Enhancing co-management and promoting best practices.

This initiative aims to encourage the successful development of sustainable aquaculture in Abu Dhabi that contributes to the alleviation of pressure on declining wild fish stocks, balance of trade and food security, economic development, employment and the preservation of precious groundwater resources.

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ha of land available for rainfed cultivation – a particularly small area compared to other parts of the world (Table 2).

Therefore, agricultural intensification offers the greatest opportunity for Arab countries to increase their food production by bridging the large yield gaps. However, agricultural intensification is a serious threat to the environment and natural resources (biodiversity, water, land, and soil) unless it is practiced in a sustainable manner, particularly in dry areas where the ecosystem is already very fragile. Thus, to bridge the yield gap the trend should and will be towards sustainable agricultural intensification of production systems. This will eventually result in agricultural modernization and sustainable agricultural development.

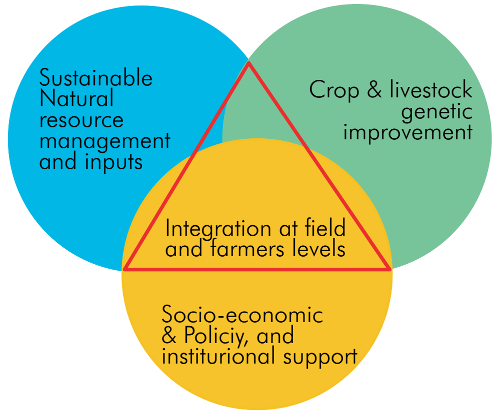
2. *Low potential areas*

Places with low rainfall areas including marginal lands are severely limited by scarce natural resources and require surviving long spells of droughts, as well as adaptation to the worsening conditions from climate change. These places thus require building resilience in the agriculture system to reduce vulnerability and risk and to enable smallholder farmers to recover from 'shocks' easily.

B. Using an integrated approach for maximum and sustainable increase in productivity

In our quest to increase agricultural productivity in the Arab region, sustainable management of natural resources is imperative to ensure that limited resources are conserved and can be harnessed for long-term food production – a cornerstone of sustainable agricultural development.

FIGURE 4 THE INTEGRATED APPROACH FOR SUSTAINABLE AGRICULTURAL DEVELOPMENT



THE DRYLAND SYSTEMS GLOBAL RESEARCH PROGRAM: AN INNOVATIVE INITIATIVE

The CGIAR's Global Research Program, Dryland Systems, led by ICARDA, responds to the vastly different needs and potential of the two different types of agro-ecosystems prevalent in dry areas around the world. Launched in 2013, Dryland Systems is the first ever of its kind research initiative that uses an innovative and holistic approach to address farming systems in dry areas globally. As opposed to focusing on several aspects of farming individually, the Dryland Systems targets agro-ecosystems as a whole, addressing crops, livestock, rangeland, trees, soils, water and policies in an integrated manner. The approach is bringing crosscutting impacts to improve people's livelihoods in a more sustainable manner, while enabling long-term food security in the dryland countries.

A partnership of research institutions and 28 countries, the Dryland Systems Research Program is taking forward the outcomes of ICARDA's on-farm, research-for-development work in more than 40 countries over the past 36 years to identify a number of "best-bet" technology and policy packages that will help countries reduce risk and improve national food security. The program is targeting five regions for large-scale impacts: (i) West Asia and North Africa, (ii) Western Africa and the Dry Savannas, (iii) Eastern and Southern Africa, (iv) Central Asia, and (v) South Asia.

With several action sites already established in the Arab region, the program will deliver a suite of proven science and technology interventions that will potentially transform the agriculture production and food security in Arab countries (drylandsystems.cgiar.org).

Sustainable agriculture development requires an integrated approach to agriculture and entails a holistic combination of science-based technological, institutional and social solutions, as indicated by its three pillars: crop and livestock improvement, natural resource management, and development of policies and institutional capacity (Figure 4).

1. Crop and livestock genetic improvement to enhance productivity, production stability, and quality of outputs. This can be achieved through breeding high-yield and stress-tolerant crop varieties and quality livestock with desirable traits for increased profitability.

2. Integrated water and land management to improve water productivity and sustainably manage water resources in both rainfed and irrigated production systems. This component is critical in ensuring sustainable management of natural resources, particularly needed in effectively combating land degradation and the adaptation/mitigation of climate change impacts for smallholder farmers.

3. Social, economic and policy research to analyze the drivers of rural poverty and provide insights on alternative livelihood strategies so research can be better targeted and larger impacts are obtained on ground. This component helps identify constraints to technology adoption and ways to overcome them through institutional support and enabling policy environment – another important link in sustainable improvement in productivity and rural livelihoods.

Based on ICARDA's experience in dry areas around the world over the last 36 years, integrating the outputs from the above mentioned components have proven to wield a multiplier effect at farm and field levels, delivering large and sustainable gains in productivity systems.

There is no silver bullet to cope with the challenges faced in Arab countries to enhance food security. However, today innovative science and technologies are available to sustainably increase crop and livestock production. But in order for these technologies to make an impact, supportive policies and effective technology transfer methods are necessary. Policymakers must also provide incentives to encourage farmers to invest in new technologies. Additionally, a commitment to long-term investments in research is critical for the effective integration of the three pillars of sustainable agriculture at the field level and for the eventual scaling out of tested intervention packages.

IV. THE POWER OF SCIENCE AND TECHNOLOGY IN ENHANCING FOOD SECURITY

The impacts resulting from ICARDA's research in collaboration with NARS clearly demonstrate the vital role of science and technology in enhancing food security. To keep pace with the growing demand for food supply with increasing population in the face of climate change, food security is obtainable only by ongoing research focusing on the impacts at the local level and scaling up the knowledge obtained through science and technology across similar agro-ecosystems for wider benefits across the rural communities in the Arab region.

A. Crop Genetic Improvement for Higher Yield and Greater Stress Tolerance

As the global population is expanding, redefining the capabilities of crop plants remains the most cost-effective and powerful means of achieving food security, particularly in dry areas. This entails robust ongoing research on plant genetics and crop improvement to increase yield potential along with crop protection through desirable traits for resistance/tolerance to abiotic (e.g. drought, extreme temperatures, salinity) and biotic

(diseases, insect pests and parasitic weeds) stresses.

ICARDA, in collaboration with its partners, is using a range of biotechnology tools – genomics, market-assisted selection, double haploids, embryo rescue, tissue culture, DNA fingerprinting – to develop improved cultivars or breeding lines that are higher-yielding and more resistant to pests, diseases and the environmental constraints in dry areas. Biotechnology tools are also used to identify the genes that confer specific traits such as early maturity to avoid drought or improved nutritional quality of food crops. Further, integrating cutting edge biotechnology techniques with conventional methods of plant breeding is considerably speeding up the process of developing new cultivars, helping to keep pace with the challenges of increasing food demands. the vital role of science and technology in enhancing food security. To keep pace with the growing demand for food supply with increasing population in the face of climate change, food security is obtainable only by ongoing research focusing on the impacts at the local level and scaling up the knowledge obtained through science and technology across similar agro-ecosystems for wider benefits across the rural communities in the Arab region.

1. The Science behind Crop Genetic Improvement

i. Germplasm collection and genebank

A crucial starting point for crop improvement is access to a rich pool of diverse crop genetic materials that can be mined for desirable traits, which can then be used to breed improved crops. ICARDA's genebank, which was established in 1983, has been playing a crucial role as a regional and global resource for genetic materials with materials collected through hundreds of collection missions over the past four decades. These include unique landraces and wild relatives of cereals, legumes and forages collected from regions in the world where some of the earliest known crop domestication practices were recorded. Since crops in these regions have naturally developed robust desirable genes from thousands of years of survival, adaptation and evolution, they are a valuable resource for international and national breeding programs seeking to develop crop varieties tolerant to climate change, diseases, pests and harsh weather conditions.

TABLE 3 ICARDA GENEBANK HOLDINGS (UP TO 2010)

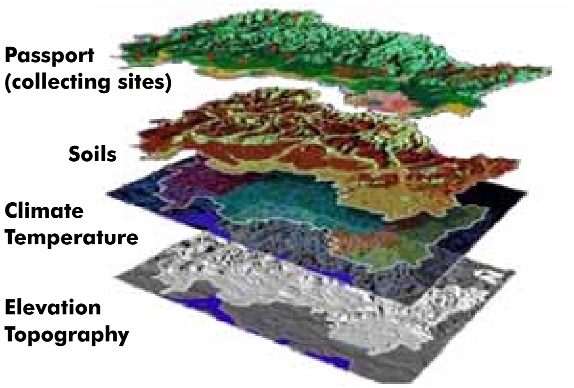
Crop	Accessions
Barely	24,975
Wheat	34,227
Wild Cereals	7,671
Food legumes	33,313
Wild food legumes	857
Forage legumes	28,469
Forage and range spp.	5,744
Total	**135,259**

To date, ICARDA's genebank holds over 133,000 accessions, 65 percent of which are unique landraces and wild relatives of cereals, legumes and forages, collected from dryland areas around the world (Table 3). The genebank, also holding over 1450 accessions of Rhizobium strains, is available as a free public good, conserving and sharing genetic resources with countries and research partners the world over. While collection efforts in the past focused on landraces and wild relatives from diverse eco-geographic origins, future collections are planned to be guided by gap analysis, using a modern Geo-Information Systems-based tool and by the targeting of valuable traits.

ii. Mining genes for desirable traits

ICARDA distributes on average 25,000 accessions a year to partner countries and other collaborating organizations for the identification of valuable traits – a process that is time-consuming, based largely on trial and error. A recent scientific innovation, the Focused Identification of Germplasm Strategy or FIGS[1] is offering a powerful option to conduct rapid mining of the genebank for useful traits. FIGS uses a combination of cutting edge mathematics and plant genetics to rapidly identify genetic traits suitable for local farming conditions (Figure 5) and is fast becoming an essential aid for researchers and countries in breeding improved varieties far more efficiently, saving both time and cost involved with the conventional method of identifying desired genes.

FIGURE 5 **THE FOCUSED IDENTIFICATION OF GERMPLASM STRATEGY**

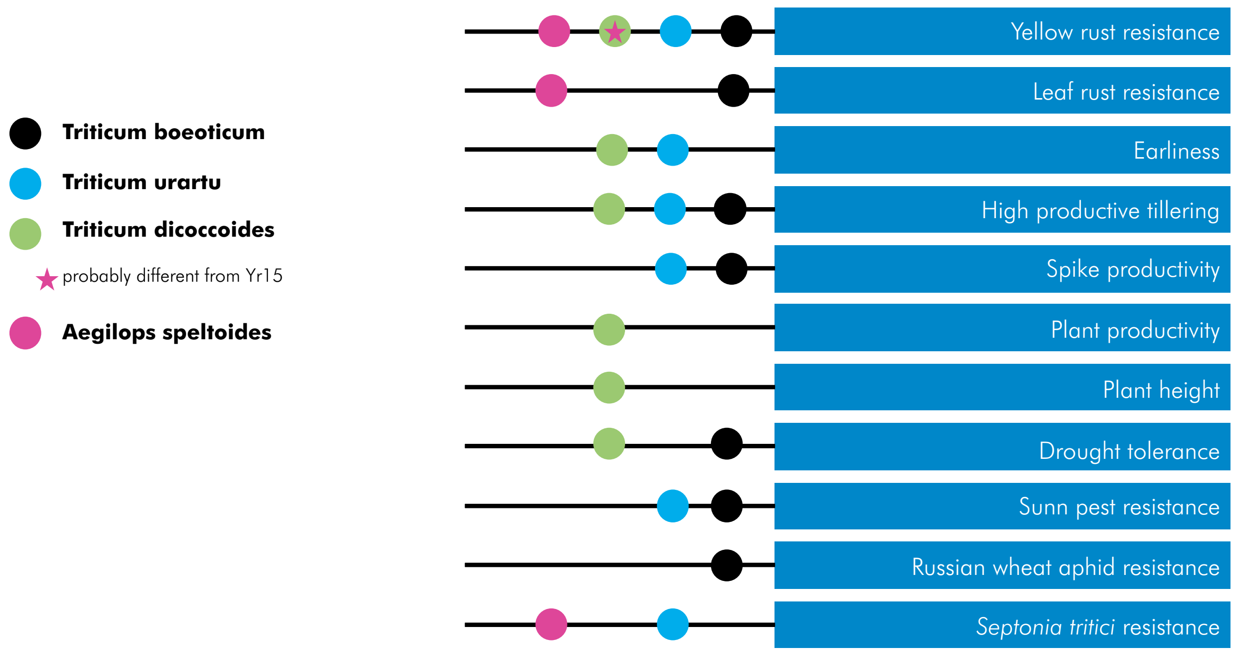


FIGS (Focused Identification of Germplasm Strategy), a powerful tool for rapid mining of agricultural genebanks, is set to revolutionize climate change response for food security in dry areas. It allows for targeting seed genetics and eventual scaling up of varieties for optimal performance in locally prevalent stresses in farming systems.

iii. Identification of genes for desirable traits through wide hybridization involving wild relatives

Hybridization techniques offer breeders in the Arab region and elsewhere an innovative pathway to developing new varieties by incorporating desirable attributes of one parent into another. The technique can be leveraged to produce high and stable yields that are also resistant to major diseases and insects, tolerant to drought, heat and salinity, and contain other useful traits like high micronutrients. This approach is bound to play an increasingly important role in enhancing food security. For example, ICARDA has enjoyed much success in identifying new genetic diversity for wheat through cross hybridization (Figure 6).

FIGURE 6 **DESIRABLE TRAITS IDENTIFIED IN WHEAT THROUGH CROSSES WITH WILD RELATIVES**



ENHANCING FOOD SECURITY IN ARAB COUNTRIES

Habib Halila

The Project for Enhancing Food Security in Arab Countries focuses primarily on improving wheat production and yield in wheat-based agricultural systems. It encompasses three main activities: (a) Dissemination of improved and proven technologies, (b) Applied research and (c) Capacity building of national programs including training of young agricultural scientists. The project started in 2010 and is funded by the Arab Fund for Economic and Social Development (AFESD), the Kuwait Fund for Arab Economic Development (KFAED), the Islamic Development Bank (IDB) and the OPEC Fund for International Development. Activities were conducted in 14 pilot sites selected in nine countries, namely Algeria, Egypt, Iraq, Jordan, Morocco, Sudan, Syria, Tunisia and Yemen.

The project is based on the research-development continuum, thus ensuring that research outputs are effectively utilized for the benefit of farming communities. Being focused on wheat, the project draws on the experience of the International Center for Agricultural Research in Dry Areas (ICARDA) with National Agricultural Research Systems (NARS) in using major research achievements in reaching self-sufficiency in wheat following sustainable intensification of wheat production. In this context ICARDA's collaboration with Syria is one of the most striking examples. In Syria, the use of improved wheat varieties, released by the national program in collaboration with ICARDA, was combined with improved water management including supplemental irrigation, timely use of production inputs, and appropriate policies, which has allowed national wheat yields to increase from 1.25 t/ha under rainfed conditions to 3.0 t/ha under supplemental irrigation. As a result, the durum wheat production has seen a four-fold increase over 28 years without a significant increase in wheat acreage, resulting in enhanced food security at household and national levels. Over the last 3 years the project has reached a total of more than 17,500 farmers. Among them, 2,000 farmers were directly involved in the project dissemination field activities.

Average impact on wheat yield level in farmers' fields

Intensive dissemination activities using large scale demonstrations of proven technological packages in farmers' fields with active farmers' participation demonstrated a clear impact on farmers' wheat yields. Yield results of participating farmers showed that in all countries wheat yield can be increased under all production systems by the use of improved technologies as compared to the use of farmers' own practices. An average increase of 27 percent was achieved in the fields of farmers across all countries involved. Taken separately the maximum average increase per ha was achieved in Sudan (68 percent under irrigated wheat systems) and the minimum average increase was recorded in Morocco (8 percent under rainfed wheat systems).

Overall impact at the level of selected project sites

1. Egypt

Selected statistical data and indicators collected from the El-Sharkia governorate site show an increase in total area sown in wheat (+8 percent), total amount of wheat sold to the government (+36 percent), average productivity (+16 percent), area of wheat grown under raised beds (RB) method and total amount of certified seeds sold to farmers (+21 percent). The wheat yield was increased from 6.2 ton/ha to 7.2 ton/ha (+16 percent). This improvement in yield led to the increase in El-Sharkia's total wheat amount sold to the Ministry of supply. This amount increased from 557,030 tons in 2009 to 755,496 tons in 2013 (+36 percent). This increase is worth about US$36,000,000 at a conservative wheat price of only US$180 per ton (personal communication, national partners).

2. Tunisia

Statistical figures collected from involved stakeholders showed that adoption of improved wheat varieties and agronomic practices in the rainfed systems of Fernana resulted in an increase in wheat production worth about US$433,171*. Similarly, in the supplemental irrigated site of Kairouan (Chebika) farmers have adopted improved wheat variety, appropriate cultural practices and irrigation management techniques. This allowed an increase in wheat production worth US$1,106,236*.

3. Jordan

The dissemination of improved wheat production technologies in Irbid sites raised the yield levels from 1.66 t/ha without project intervention to 1.83 t/ha under field demonstrations. Yet the potential increase is still higher as shown by the results obtained in the wheat demonstrations (2.85 t/ha). The additional production increase in just one year of project interventions in a small wheat growing area is worth US$207,000*.

TABLE **GRAIN WHEAT YIELD (T/HA) OBTAINED IN THE DEMONSTRATION FIELDS VERSUS FARMERS' FIELDS AVERAGE OF 2011/2012-2012/2013 SEASONS**

Country	Egypt	Jordan	Morocco		Sudan	Syria		Tunisia		Yemen*
Production System**	I	R	R	SI	I	R	SI	R	SI	SI
Participating Farmers	8.23	2.59	4.00	5.79	3.60	2.77	5.81	2.92	5.79	4.20
Non-Participating Farmers	6.56	2.08	3.72	4.93	2.14	2.45	5.16	2.32	4.46	2.90
Average Increase (%)	25	25	8	18	68	13	13	26	30	45
Maximum Yield	9.87	3.68	6.90	7.45	5.89	4.05	6.90	4.04	8.62	5.10

Average Yield Increase: 27 percent
Maximum Yield Increase: 78 percent

*Data of 2012-2013 season
**R: Rainfed, SI: Supplemental Irrigation, I: Full irrigation

4. Morocco

In Tadla in Morocco, where supplemental irrigation is practiced, the project results indicated that the deficit supplemental irrigation technology can lead to substantial saving in irrigation water which could reach an average of 644 cubic meters per ha. It is expected that at least 20 percent of the cereal cropped area in Tadla will be covered by the deficit supplemental irrigation technology in the coming two years. The resulting saving in water is expected to be around 1.5 million cubic meters and can be used to irrigate an additional 400 ha using the deficit irrigation technology. Hence, and at a yield level of 7.40 t /ha, an additional production of 3,000 tons of wheat is expected. At the current wheat price in Morocco of US$365 (personal communication, national partners), the additional 3,000 tons of wheat will be worth US$1,095,000. In order to enhance the dissemination and uptake of the improved technologies, ICARDA and its NARS partners worked closely together to better define and streamline extension methodologies which could be considered as relatively innovative and took into account the specificity of each country and the way of research. Extension and development institutions are actually working together at the local level. These methodologies are briefly described below:

Mass dissemination approach (Egypt)

This approach consists of implementing, at a given site/village, the highest possible number of demonstration plots in farmers' fields in order to cover different areas, types of soils and irrigation water management systems. Every plot is supervised by a village-based extensionist linked to a wheat extensionist and working under the supervision of the Governorate extensionist. In addition, every 8-10 fields are closely supervised by a researcher from the project team which involves improvement specialists, pathologists and soil scientists/plant nutritionists.

Leading and satellite (clustered) farmers approach (Tunisia and Morocco)

This approach is based on selecting leading progressive farmers in a given area. In the selected farmers' fields a full improved wheat production package is demonstrated on large plots. These plots are called platforms in Morocco. Around each leading farmer (platform) a group of 8 - 10 satellite farmers is selected. The satellite farmers are coached with regard to wheat improved technologies, either by installing a simple problem solving demonstration (Tunisia) or through direct technical advice provided during Farmers Field Schools by project extensionists and researchers on the best practices to be used (Morocco). Moreover, an innovative approach, inspired from the Indian experience, was used for the first time in Tunisia in order to provide farmers with prompt access to technical information and advice. The approach is based on mobile phone and Short Messaging Service (SMS) technologies. A preliminary impact assessment of the approach shows that SMS technology was welcomed and accepted by farmers.

Multi-tool dissemination approach (Algeria, Sudan, Syria, Jordan, Yemen and Iraq)

This approach is based on the classical technology transfer methodology. It consists of implementing a limited number of demonstration plots conducted under farmers' conditions being distributed randomly across a given area/site. Farmer Field Schools, field days, and travelling workshops are the main tools to disseminate and popularize the improved technologies.

* Price of one ton of wheat is US$350 in Tunisia and US$518 in Jordan (personal communication, national partners)

Dr. Habib Halila, Project Coordinator, "Enhancing Food Security in Arab Countries".

Using wide crosses in the wheat breeding program involving wild relatives, namely Triticumboeoticum, T. uratu, T. dicoccoides, and Aegilopsspeltoides, resulted in identifying desirable traits for high yield potential, such as high productive tillering and productive spikes, as well as tolerance to abiotic stresses such as drought, and resistance to biotic stresses such as yellow and leaf rusts, Sunn pest and Russian wheat aphids.

2. Achievements in Crop Genetic Improvement

i. Enhancing crop yield potential

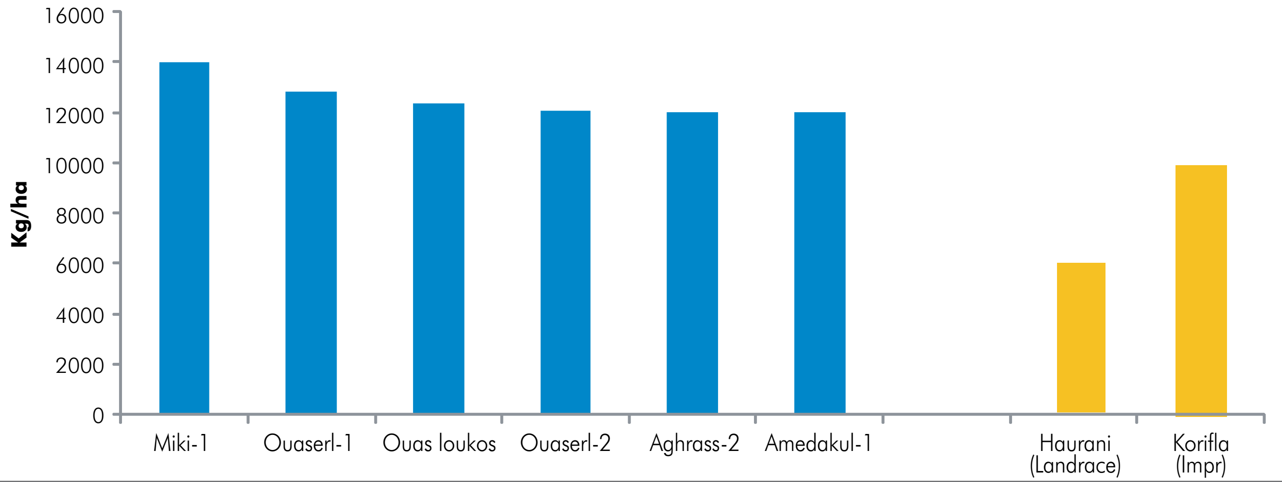
Global wheat production must increase 2 percent annually until 2020 to meet future demands. The development of high-yielding wheat germplasm with enhanced water-use efficiency, heat tolerance, end-use quality, and durable resistance to disease and pests is vital to meeting this need. Several high-yielding wheat cultivars with resistance to heat stress, which is common in most production zones across the Arab region, have already been developed and have demonstrated remarkable success.

Over the past three decades, ICARDA's research, in collaboration with NARS, has led to the release and distribution of over 900 seed varieties of cereals (wheat and barley) and legumes (chickpea, faba bean, lentil, field peas and grasspea) that have been adopted by smallholder farmers across the dryland countries with the help of respective NARS. This includes 111 improved varieties of durum wheat and 230 improved varieties of bread wheat released in developing countries. These varieties are providing higher yields; better tolerance to drought, heat, cold and salinity; and improved resistance to diseases, weeds and insect pests. The total overall benefits of the improved varieties are estimated at US$850 million per year.

The yield potential of ICARDA's recently developed bread wheat genotypes, e.g. lines with the Attila genotype, increased yields to 11.1 tons/hectare in Egypt, while durum wheat yields of as much as 14 tons per hectare were achieved with varieties such as Miki 1 (Figure 7).

A number of legume varieties have also been developed and widely adopted, contributing to higher farm incomes and better nutrition. Twenty varieties of faba bean varieties have been released by the Egyptian national program in cooperation with ICARDA. Those varieties have increased productivity by 20-30 percent compared to local or even improved varieties. Similarly, for lentils and the large seeded Kabuli chickpea, yield advantages ranged between 20-30 percent compared to local checks and other improved cultivars. Gokce, a variety of the kabuli type of chickpea, was developed by ICARDA and Turkish national scientists and is now grown on about 70 percent of Turkey's chickpea area, reaching over 550,000 ha. It offers a yield advantage of 300 kg/ha over other varieties, substantially increasing productivity and incomes.

FIGURE 7 YIELD POTENTIAL OF RECENTLY DEVELOPED DURUM WHEAT GENOTYPES AT ICARDA



ii. Building crop tolerance to drought, heat and cold

With the serious implication of climate change in Arab countries, agriculture is facing more weather variations and extreme events such as more frequent droughts and extreme temperatures, particularly higher temperature. Therefore, building crop tolerance to abiotic stresses, particularly drought and heat tolerance, have become of critical value in enhancing food security and helping countries adapt their agriculture to climate change.

Developing synthetic wheat developed by crossing tetraploids wheat with wild relative Triticumurartu has shown strong drought tolerance. In 2007, synthetic wheat lines yielded 1.5 to 1.6 tons per hectare (Table 4) in Syria when the country was struck by severe drought even as the 211 mm rainfall was barely sufficient for the hardy barley crop. The yield advantage of the synthetic wheat ranged between 15 to 45 percent more than the improved cultivars Cham 6 and Atilla 7.

The success of high-yielding wheat cultivars with resistance to heat stress is clearly being demonstrated in Sudan where the hot temperatures severely limit the inherent potential of growing wheat. This innovation of science has made wheat an attractive crop in the south of Khartoum where heat stress once prevented its cultivation. Now heat tolerant and short season wheat varieties are grown in the Gezira Scheme south of Khartoum. These varieties have also been introduced and evaluated in Nigeria in the 2012/2013 season where three varieties proved to be highly adapted with promising yield potential, and will be released to farmers after establishing 6-8 tons per hectare of yield.

TABLE 4 YIELD OF "SYNTHETIC DERIVATIVES" COMPARED TO PARENTS UNDER DROUGHT STRESS (TEL HADYA, SYRIA, 2008, RAINFALL ~ 211 MM)

Parent Variety	Yield (tonne/hectare)	Percent Recurrent Parent
Cham 6*2/SW2 (synthetic wheat)	1.6	147
Cham 6*2/SW2 (synthetic wheat)	1.5	138
Cham-6 (improved)	1.1	100
Attila-7 (improved)	1.3	-

Another example is the success of winter chickpea which was grown as a spring crop in West Asia and North Africa. Spring chickpea has always faced serious terminal drought since it survives on residual moisture. However, winter chickpea, which is cold tolerant and tolerant to Aschocyta blight disease, avoids terminal drought and benefit from rain in winter to double its productivity and double farmers' incomes. Similarly, drought-tolerant lentil varieties have increased yields and incomes for farmers in the dry climate of Jordan, Libya and Syria.

iii. Fighting Pests and Diseases

Science plays a key role in combating pests and diseases that cross national boundaries or emerge in areas where they have not been experienced before. An example is a new race of stem rust disease of wheat, named Ug99, which is a threat to rural livelihoods and regional food security.

Ug99 was identified in Uganda during the 1998/1999 growing season and is a serious threat because it kills the whole plant completely, rather than infecting parts of it. Currently, the environment in the Arab region is not very conducive for Ug99. However, changing climates are making local environments vulnerable to Ug99 and are allowing various types of wheat rust to spread rapidly to areas previously unaffected, making it harder to manage and protect the wheat crops. Additionally, aggressive new types of rust are emerging, favoring warmer climates and fueling the spread of the disease.

Breeding disease- and pest-resistant crops

One way of combating diseases is to breed for resistant wheat cultivars or varieties by screening germplasm and breeding lines for durable resistance (Figure 8). Scientists inoculate the plants with rust spores and observe which genotypes have the healthiest plant growth at both seedling and adult stage. All resistant wheat variety releases now in the Arab countries have resistance to stripe or yellow rust and black stem rust (Ug99 strain). These resistant varieties have been multiplied through the rapid seed multiplication program, and resistant seeds have been distributed to farmers mostly through the public sector, although the private sector also plays an important role in this function.

Amongst the many examples on breeding for disease resistance, ICARDA's improved wheat cultivars with resistance to the Hessian fly are ensuring the stability of Moroccan wheat yields. The Hessian fly is a major destructive pest of wheat in North Africa, South Europe, North America and North Kazakhstan. The improved varieties have been extended to Moroccan farmers to combat the Hessian fly through demonstrations on farmer fields, along with capacity building initiatives that teach producers how to identify diseases and pests and the optimal time to apply pesticides.

As another example, ICARDA's initiative in Ethiopia for the development and distribution of high-yielding, rust-resistant wheat varieties is protecting smallholder farmers against the devastating effect of the strip rust disease. The 2010 outbreak of the disease had crippled the wheat production in the country, leaving many farmers without a source for livelihood.

These examples are demonstrative of the need for breeding disease-resistant crops and for Arab countries to invest in such programs. The improved varieties are not only protecting the crops but are raising the incomes of farmers through higher yields. However, once a new type of strain of disease emerges, it can take several years to breed a resistant variety. Therefore, it

FIGURE 8 **IMPROVED WHEAT VARIETIES RESISTANT TO DISEASES** a. Wheat variety resistant to stripe rust disease (center) demonstrate tolerance and healthy crop as compared to conventional varieties (left and right rows) b. Wheat variety resistant to Hessian fly

a.


b.


is necessary to provide farmers with short-term strategies. As a result, ICARDA has been working closely with farms in the Arab countries and beyond to monitor rust outbreaks and develop early warning systems. These systems raise the alarm for immediate spraying programs and are essential for dealing with rapid outbreaks of rust.

Integrated Pest Management

Insect pests cause widespread damage to crops in many parts of the Arab region. Integrated Pest Management (IPM) is an environmentally friendly approach to pest control that combines an extensive range of organic techniques to control and prevent the growth and spread of pest populations. It emphasizes the use of cultural and biological interventions and supports the targeted use of pesticides only when alternative methods have been exhausted; costs are not excessive and there is no threat to existing agro-ecosystems.

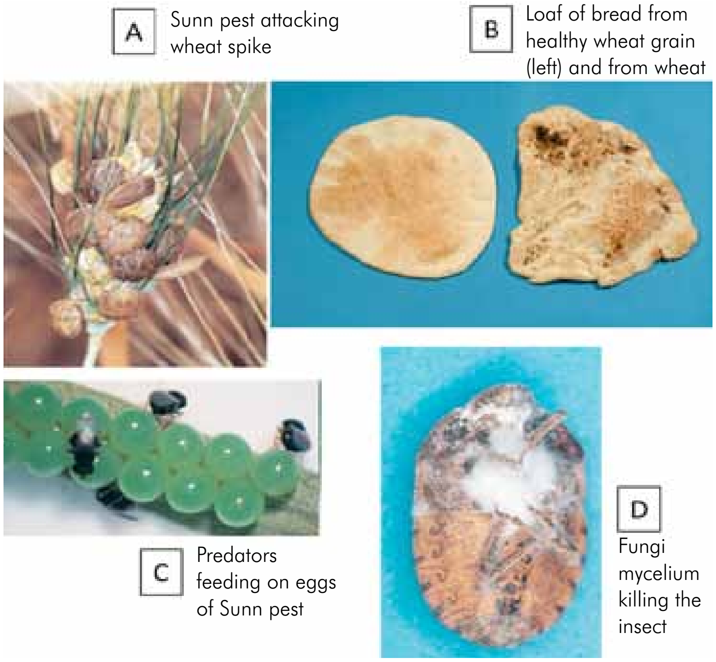
One example is the Sunn pest which impacts over 15 million ha of wheat in West Asia, Central Asia, and East Europe annually. Severe infections have been known to reduce wheat yield by 50-90 percent in some areas. Under ICARDA's IPM program, researchers focus on several components, such as hand collection of Sunn pest in overwintering sites; use of insect-killing fungi in overwintering sites; conservation and enhancement of egg parasitoids; and genetic resistance at the vegetative stage (Figure 9).

The use of natural enemies (parasitoids that attach Sunn pest eggs) reduces pest populations without the need for excessive doses of pesticides, which lowers a farmer's costs and protects the environment. ICARDA's Sunn pest research has helped change national policies in West Asia. Government-support aerial sprays have been replaced with targeted ground applications on over three million hectares. In addition, revised "economic thresholds" have been implemented, significantly reducing pesticide use (Figure 10).

B. Increasing Water Productivity and Enabling Sustainable Management of Natural Resources in Dry Areas

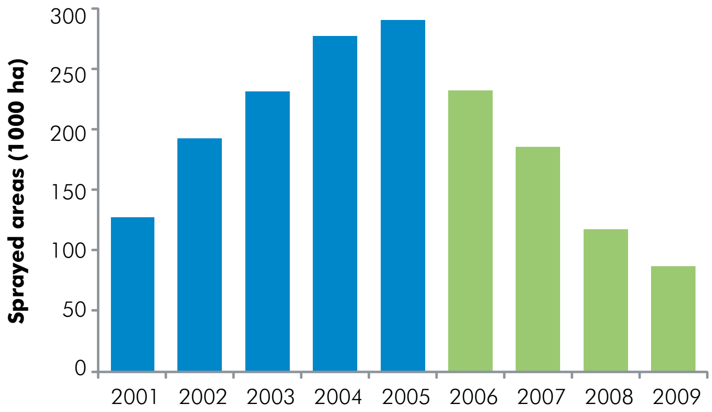
Sustainable increases of water productivity – at the farm and basin levels – are major concerns in Arab countries. Community participation is

FIGURE 9 **SUNN PEST DISEASE IN WHEAT AND IPM OPTIONS TO FIGHT THE DISEASE**



Using IPM, eggs and fungi act as biological control agents against Sunn pest disease, offering an environment friendly and cost-reducing method to control the disease.

FIGURE 10 **THE REDUCED AREA OF SPRAYING AGAINST SUNN PEST IN SYRIA SINCE 2005, SAVING THE FARMERS COSTS OF EXPENSIVE PESTICIDES (ICARDA)**



an integral part of the water management effort, along with efficient use of resources and the use of technologies that increase water productivity.

Several innovative technologies and approaches have been demonstrated to improve the productivity of water depending on the type of agro-ecosystem – rainfed, irrigated and marginal lands. These include:

ENHANCING WHEAT SELF-SUFFICIENCY IN SYRIA

Majd Jamal

Agriculture is a very important sector in the national economy of Syria. Over the last decade, the contribution of agriculture to the national GDP dropped from 24 percent in 2006 to 16 percent in 2010 due to the developments of other sectors. The total labor force working in agriculture is around 20 percent of the Syrian population, contributing to the national total trade of up to 14 percent and providing raw material to agro-industry business.

Wheat is a major agriculture crop in Syria and it is highly contributing to the national food security. Syria experienced difficulties in providing sufficient wheat flour to its citizens in the late 80's of the last century. A decision has been made at a high political level after this crisis, according to which the country is to produce its needs from wheat and the government is to ensure the availability of natural and agricultural resources, and limit the impacts of environmental and climatic conditions.

Challenges Facing Agriculture in Syria

As other countries in the dry areas, Syria is facing many challenges to its agriculture sector, including: High population growth, fragmented agriculture holdings, lack of adequate water resources, lack of financial resources and limited investments due to the uncertainty of the agricultural investment. In addition, there have been international economic changes (trade liberalization, trade agreements, and tariff concessions), agricultural subsidies of rich countries, strong competition, and macro policies problems such as fiscal and financial policies, interest and exchange rates, pricing, and subsidies.

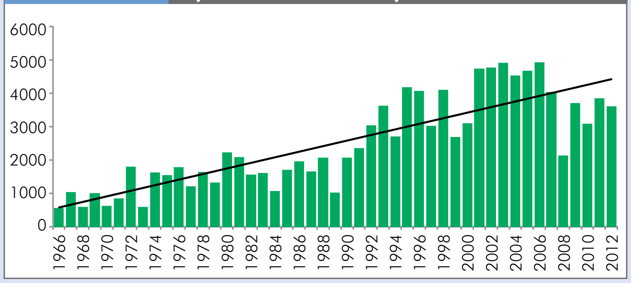
Syrian Policy on Wheat Self-Sufficiency

The Syrian policy to achieve self-sufficiency in wheat production was concentrated on the following changes:

• **Planning policy:** Applying a top-bottom initiative of the Annual Agricultural Production Plan which took into consideration local discussion of the plan and bottom to top process to formulate the plan, was then endorsed on the central level and applied across the country.

Licenses were given to farmers to plant wheat or other major crops. The succeeded five year plans increased the total areas of wheat in the country from 1,449,000 hectare in 1980 to 1,603,000 hectare in 2012. Production has increased throughout that period as shown in the figure below. In the 2000's, the annual wheat production in Syria reached about 5 million tons, where about 3.5 million tons was for domestic consumption and the surplus for export.

WHEAT PRODUCTION IN SYRIA (THOUSAND TONS)



• **Input and credit policies:** A credit policy was applied through the Agricultural Cooperative Bank (ACB) where the subsidized interest rate was around 6 percent -8 percent, in addition to cash loans per hectare, and in kind loans as seeds, pesticides, fertilizers or even irrigation networks.

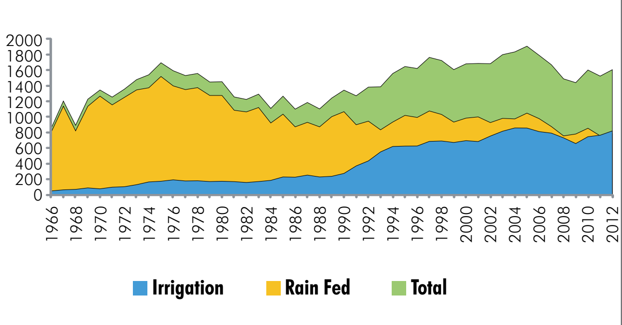
Improved certified seeds were produced and distributed to farmers by the General Establishment for Seed Multiplication (GOSM) directly or through ACB. The improved and certified seeds covered one-third of the planted areas in the country annually.

• **Irrigation policy:** The Tenth Five-Year Plan adopted policies and methods related to management and investment of water resources. Supplemental irrigation was adopted to increase productivity, water resources obtained from government irrigation networks and underground water which was economic due to subsidized energy for water pumping. The overuse of underground water pumping caused lowering of the water table in many areas, even though productivity of wheat was increased.

The irrigated area of wheat increased from 12 percent in 1980, to a total cultivated wheat area of 50 percent in 2012.

• **Plant protection policy:** Pest control services were free, especially through extension and plant protection

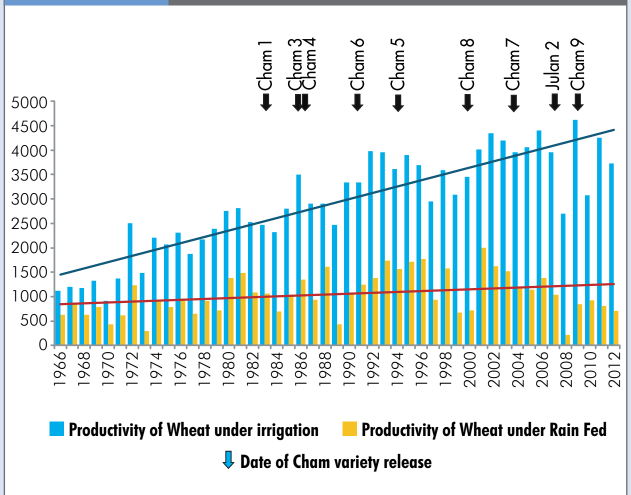
TOTAL, RAIN FED AND IRRIGATED AREAS OF WHEAT IN SYRIA (OOO HA.)



departments. In-kind loans were given as pesticides from the agricultural bank with high subsidy. Spraying programs for major pests were conducted in some areas using aircraft, either for free or against minimum fees.

• **Agricultural research and extension policies:** Cooperation between the National Research System and several international and regional organizations, especially ICARDA, played a major role in capacity developments and joint research to release new varieties of wheat, the Cham series being one of the most adapted series with high productivity both for rain fed and irrigated areas. Those newly released varieties (more than 28 in total) were tolerant to biotic and abiotic stresses and led to a high increase in productivity, especially in irrigated areas.

WHEAT PRODUCTIVITY IN SYRIA (TON/HA)



Research results including the new released varieties, fertilizer recommendations, supplemental irrigation methods, and total agricultural practices packages were demonstrated with pioneer farmers through an extension service which has developed to cover most of the country (more than 850 extension unit in 2011). With the help of ICARDA and other organizations, field days were conducted and the new technologies were spread amongst farmers.

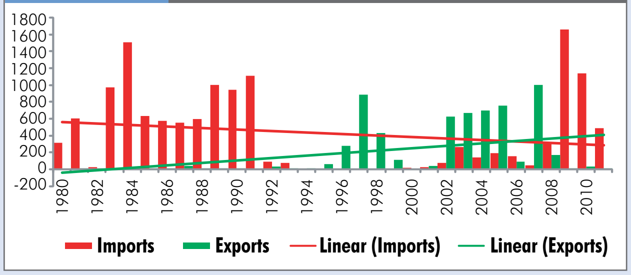
The impact of agricultural technologies on the increase of wheat productivity:

A study was conducted in the late 90's between the Agricultural Research at the Ministry of Agriculture and Agrarian Reform and the International Center for Agricultural Research in Dry Areas (ICARDA) on the adoption of modern agricultural technologies and its impact on wheat production in Syria. The study indicated that there has been a shift in agricultural policy in Syria – more focus is being placed on enhancing the productivity of both durum and bread wheat through the use of high-yielding varieties, chemical fertilizers, and pest-control measures suited to local conditions. Irrigation infrastructure has improved, extension and credit institutions have become available, and farm mechanization is being encouraged. The result has been noticeable since 1993 when wheat production exceeded the demand. The study found that about 32 percent of this increase is due to the impact of the use of improved varieties, 18 percent to fertilizer, 27 percent to irrigation, and 23 percent to improvement in land and crop management practices. Approximately 30 percent of the increase came from supplemental irrigation areas, 33 percent from fully irrigated areas, and 38 percent from rainfed areas.

• **Marketing and price policies:** Wheat marketing had been under government control, farmers were offered very profitable prices mostly above the world market prices to enhance the production of wheat in the country.

• **Trade policy:** Foreign trade is mostly government controlled; only small quantities are imported by the private sector for milling and some other processing industry. Starting in the early 90's the self-sufficiency was established and some quintiles were exported. Only in some dry years wheat was imported, especially in the 2008-2009 season when it was a very dry. The current crises in Syria prevented some farmers from selling their wheat to the government, which resulted in certain wheat imports.

WHEAT IMPORTS AND EXPORTS IN SYRIA (000 Ton)



Policy impacts analysis

The impact of agricultural policies adopted over the last 20 years was positive on the increase of wheat production, due to the development of both horizontal and vertical dimensions. Between 1990 and 2012 the production increased by 74 percent – from that percentage 74 percent was due to improvements in productivity and 26 percent due to the expansion in area. Statistics show that the average ratio of cultivated area to planed area of wheat between 1996 and 2013 is 104 percent. The highest was 124 percent, in 2001, and the lowest was 82 percent, in 2013.

Positive and negative Impacts of Agricultural Policies

The positive impacts of the agricultural policies adopted were: Increasing cultivated land in both rain-fed and irrigated systems, achieving self-sufficiency in many agricultural products, increasing per capita calorie intake, increasing the aggregate value of the agricultural production, increasing the raw and processed agricultural exports share of the total exports and developing rural infrastructure such as agricultural roads, electricity, water, communication, storage, transport, etc.

The negative impact of the agricultural policies adopted were: deteriorating soil fertility and contamination of soil and water due to the excessive use of water and shortage of water supply (particularly underground water due to random wells drilling and irrational water use). Holding fragmented land ownership impeded agricultural mechanization due to heritage system and absence of joint stock investment systems, marketing, export and processing activities were not in line with the agricultural production increase.

Dr. Majd Jamal, Assistant Director General for Government Liaison at International Center for Agricultural Research in Dry Areas (ICARDA).

- Modernization of irrigation systems and improving the efficiency of surface irrigation
- Modifying cropping patterns to enhance water productivity and income
- Supplemental irrigation (systems and management)
- Macro- and micro-water catchments (Vallerani and other types)
- Deficit irrigation to manage water in water scarce areas
- Integrated watershed management

Other approaches to produce more from less have led to high impact innovations, both increasing and creating new revenues of incomes for smallholder households in dry areas. Following are some examples.

1. Harnessing grey water for irrigating

ICARDA and the National Center for Agricultural Research and Extension Services (NARES) in Jordan have concluded a project developing and promoting community-based interventions for the productive use of grey water. Greywater is the output from bathtubs, showers, sinks, floor drains, and washing machines, which can be used for the irrigation of plants with little or no treatment. The project focused on grey water as an alternative source for irrigation in gardens and on small-scale farms. As a result of the project, 13 greywater treatment units have now been installed in the Madaba governorate of Jordan. Additionally, other communities have visited the project site to learn more about the water treatment units and the technology is now being scaled out to Lebanon and Palestine.

2. Using less to produce more with soilless farming

Soilless production systems are a proven and highly efficient means of improving water and fertilizer productivity within a protected environment. ICARDA and its partners have focused on introducing soilless systems, including in the Arabian Peninsula. Scarce water severely constrains farming in the Arabian Peninsula, but farmers have increased their yields and water productivity by 50 percent on average by using technology "packages" for protected agriculture and hydroponics (soilless farming).

Additionally, ICARDA's scientists worked with smallholders in Oman, Kuwait, Qatar and the UAE to introduce simplified and optimized soil-less techniques for the production of high value crops such as cucumber, tomato, strawberry, lettuce, etc. Packaging a set of innovations such as improved greenhouse design to tolerate high temperatures, integrated pest management practices that reduce harmful pesticide use, and hydroponics systems with automated water and plant nutrients, the research initiatives have been able to maximize productivity per unit water and land for protected agriculture (Figure 11).

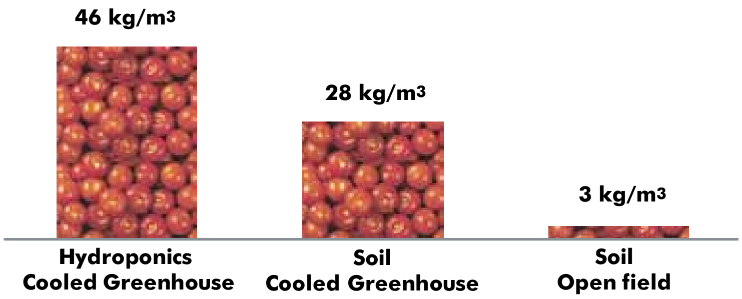
Encouraged by the substantial returns, Oman, the Emirates, Qatar and Bahrain have implemented a catalytic incentive policy to encourage farmers to convert from conventional soil culture to soilless farming and adopt the integrated production and pest management technologies.

3. Increasing water productivity through raised bed irrigation

Raised bed farming is an ancient water-efficient farming practice in Egypt with many conservation benefits. It reduces water application to the land, which minimizes water loss from percolation. This results in good aeration of the roots, efficient use of fertilizer, and easier weed control. However, smallholder farmers have historically had difficulty benefiting from this technology because the machinery for bed planting is expensive and not suited for fragmented lands.

ICARDA scientists, in partnership with NARES, recently developed an innovative adaptation of the machinery required for raised bed planting. This is changing the game for smallholder farmers in Egypt's Nile Delta region. Raised bed cultivation of wheat led to 24 percent saving in irrigation water, 34 percent increase in wheat yield, and 78 percent improvement in water use efficiency for farmers in the Al-Sharkia province (Figure 12). Given its simplicity and impressive results, the technology is rapidly gaining momentum in Egypt and is also being transferred to countries such as Sudan, Ethiopia, Eretria, Nigeria, Iraq and Morocco.

FIGURE 11 INCREASE IN WATER PRODUCTIVITY FOR TOMATOES FROM HYDROPONICS PRODUCTION SYSTEMS



C. Managing salinity to boost food security

The build-up of salts in soil affects agricultural land across the world, but it is most acute in dry areas. Salinity negatively impacts crop yields, damaging a farmer's income or even forcing them off their lands. Unfortunately, there are limited strategies for reducing or managing salinity in many impacted countries. Through its country partnerships in Egypt, Iraq and Iran, ICARDA is developing research-based coping strategies for farmers and water managers dealing with salinization.

Salinity in parts of Iraq is so pervasive that its impact on farming systems is a major constraint

FIGURE 12 RAISED BED IRRIGATION IN EGYPT LED TO 24 PERCENT SAVING IN IRRIGATION WATER AND A 34 PERCENT INCREASE IN WHEAT YIELD

to agricultural productivity. ICARDA's research in the Mesopotamian plain in Iraq tackled the problems caused by limited water availability; the irrigation water being impacted by salinity; and the age-old irrigation practices leading to widespread salt accumulation in the soil and ground water. The research identified a number of recommendations for tackling soil salinization to ensure future food security. In particular, it advised on improving drainage facilities as a paramount step in ensuring Iraqi farmers are able to continue to produce successfully. ICARDA also developed an innovative approach for modeling and mapping salinity using remote sensing and field surveying, which contributes to management decisions about where to develop agriculture in the country.

D. Promoting sustainable farming through conservation agriculture

Conservation agriculture is the practice of not plowing farmlands and leaving crop residue in the field for improved soil fertility and water conservation. In the world's dry agro-ecosystems, conservation agriculture can bring direct benefits to smallholder farmers, particularly in the marginal farming areas of low-income countries. Two factors that are needed for the successful adoption of conservation agriculture for drylands farming are appropriate technologies and a favorable policy environment. For conservation agriculture to make an impact in Arab countries, there needs to be a change in perception among decision-makers about the benefits of this technology. ICARDA is concentrating on directly demonstrating the benefits of conservation agriculture to the communities. As a result, farmers who convert to zero-tillage rarely, if ever, return to plowing.

Work by ICARDA and partners, particularly in Syria and Iraq, has shown significant reductions in costs and increased profits for smallholder farmers in developing countries adopting zero-tillage and early sowing. Based on the field trial results and farmers' experiences, conservation agriculture has demonstrated increase in incomes from wheat by up to US$200/ha in Syria and US$300/ha in Iraq (Figure 13).

E. Enhancing agricultural productivity and better livelihoods in marginal lands

Crop-livestock integration is a crucial element in dryland farming systems allowing it to leverage available resources in a mutually beneficial manner. ICARDA and its partners have developed and refined a range of methods to effectively integrate crop-livestock-rangeland production systems.

These include:

- Barley production with alley cropping of shrubs
- On-farm feed production
- Feed blocks produced from agro-industrial by-products
- Spineless cactus and fodder shrubs

FIGURE 13 PROMOTING CONSERVATION AGRICULTURE THROUGH DEMONSTRATION AND INNOVATION OF LOCALLY FABRICATED LOW-COST ZT SEEDERS (RIGHT); WHEAT GROWING ON CROP RESIDUE (LEFT)

IMPROVING SOCIO-ECONOMIC STATUS OF THE YOUTH FOR ENHANCED HOUSEHOLD FOOD SECURITY: ISLAMIC DEVELOPMENT BANK INITIATIVE

Nur Abdi

The recent economic growth in the MENA Region has not created the required number of jobs to absorb the growing labor force and unemployment, especially among the youth – a critical challenge the MENA region is faced with.

According to the International Labor Organization of the United Nations, youth unemployment is highest in the MENA region where one out of four young people are unemployed—roughly double the world average. In search of employment, youth migration from rural areas to urban cities is increasing in the Arab world. This youth urban influx is due to a number of factors including the youth's disinterest in agricultural careers. This is directly affecting the region's agricultural production, food security and growth of the rural economy. Youth who remain in the rural areas often lack financial means, education, training and market access necessary to generate enough income to maintain acceptable levels of household food security. Those who migrate to urban areas are often unable to earn enough income to achieve food security.

In mid-2012 the Islamic Development Bank (IDB) launched the Youth Employment Support (YES) program with a total financing of US$ 250 million to address the above challenges. The program is being implemented in four countries in the MENA region including Egypt, Tunis, Libya, and Yemen. When completed, the program is expected to decrease unemployment by 15 percent and poverty by 10 percent in the target projects locations.

The program finances employment generation projects in rural areas, and capacity building activities for skill enhancement and skill alignment with market needs. Under the employment generation, the program finances value chain development in horticulture and high value commodities such as coffee and honey. In addition, the program provides microfinance to support establishments of Small and Medium Enterprises (SMEs) in the agricultural sector.

Nur Abdi, Senior Agriculture Specialist at Islamic Development Bank (IDB), Jeddah.

- Natural pasture enhancement and rangeland management
- Increased animal productivity: animal health and nutrition, better use of genetic resources including wild breeds, improved flock management and better access to markets and by-products
- Rehabilitating degraded rangelands and improving grazing management

Indigenous breeds of small ruminants are an important component of this integrated production system that is highly adaptable to changes in the environment. Years of livestock research at ICARDA has yielded complete characterization of all the indigenous ruminant breeds in Central and West Asia and North Africa and is freely available as an international resource. Water productivity is also a key issue in crop-livestock systems. Technologies have been developed to enhance water productivity for feed production through feed selection, use of residues, feed water management and multiple uses of water. Traditional systems have been adapted to more sustainable practices, such as "tabia" and "jessour" systems of Tunisia which have been adapted for water harvesting and watershed management. Other modifications can help reduce the pressure on rangelands, such as barley/livestock systems and considering rangeland/livestock versus confined feeding.

V. THE OPPORTUNITY IN BRIDGING THE YIELD GAP TO ENHANCE FOOD SECURITY

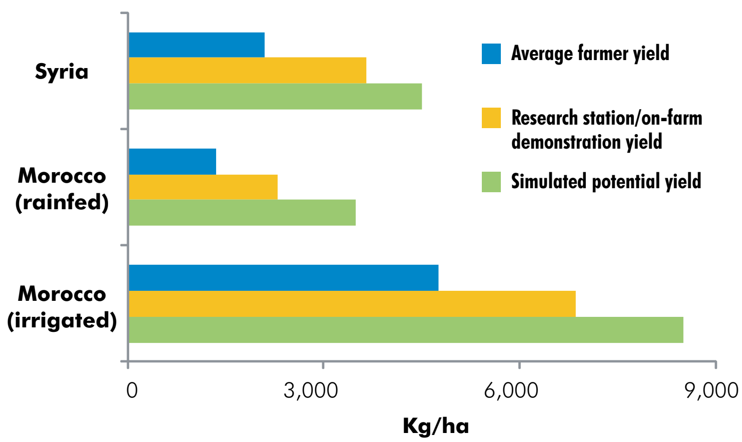
An analysis of yield gap between the average farmers' yields and demonstration trials on research station indicate a substantial opportunity in increasing the productivity for Arab countries. Using wheat production in Morocco and Syria as an example, the average yield gap was calculated to be 45 percent for irrigated systems in Morocco and 82 percent for rainfed systems in Syria (Figure 14). Understanding the reasons behind yield gaps is an important step to identifying best suited solutions and successfully bridging the gap. Based on ICARDA's research, the yield gaps between potential and actual yields could have several reasons, as shown in Figure 15. Key strategies to reduce yield gaps, therefore, include:

- Increasing the efficiency of technology transfer;
- Use of recommended practices: sowing date, seed rate, fertilizer amount, rotation, use of proper farm machinery, and disease and pest management practices;
- Proper targeting of varieties to production zones;
- Timely availability of inputs: quality seed, water, and fertilizers; and
- Government intervention and policies to strengthen input availability and crop marketing.

VI. THE CRITICAL ROLE OF PARTNERSHIPS

The decades of research in agriculture has proven the transformative potential of science and technology. The big question is how to realize the potential of the available technologies and continue making advances much needed to keep pace with the needs of our fast changing world. The key lies in forging effective research partnerships, which allows players to leverage mutual interests as well as complementarities for wider gains.

FIGURE 14 WHEAT YIELD GAP ANALYSIS FOR MOROCCO & SYRIA (1995-2004)



Source: Pala et al., 2011.

A. Stakeholder partnerships to link research to development

In order to fully benefit from advances in science and technology, research must be linked to development. Uptake and scaling out new farming technologies to communities is vital for wider impacts and benefits, which needs an effective partnership amongst all the stakeholders.

To ensure the success of research-for-development initiatives, ICARDA has found it most effective to partner with NARES, local universities and research institutions, and farmer groups. The Arabian Peninsula Regional Program (APRP) supported by the Arab Fund for Economic and Social Development (AFESD) and International Fund for Agricultural Development (IFAD) serves as a model example where its outcomes are being adopted for nationwide uptake and are ready to bring a substantial improvement in the livelihoods of farmers, all through a robust partnership. ICARDA's scientists are working hand-in-hand with NARES in seven beneficiary countries, local universities and research institutions and pilot farmer groups to develop, demonstrate and validate technology packages to improve rural livelihoods and promote sustainable practices by maximizing the efficiency of water use – a critical performance measure in the severely water scarce region.

Amongst several successes of the partnership, APRP identified indigenous forages with high water use efficiency, such as Buffel grass, and is promoting it to replace the more commonly grown forage. While this has the potential to reduce the average annual water requirement by half, farmers are also experiencing increased fodder production. In Oman, farmers are saving 55 percent water by adopting Buffel grass over the popular Rhodes grass. In the United Arab Emirates (UAE), farmers are saving roughly 850 m3 of water for each ton of dry matter produced compared to Rhodes grass, translating to an

THE INTEGRATED APPROACH TO IMPROVING PRODUCTIVITY: MAXIMIZING GAINS FROM GRAINS

In Syria, the use of improved wheat varieties released by the national program in collaboration with ICARDA was combined with improved water management, timely inputs, and appropriate policies. Supplemental irrigation was introduced as part of an agronomic package in rainfed areas where water is a limiting factor.

National wheat yields increased from 1.25 t/ha under rainfed conditions to 3 t/ha under supplemental irrigation with appropriate cultivars. Supported by a favorable shift in national policy, annual durum wheat production in Syria has increased four-fold over the last 28 years without a significant increase in wheat acreage, resulting in enhanced food security at household and national levels.

This increase in production is equivalent to an annual increase in national incomes of about US$350 million.

Syria has now evolved from a wheat importing to a wheat exporting country. Interestingly, and in contrast to the experience of many other countries (where large farmers have tended to benefit most), in Syria the benefits of this research spread across all farmers – small, medium, and large.

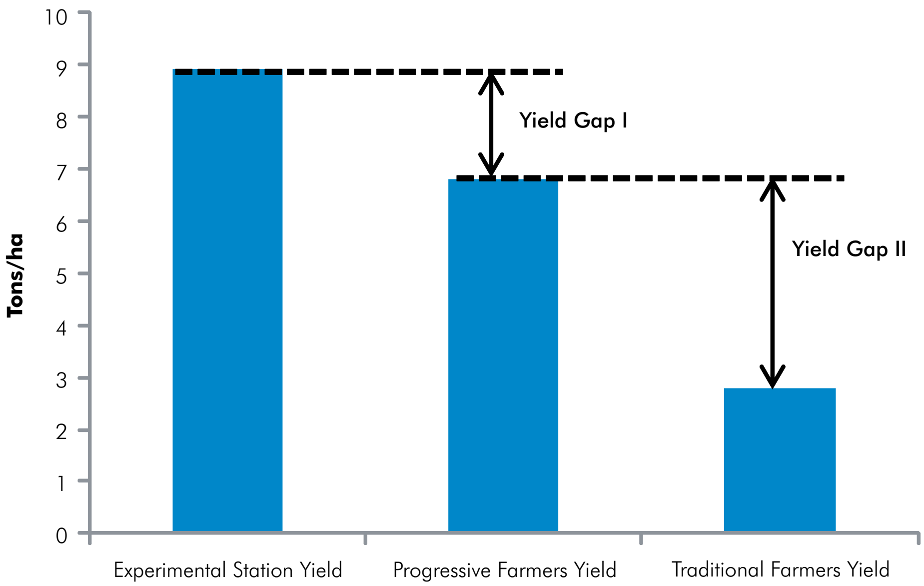
This success story demonstrates the potential of integrated approach – crop improvement with natural resources management in an enabling policy environment – in transforming national food security.

average annual increase of US$545/ha. UAE has thus decided to ban the cultivation of the Rhode grass and replace it with the highly water-efficient Buffel grass and is providing farmers with favorable loans with built in catalytic matching grants. Similarly, Oman, the Emirates, Qatar and Bahrain are introducing incentives to encourage uptake of soilless culture technology package, which were validated and disseminated by the initiative (section IV.B.2).

B. Bilateral and multilateral partnerships for large-scale research, large-scale benefits

Working in bilateral and multilateral partnerships in support of promising research is of great value to the participating countries and the region as it builds collaboration amongst scientists in addressing similar challenges and goals of seeking new technological solutions to food security.

FIGURE 15 **YIELD GAP ANALYSIS OF WHEAT IN TUNISIA**



Biological constraints

- Variety
- Water
- Weeds
- Diseases and insect pests
- Soil fertility
- Soil Problems (e.g. salinity)

Socio-economic constraints

- Input availability
- Cost and returns
- Credit
- Prices
- Tradition and attitudes
- Knowledge
- Input availability
- Institutions and Policies

The project on Food Security in Arab countries supported by Arab Fund (AFESD), the Kuwaiti Fund for Economic Development (KFED) and the Islamic Development Bank is exemplary of the impacts of such partnerships, presented as a case study in this chapter.

Another example of such a partnership is ICARDA's Water and Livelihoods Initiative (WLI). Established by ICARDA, NARES from seven countries in the Arab region, and the United States Agency for International Development (USAID), the WLI offers a unique opportunity for dryland countries to come together and tackle large-scale research needed to develop solutions for land degradation and water scarcity.

The WLI is a benchmark site-based initiative that develops and tests technologies at one site and scales them out to similar agro-ecosystems within the partnership locations. The scientific cooperation ensures that a strong body of data and analysis from different disciplines is available to evaluate the effects of land and water management technologies and their suitability for scaling up to similar agro-ecosystems.

The initiative is developing and pilot-testing an integrated water, land-use and livelihoods strategy for different agro-ecosystems – targeting rainfed in Lebanon, Tunisia and Syria; irrigated in Yemen, Iraq, Tunisia and Egypt; and rangeland in Jordan and Palestine. As of 2012, the WLI team had explored 40 different technologies for sustainable water and land management across benchmark sites. Some of the technologies are at the pilot stage while others like raised bed irrigation, tested in Egypt with robust demonstration of results, are on their way to be scaled out to Iraq, Sudan, Tunisia, and Ethiopia. In another strategy to improve livelihoods of farmers, the initiative is testing and validating improved methods of protected agriculture for maximum water productivity at the benchmark sites in Iraq.

C. Public-private partnerships as catalysts and enablers

Public-private partnerships often act as catalysts, and in some cases are the key enablers to bridging the last mile in scaling out technologies and bringing about a major change. The approach provides a win-win solution by helping align public and private needs to move vital projects forward and in disseminating new technologies.

For example, ICARDA's research has revealed that countries' low uptake of conservation agriculture practices in Central Asia, West Asia and North Africa is because 'zero till' seeders are neither adapted nor affordable to local needs. Seeders available from Brazil, Europe or North America cost between US$30,000 and US$60,000 and were not suitable for smallholder agriculture.

To address this bottleneck, ICARDA partnered with the local machinery manufacturers in Northern Syria, Northern Iraq (Mosul) and Jordan to adapt conventional market seeders to zero-tillage mechanism so they are affordable for smallholder farmers in the region. Prior to involvement in this project, the local manufacturers were unaware of zero-tillage technology. The scientists from ICARDA and Australia's University of South Wales worked with local agricultural machine manufacturers to develop and produce a 3.6m prototype. The converted zero-till seeder was field tested at ICARDA's Maru Research Station in Irbid (Jordan) during the 2012/13 season with promising results. Aside from bringing sustainable practices to farmers, the partnership set up a new stream of revenue for the local manufacturers, which is also spinning-off new jobs for repair and maintenance of the machine.

Another public-private partnership between ICARDA and the Mexican company Impulsora Agricola (IASA) focused on malting barley for enhancing the income of the resource-poor. Through its barley improvement program, ICARDA delivers to IASA advanced barley genotypes that have the best potential to be adapted to Mexican conditions. IASA tests these genotypes for malting quality and provides the data to ICARDA to share high quality malt with national partners such as Ethiopia where rural women produce local brews. Through this partnership with IASA, ICARDA is tapping into a new research opportunity in malt barley improvement, while increasing incomes for rural women and farmers in dry areas.

VII. CONCLUSION AND RECOMMENDATIONS

Existing science and technology tools and resources offer the capability to increase agricultural production in Arab countries but sustainable management of natural resources must be the cornerstone of agricultural practices in the fragile agro-ecosystems of the region.

Emphasis is needed on:

- Enabling policy environment and political support
- Investment in science and technology, and research in wheat improvement and crop management
- Investment in agricultural development
- Sustainable intensification of wheat production systems
- Better water management and high fertilizers
- Effective seed production and delivery system, both formal and informal
- Extension and effective technology transfer mechanisms
- Capacity development and institutional support
- Innovative partnership and networking

Many smallholder farmers in the region are trapped in a perpetual cycle of poverty, poor crop yields, scarcity of natural resources, and a lack of supportive policies and institutions. The rapidly increasing population and a markedly higher vulnerability to climate change than other parts of the world will continue to aggravate the challenges faced by local communities. As a result, investment in science and technology to support agricultural development in Arab countries is critical.

However, the benefit of science and research is intimately linked to the strength of partnerships. Drawing on three decades of experience, strategic partnerships among Arab countries and between them and the rest of the world are decidedly key, and the biggest strengths for successful research for development. Such partnerships allow for a link between research and development, connect scientists on larger challenges for continued progress, and benefit all the stakeholders – the farmers, rural communities and the nations at large.

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NOTES

1. Developed by ICARDA in partnership with the Vavilov Institute of Plant Industry, Russia and the Grains Research and Development Corporation, Australia.

AGRICULTURAL RESEARCH INSTITUTIONS IN THE ARAB COUNTRIES (Selected list)

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GCC			
Bahrain	Arabian Gulf University	layla@agu.edu.bh	www.agu.edu.bh
Kuwait	Public Authority of Agriculture Affairs & Fish Resources - Department of Plant Research & Nurseries	salwa@paaf.gov.kw info@paaf.gov.kw	www.paaf.gov.kw
	Kuwait University	president@hu.edu.kw	www.kuniv.edu
	Kuwait Institute for Scientific Research (KISR)	public_relations@kisr.edu.kw	www.kisr.edu.kw
Oman	Scientific Research Committee	trc@trc.gov.om	https://home.trc.gov.om
	Sultan Qaboos University	vcoffice@squ.edu.om	www.squ.edu.om
Qatar	Qatar National Research Fund	aaltaie@qf.org.qa	www.qnrf.org
	Biotechnology Center – Ministry of Environment	mjmmarri@moe.gov.qa sddasmal@moe.gov.qa	www.moe.gov.qa/
Saudi Arabia	Food and Agricultural Sciences College	hkahtani@ksu.edu.sa	colleges.ksu.edu.sa
	Najran Horticulture Development Research Center	bstanh@awalnet.net	www.moa.gov.sa/najres/portal
	King Saud University	info@ksu.edu.sa	ksu.edu.sa
UAE	Abu Dhabi Food Control Authority (ADFCA)	Rashed_alshariqi@adfca.ae	www.adfca.ae
	Environment Agency – Abu Dhabi (EAD)	aayyash@ead.ae	www.ead.ae
	College of Food and Agriculture	cfa@uaeu.ac.ae	www.cfa.uaeu.ac.ae
	Sharjah Agricultural Research station	dlindsay@sharjah.ac.ae	www.moew.gov.ae
	Dubai Biotechnology and Research Park	info@dubiotech.com	www.dubiotech.ae
Yemen	Agricultural Research and Extension Authority (AREA)	aprp-yemen@cgiar.org alaqil55@hotmail.com	www.area.gov.ye
	Hadhramout University of Science & Technology	hadhramoutuni@y.net.ye	www.hist.edu.ye
	Faculty of Agriculture - Sanna University	ribbon_co@yahoo.com	www.su.edu.ye
Levant			
Iraq	College of Agriculture/ Univ. of Baghdad	info@uobaghdad.edu.iq	www.coagri.uobaghdad.edu.iq
	Agricultural Research Directorate - Ministry of Agriculture	agro_sbar@moagr.org	www.zeraa.gov.iq
	College of Agriculture and Forestry / Univ. Of Mosul	agriculture@uomosul.edu.iq	agriculture.uomosul.edu.iq
Jordan	National Center for Agricultural Research and Extension (NCARE)	Director@ncare.gov.jo	www.ncare.gov.jo
	Faculty of Agriculture, University of Jordan	admin@ju.edu.jo	agriculture.ju.edu.jo
	Faculty of Agriculture, Jordan University of Science &Technology	deanagr@just.edu.jo	www.just.edu.jo
	Higher Council for Science and Technology	info-sg@hcst.gov.jo	hcst.gov.jo
Lebanon	Lebanese Agriculture Research Institute (LARI)	lari@lari.gov.lb	www.lari.gov.lb
	Faculty of Agricultural & Food Science - AUB	fafs@aub.edu.lb nahla@aub.edu.lb	www.aub.edu.lb
	National Council for Scientific Research	hamze@cnrs.edu.lb	www.cnrs.edu.lb
	Industrial Research Institute	pr@iri.org.lb	www.iri.org.lb

Country/ Region	Organization Name	Email	Official Website
Palestine	Applied Research Institute - Jerusalem (ARIJ)	pmaster@arij.org	www.arij.org
	Land Research Center (LRC)	lrc@palnet.com	www.lrcj.org
	Water and Environmental Studies Institute (WESI) - An-Najah National University (ANU)	wesi@najah.edu	wesi.najah.edu
Syria	General Commission for Scientific Agricultural Research (GCSAR)	gcsar-dir@live.com	www.gcsar.gov.sy
	National Agricultural Policy Centre (NAPC)	usama.saadi@napcsyr.net	www.napcsyr.net
	General Organization for Seed Multiplication (GOSM)	info@gosm.gov.sy	www.gosm.gov.sy
Nile Valley			
Egypt	The Agricultural Research Centre (ARC)	nabilomarster@gmail.com	www.arc.sci.eg
	The National Water Research Center (NWRC)	nwrc@nwrc-egypt.org motaleb@nwrcegypt.org	www.nwrc-egypt.org
	National Research Center (NRC)	info@nrc.sci.org	www.nrc.sci.org
	The Academy of Scientific Research and Technology (ASRT)	info@asrt.sci.eg	www.asrt.sci.eg
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	Ecole Nationale Supérieure Agronomique (ENSA)	dfcre@ensa.dz	www.ensa.dz
	Centre de Recherche Scientifique et Tech-nique	crstra@crstra.dz crstra_biskra@yahoo.fr	www.cnrs.fr
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	Agricultural and Veterinary Institute Hassan II (IAV)	dg@iav.ac.ma	www.iav.ac.ma
	Ecole Nationale d›Agriculture (ENA) – Me-knès	DF@enameknes.ac.ma	www.enameknes.ma
Tunisia	Institution de la Recherche et de l›Enseignement Supérieur Agricoles (IRESA)	bo.iresa@iresa.agrinet.tn damaziz@yahoo.fr	www.iresa.agrinet.tn
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	Institut National de Recherche Agonomique de Tunisie (INRAT)	bo.inrat@iresa.agrinet.tn	www.inrat.agrinet.tn
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Potential of Rainfed Agriculture and Smallholder Farmers in Food Self-Sufficiency

Kamel Shideed
Ahmed Mazid
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Nearly 70 percent of the world's hungry people (estimated at 870 million) live in rural areas and depend predominantly on agriculture and food production for their livelihoods. Arab countries are no exception. Here, some 25 percent of population is poor and 76 percent of the poor live in rural areas (WB, FAO and IFAD, 2009). In Arab countries, nearly 44 percent of the population lives in rural areas, where poverty is disproportionally intensified. In Egypt and Sudan, some two-thirds of the population are rural. In Yemen, the rural population accounts for 70 percent of the total population. For these countries, as well as Morocco, agriculture is the main source of employment and livelihoods. In other drylands countries in this region, (Tunisia, Algeria, Syria, Iraq) agriculture is also a considerable job market. Across all Arab countries, agriculture employs nearly one-third of total labor force.

Globally, Arab countries are the most vulnerable in terms of their food security. The cereal import dependency ratio of all Arab countries is nearly 74 percent, set against the average of 1990-2011 period, which is the highest globally. The world cereal import dependency ratio is about 16 percent and that of developing countries is 15.5 percent. As such, Arab countries are the most vulnerable to shortages of food supply and fluctuations of food prices in the international markets.

A wide range of tested and proven technology solutions is available to countries to address these issues. But the adoption rates of improved technologies remain low due to several constraints, notably the lack of an enabling policy environment, that is critical to enhance large-scale uptake and adoption. Well designed and implemented policies are the key to the efficient use of scarce resources and farm income growth – two factors that help ensure improved national food security.

A high level of national capacity in the Agricultural Research and Development sector (R&D) is the main factor behind the success of some countries in achieving sustainable and long-term agricultural productivity growth. Studies of Total Factor Productivity (TFP) show that public investments in agricultural R&D are a strong determinant of agricultural productivity growth in developed and developing countries. Enabling policy and institutional environments is a further factor contributing to TFP growth.

This chapter focuses on rainfed agriculture, which accounts for more than 80% of the region's cropland, the bulk of its food staples.

I. INTRODUCTION

Although the Global Hunger Index (GHI) fell by nearly 34 percent between 1990 and 2013, some 870 million people remain chronically undernourished (Welt Hunger Hilfe, IFPRI and Concern worldwide, 2013).

Despite remarkable growth in agriculture in the past 50 years, the world still faces a critical challenge of feeding a population expected to reach nine billion by the year 2050. The goal for the agricultural sector is no longer simply to maximize productivity, but to optimize across a complex combination of production, rural development, environmental, social equity and food consumption outcomes (Pretty et al., 2010).

In dry areas, where water is the most limiting factor, achieving this goal will require coordinated action on: optimizing the use of scarce water resources; developing policies that support more productive and sustainable food production systems; narrowing the gap between potential and actual crop yields; and diversifying farming systems, with intensive but sustainable production methods.

Future growth in food production must come mainly from productivity growth and intensification, rather than expansion of cultivated areas. One priority will be to reduce the difference between yield potential and actual yields achieved today on-farm. Actual yields are of the order of 60 percent of potential, as documented in a range of different farming systems in Southeast Asia, Central Asia and Latin America (Godfray et al., 2010). Closing this yield gap involves transferring known technologies and practices to farmers, and "putting in place the institutional structure – including markets, finance, and approaches to manage risk – that farmers need to adopt the technology" (Keating et al., 2010).

Investments in agricultural research and development have been declining (in real terms) in most of Arab countries. Renewed public investment in agricultural research is urgently needed. Today, research must address a more complex set of challenges, including natural resources management and climate change, as well as the traditional objectives of increasing food production and agricultural productivity.

II. CONSTRAINTS TO AGRICULTURAL PRODUCTION IN DRY AREAS

Dry areas cover more than 40 percent of the world's land area and are home to 2.5 billion people—over one-third of the global population. Of these, one-third depends on dryland agricultural production systems for their food security and livelihoods.

Under these conditions, diversification of farming systems through crop rotation, practices such as conservation agriculture, effective and efficient use of water and other agricultural inputs have been pinpointed as a high priority by the international development and research community – for action to enhance food security and reduce vulnerability to climate change (Amman Declaration, February 2010).

Concerns about small-scale farmers in the face of modernization and globalization are rising. Price changes in international markets are often transmitted into the domestic markets, which affect every consumer and can have a disproportionately negative effect on small farmers (Huang, Wang and Qui, 2012).

Higher and more volatile food prices are a major cause for concern. The 2008 spike in food prices significantly reduced the purchasing power of poor people in developing countries – for example, by up to 32 percent in Arab countries (Shideed, 2008). Such price spikes are likely to re-occur in the future.

A recent study on the "water footprint of humanity[1]" shows that water used by the agricultural sector accounts for nearly 92 percent of annual global freshwater consumption, the largest proportion of which is the green water footprint (FP) accounting for 74 percent (Hoekstra and Mekonnen, 2012). Industrial production contributes 4.4 percent to the total WF and domestic water supply 3.6 percent. The global annual average WF related to all sectors (agricultural, industrial and domestic supply) is 74 percent green, 11 percent blue and 15 percent gray.

Farmers generally over-irrigate as a result of their perceptions of water requirements and their expectations of rainfall and market values. Studies in Syria, Iraq, Jordan and Egypt – by ICARDA and the UN Economic and Social Commission for Central and West Africa – showed that farmers over-irrigated wheat by 20-60 percent (Shideed, et. al., 2005). Producers perceive water as a fixed input in the short run, but allocable among competing crops on the farm. As water prices were highly subsidized, they did not have a major impact on water allocation.

Water use efficiency (WUE) is low in many areas. For example, it is 40-60 percent for irrigated agriculture in Syria (MunlaHasan, 2007). This low figure is due to the widespread use of traditional surface irrigation methods with their low efficiency, high seepage and evaporation losses and uneven field coverage. A recent study (Yigezu et al. 2011b) measured the economic and environmental impacts of wheat farmers in three provinces in Syria if they would shift from traditional supplemental irrigation to improved supplemental irrigation (ISI). At the current adoption level (22.3 percent), ISI helps save at least 120 million m^3 of water per year. Introducing a water use charge of US$0.20 for every cubic meter applied in excess of the recommended application rate can lead to near-universal adoption and conserve an additional 46 million m^3 of water per year (Yigezu et al., 2011a). Such a policy would also increase total farm profits by US$16.14 million per year, and generate a total yearly impact of US$36-90 million.

Climate change is amplifying food security challenges, as it impacts all aspects of food security. It affects crop yields, the availability and distribution of freshwater and rainfall, food prices (Vermeulen, 2014).

In summary, the problem faced by people and countries in dry areas amounts to more than resource scarcity. It is a combination of resource limitations, land and water degradation, and the low efficiency of resource use. Under conditions of resource limitations in dry areas – particularly water – future increases in productivity and production for improving food security and ensuring environmental quality, need to come from enhancing the efficiency of resource-use rather than by using more inputs or increasing the food production area.

A wide range of technology solutions is available. Enabling policies that encourage wider adoption and higher resource-use efficiency are critical to achieve productivity growth and food security targets.

III. STATUS OF FOOD SECURITY AND CONTRIBUTION OF RAINFED FARMING TO TOTAL FOOD PRODUCTION IN ARAB COUNTRIES

The majority of Arab countries are ranked "low" in terms of severity of hunger (GHI≤4.9), with Sudan and Yemen classified in the "alarming" category (GHI= 20.0-29.9). In total, there are more than 15 million undernourished people in Arab countries.

Most of Arab Countries' food production is in rainfed areas. Nearly 83 percent of seasonal crop areas are rainfed (Table 1). The total rainfed area of seasonal crops was more than 35 million hectares in 2011, while the irrigated area of seasonal crops was 7.9 million hectares. In addition, there are more than 5 million hectares of permanent crops in rainfed areas and nearly 3 million hectares under irrigation. Most farmers in rainfed areas are smallholder farmers, where agriculture and farming are the main source of their livelihoods.

TABLE 1 **RAINFED AREA OF SEASONAL CROPS (PERCENT)**

Country	2010	2011	Average
Jordan	67	69	68
Tunisia	83	83	83
Algeria	87	88	87.5
Sudan	92	93	92.5
Syria	70	66	68
Somalia	86	86	86
Iraq	35	34	34.5
Lebanon	34	34	34
Libya	89	89	89
Morocco	87	79	83
Mauritania	94	94	94
Yemen	64	52	58
Total	**83**	**82**	**82.5**
Additional Useful Statistics (million ha)			
Seasonal crops irrigated areas	6.99	7.89	7.44
Seasonal crops rainfed areas	35.31	35.63	35.47
Permanent crops irrigated areas	2.69	2.96	2.82
Permanent crops rainfed areas	5.02	5.14	5.08

Source: compiled from FAO data.

As a result of rainfall variability, temperature fluctuations and frequent drought, farming in rainfed areas is highly risky and unpredictable, implying that food production in Arab countries is insecure. This is evident in FAO food security indicators (FAO, 2013). Two important indicators of food security vulnerability are the cereal import dependency ratio and the value of food imports in total merchandise exports. The quantitative data of these indicators are summarized in Table 2. These data indicate that the cereal import dependency ration of all Arab countries is 73.9 percent as an average in the 1990-2011 period, which is the highest globally. The world cereal import dependency ratio is 15.7 percent and that of developing regions is 15.5 percent.

These data clearly indicate that the Arab countries are the most vulnerable in terms of their food security globally. As such, these countries are the most vulnerable to shortages of food supply and fluctuations of food prices in the international markets. This situation is further complicated by the fact that the value of food imports accounts for nearly one-third of total merchandise exports, while food imports represent only 5.6 percent of the world total merchandise exports.

Some 80 percent of the world's cultivated area is rainfed and produces 62 percent of the staple food (Haddad, et al., 2011). Likewise, Arab countries depend mainly on rainfed agriculture where most cereal production is taking place. However, investments in rainfed agriculture do not match the high and increasing importance of rained farming currently contributing to food production. Rainfed agriculture has been neglected in favor of irrigated agriculture over the past five decades.

The contribution of rainfed farming to food security in Arab countries can be substantially enhanced through increased adoption of currently available technologies supported by enabling policy and institutional environments (Khouri, Shideed and Kherallah, 2011). Rainfed farming can contribute more significantly to achieve new targets of food security if desired investment levels are realized. On-farm results show the huge potential for improving land and water productivity and profitability of smallholder rainfed agriculture.

IV. SOURCES OF FOOD PRODUCTION GROWTH IN ARAB COUNTRIES

A. Agricultural Productivity Growth Globally and in Arab Countries

Increasing agricultural productivity has always been the world's strategy for enhancing food security in response to the increase in demand from growing populations. Throughout the 20th Century real agricultural prices (inflation-adjusted) decreased, implying that supply exceeded demand for agricultural commodities, while the world population multiplied by 3.7 times. This was the case because the success in increasing agricultural production during the 20th century was not due to the expansion of agricultural resources. However, in the 1990s this story took a turn. Inflation-adjusted prices for agricultural commodities rose by 63 percent between 2000 and 2011 according to the International Monetary Fund. The energy sector's demand for agricultural products and rising environmental controls has raised questions about the limits of agricultural productivity growth. The primary concern is whether the gains were achieved in the 20th century can be carried into the 21st century. The aim is also to try to increase the productivity in the poor areas where the farmers themselves live. Rainfed areas are a clear target here, so increasing productivity can better serve the needs of poor and vulnerable populations.

Agricultural productivity is measured as the aggregate total factor productivity (TFP)[2] of the sector. Figure 1 explains the long-term trend in productivity of land and labor resources. During the last 50 years industrialized countries were able to increase the "technology frontier", defined as the highest land-and-labor productivity combination. Previous studies summarized the performance of TFP growth as follows (Fuglie, Wang and Ball, 2012):

Based on "technology frontiers" achieved in 1961/65 and 2006/2009, labor productivity grew faster than land productivity in most regions. During the 20th century, the regions that saw a rise in their technology frontier, were those where labor productivity grew faster than land productivity as the average area per worker rose (except South Asia and Sub-Saharan Africa).

Public investment (whether local or external) in agricultural research and development (R&D), has played a major role in encouraging productivity growth.

Agricultural productivity growth has its own consequences on economic welfare, trade competiveness, poverty alleviation, and the environment. Studies on Indian and Sub-Saharan Africa experiences have proved that agricultural productivity growth has led to a reduction in poverty in these regions.

In measuring China's agricultural productivity during the 1993-2005 period, demonstrated that China's agricultural productivity growth showed high rates, averaging around 4 percent per year.

- As for India, agriculture remained the main employment sector between 1961 and 2009, even though the agricultural share of gross domestic product (GPD) fell noticeably during that period. For India's poor and least educated workers, agricultural employment is very important, as they are less able to enter non-farming sectors.

- It is thought that low agricultural growth rates undermine the severe poverty and food insecurity that much of Sub-Saharan Africa (SSA) suffers from. Estimates of TFP growth in Sub-Saharan Africa showed flat or declining productivity from the 1960s to the early 1980s. After that, a constant moderate TFP growth was achieved. Such

TABLE 2 CEREAL IMPORT DEPENDENCY RATIO, AVERAGE OF 2007-2009

Region/Country	Cereal Dependency Ratio (percent)
World	**15.7**
Developing Regions	**15.5**
Africa	**30.1**
North Africa	**49.9**
Algeria	70.9
Egypt	35.5
Libya	91.8
Morocco	53.6
Tunisia	60.2
Sub-Saharan Africa	**21.5**
Asia	**10.0**
Caucasus and Central Asia	**19.2**
South Asia	**5.6**
West Asia	**82.6**
Iraq	61.5
Jordan	100.0
Lebanon	88.5
Palestine	96.1
Saudi Arabia	82.9
Syria	49.1
Yemen	82.5
All Arab Countries	**73.9**

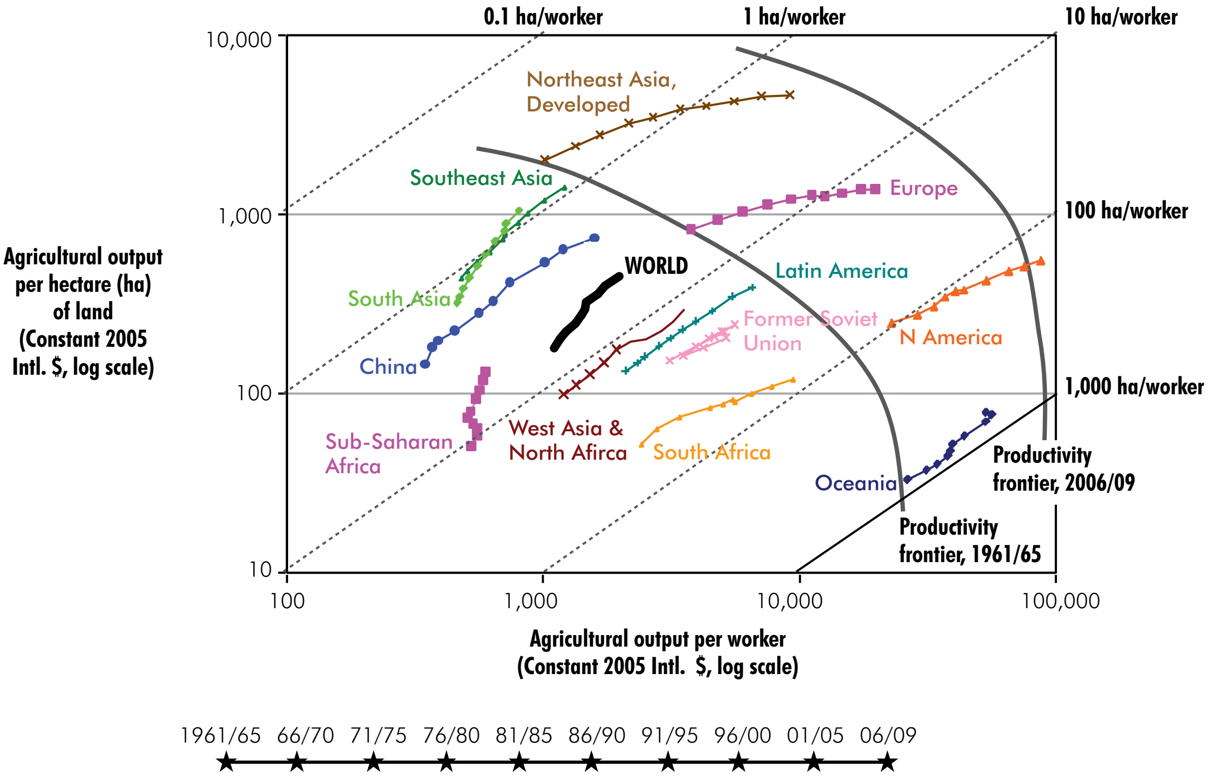
Source: Compiled from FAO- Food Security Indicators (December 20th, 2013).
Note: Cereal import dependency ratio= cereal imports/(cereal production + cereal import-cereal export).

recovery in agricultural productivity growth was due to the structural adjustment reforms that were applied in a number of SSA countries beginning around this time and continuing into the 1990s.

- For Arab countries, TFP fluctuated over decades and among countries (Table 3). Egypt, Libya, Tunisia and Saudi Arabia have maintained (though fluctuated) positive agricultural productivity growth during the last five decades. Egypt sustained annual productivity growth of more than 2.7 percent over the last three decades. Whereas, Libya achieved steady TFP of more than 3.0 percent annually over the five decades. Jordan and Saudi Arabia achieved the highest TFP (more than 5.0 percent) among other Arab countries in the 2000-2009 period. Likewise, Algeria and Morocco witnessed high annual productivity growth (more than 4.0 percent) during the last decade. Countries that have maintained positive or increased TFP growth over the last two decades are Algeria, Egypt, Libya, Morocco, Jordan, KSA and Yemen. Other Arab countries experienced considerable fluctuations in their agricultural productivity growth over the last 50 years, and particularly during the last two decades. Some countries in this category experienced negative growth rates in the last decade. These are not encouraging trends in addressing food insecurity in the Arab countries.

- Previous results show increasing TFP growth at the world level as a result of improved productivity performance in

FIGURE 1 **LONG-TERM TREND IN LAND AND LABOR PRODUCTIVITY**
AGRICULTURAL LAND AND LABOR PRODUCTIVITY HAS STEADILY IMPROVED SINCE 1960, BUT DEVELOPING COUNTRIES LAG DECADES BEHIND DEVELOPED COUNTRIES



Agricultural output is the composite of 190 crop and animal commodities valued at constant 2005 international prices; agricultural land is total cropland and permanent pasture; agricultural labor is the number of economically active adults employed in agriculture. X and Y axis are in log values.

Source: Fuglie, Kheith O.; Wang, Sun Ling; and Ball, V. Eldon. 2012. Introduction to productivity Growth in Agriculture. Chapter 1 in Productivity Growth in Agriculture: An International Perspective (eds. Fuglie et al.), CAB International 2012.

MILLION TREE CAMPAIGN FOR PALESTINIAN FARMERS

Mariam Al Jaajaa

The Million Tree Campaign (MTC) is a grassroots movement for food security designed to bolster Palestinian farmers' ties to their land through large scale tree planting. The campaign is a program of the Arab Group for the Protection of Nature (APN), a non-profit organization established in 2003 to strengthen the capacity of the Arab peoples to sustain the region's natural resources and to gain sovereignty over them (www.apnature.org).

The campaign works to replant fruit trees in Palestine as a means of counteracting the damage wrought by the Israeli occupation around the areas where settlements, by-pass roads, and the wall are being built. Since 2001, destructive practices as part of the occupation have resulted in the uprooting of almost 2.5 million trees. These trees were an important source of food and income in Palestine.

The MTC draws together various partners in Palestine, including the Palestinian Agricultural Relief Committees and the Palestinian Agricultural Farmers Union. Established in 2000, the campaign has resulted in planting the first million trees in April 2008.The second MTC was launched in the same year, and 983,000 trees have been planted so far (as of June 2014).Olive trees have accounted for the largest proportion of planted trees due to their importance to Palestinian food culture and economy. Other planted trees have included citrus, apple, grape vineyards, pomegranate, figs, and various stone fruits including apricots, peaches, plums, and almonds. The campaign has been expanded to re-build and rehabilitate water facilities such as collective wells and irrigation systems.

The MTC has benefited more than17,000 farmers so far, providing food and income to close to 85,000 family members. It has also helped farmers retain their properties since cultivated land is more difficult to confiscate by the Israeli occupation.

To complement its grassroots campaign, APN has also played a key role in shaping global policies affecting the right to food for peoples under occupation, and against environmental violations in times of conflict. The main aim of this effort is to integrate human rights norms in these policies while addressing the causal factors that produce food insecurity.

Mariam Al Jaajaa, General Manager, Arab Group for the Protection of Nature (APN).

TABLE 3 **AGRICULTURAL PRODUCTIVITY GROWTH (TFP) IN ARAB COUNTRIES**

	Average Annual Growth (percent)				
Countries	**1961-1970**	**1971-1980**	**1981-1990**	**1991-2000**	**2000-2009**
Algeria	-1.29	-0.93	3.07	0.72	4.12
Egypt	1.30	1.41	2.71	2.82	2.76
Libya	8.00	3.48	3.60	4.46	3.02
Mauritania	-0.95	0.53	-0.52	0.39	0.57
Morocco	3.70	-0.71	4.14	0.58	4.11
Tunisia	0.75	1.48	3.51	0.38	1.34
Iraq	0.85	2.85	1.45	0.39	-0.23
Jordan	-8.84	3.94	3.80	2.12	5.87
Kuwait	-0.74	2.04	0.08	7.05	-0.23
Lebanon	3.44	2.01	8.83	-1.43	3.83
Oman	-1.29	2.40	-2.64	3.92	-2.25
Saudi Arabia	0.06	1.68	6.35	2.12	5.12
Somalia	0.40	1.30	-0.32	1.55	0.41
Sudan	-1.12	1.07	0.54	1.94	0.04
Syria	-0.19	6.15	-2.45	2.65	-0.12
UAE	2.71	3.93	-0.51	8.20	-4.73
Yemen	-2.94	1.31	1.44	1.72	2.24

Source: compiled from: Productivity Growth in Agriculture-An International Perspective. Edited by K.O. Fuglie, S.L. Wang, and V.E. Ball. CAB International 2012.

developing countries. The wide variation in agricultural TFP growth rates among countries is explained by differences in national capacities in agricultural and industrial research. National capacity for agricultural R&D is the most important factor explaining the sustainable long-term agricultural productivity growth in some countries and not in others. Countries with national research systems capable of continuously producing new technologies adaptable to local farming systems generally achieve higher growth rates in agricultural TFP. In addition, actively collaborating with international research institutions facilitates spillover impacts of technology and thus significantly raises returns to national agricultural research investments. The presence of an enabling environment that encourages the uptake and adoption of new technologies and practices is another factor that explains cross-country differences in agricultural TFP.

TFP growth in different regions since the mid-1990s is summarized in Table 4:

Global agricultural output growth peaked at 2.7 percent per year in the 1960s and maintained its annual growth at 2.1 and 2.5percent for every decade in the last 40 years (Table 5). An important observation associated with this growth is the shift in the source of output growth from being primarily input driven to productivity driven (Fuglie, 2012). Growth in total inputs declined from 2.5 percent in the 1960s to 0.7 percent in the 2000s, whereas annual TFP growth rose from 0.2 in the 1960s to about 1.7 percent since 1990 (Fuglie, 2012).

The steady growth in total yield of 2.1 percent per year during the past five decades has driven the trend in the annual output growth. The growth rate of cereal yield, however, has slowed down after 1990. Its annual growth rate decreased from 2.5 percent in the 1970s and 1980s to 1.3 percent in the 1991-2009 period. But this decline in cereal yield does not significantly affect the growth of agriculture as it has been offset by productivity improvement in other commodity groups.

TABLE 4 **STATUS OF TFP IN DIFFERENT COUNTRIES**

Country/Region	Status of productivity growth since mid-1990s
China	Very strong (high) in coastal provinces but slows down in the rest of the country.
Brazil	Experienced robust high agricultural productivity growth
USA	Productivity growth has been moderately strong in the Corn Belt and Lake states. Low Plain States, Appalachia, California and Florida.
Australia	Dryland agricultural TFP has been stagnant nationally
Sub-Saharan Africa (SSA)	Good productivity growth in a number of countries. Some of it is recovery of declining TFP in earlier years. SSA remains the biggest challenge in achieving sustained and long-term productivity growth in its agricultural sector. The region maintained low TFP growth.
Arab countries	Predominantly low or moderate annual TFP growth.

High = Average annual TFP growth > 3 percent
Moderate = Average annual TFP growth > 1-3 percent
Low = Average annual TFP growth < 1 percent

TABLE 5 **AGRICULTURAL OUTPUT AND PRODUCTIVITY GROWTH, 1961-1970 / 2001-2009**

	(Annual percent)									
	1961-1970		1971-1980		1981-1990		1991-2000		2001-2009	
Region	Output growth	TFP	Output growth	TFP	Output growth	TFP	Output growth	TFP	Output growth	TFP
All developing countries	3.15	0.69	2.97	0.93	3.43	1.12	3.64	2.2	3.34	2.21
Sub-Saharan Africa	2.95	0.17	1.19	-0.05	2.82	0.76	3.05	0.99	2.69	0.51
West Asia and North Africa	2.87	1.40	3.05	1.66	3.64	1.63	2.82	1.74	2.35	1.88
North Africa	2.62	1.32	1.58	0.48	4.53	3.09	3.34	2.03	3.57	3.04
West Asia	2.98	1.21	3.65	2.21	3.29	0.95	2.60	1.70	1.77	1.34
Central Asia & Caucasus	3.41	-0.36	0.71	2.02	0.56	-0.89	0.08	0.65	4.33	2.45
All developed countries	2.05	0.99	1.93	1.64	0.72	1.36	1.32	2.23	0.58	2.44
World	2.74	0.18	2.30	0.60	2.21	0.62	2.21	1.65	2.49	1.84

Source: compiled from: Productivity Growth in Agriculture-An International Perspective. Edited by K.O. Fuglie, S.L. Wang, and V.E. Ball. CAB International 2012.
North Africa: Algeria, Egypt, Libya, Morocco, Tunisia.
West Asia: Bahrain, Iran, Iraq, Jordan, Kuwait.

In his decomposition of global output growth into inputs and TFP sources, Fuglie (2012) defined TFP as the residual (difference) between output growth and input growth. His estimates indicated that TFP accounted for some 40 percent of gross output growth and inputs represented 60 percent. In the recent decade, 2001-2009, TFP has grown faster and accounted for 74 percent of the global agricultural production. The same trend was experienced in developing countries where productivity growth doubled in the last two decades reaching 2 percent per year. The North Africa region (Algeria, Egypt, Libya, Morocco and Tunisia) experienced accelerated TFP growth in the 1990s and 2000s, among other developing regions. Likewise, the West Asia region (which includes four Arab countries: Bahrain, Iraq Jordan and Kuwait) maintained positive, but fluctuating productivity growth during the last two decades. The growth in TFP peaked in 2001-2009 in Central Asia and Caucasus countries, reaching 2.45 percent per year compared to 0.65 in the 1990s. The only exception is Sub-Saharan African countries where TFP growth remained less than 1 percent annually.

Figures 2 and 3 present, respectively, the output and TFP growth for the whole world, developing countries, North Africa region, and West Asia and North Africa region (WANA). In all cases, productivity was the main source of output growth during the 2000s. The association between TFP growth and output growth is more evident in the North Africa region. This region's average TFP growth was the highest during the last decade compared to the productivity growth in developing countries and the whole world.

B. Sources of output growth of major commodities in Arab countries

Wheat production in Arab countries has grown at an annual rate of 3 percent between 1961-2012 period, mainly driven by the yield growth achieved before 1990 (Table 6). The wheat output growth rate drastically slowed down since then due to the sharp decline in wheat yields since 1991. This is an alarming trend, given the importance of wheat to Arab food security. The output of food legume crops (chickpea, faba bean and lentil) experienced modest growth during the past 50 years and was mainly driven by yield growth. Fluctuations in yields and planted areas of these three commodities have

FIGURE 2 OUTPUT GROWTH, 1961-1970 TO 2001-2009 (PERCENT PER YEAR)

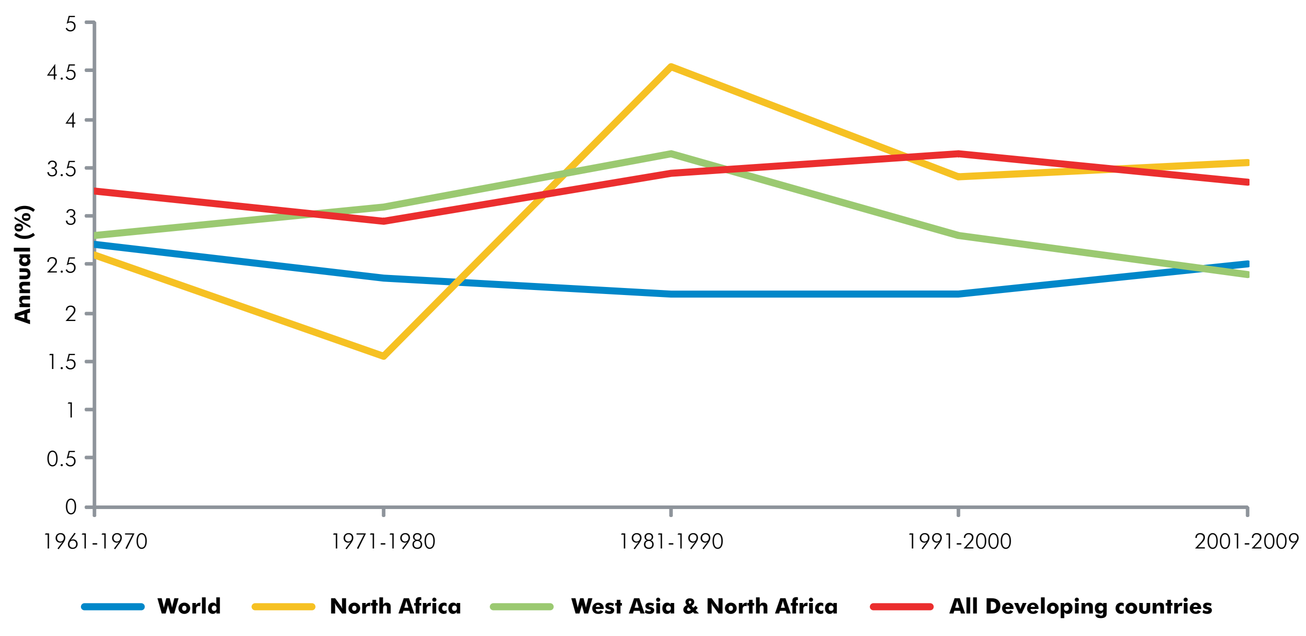
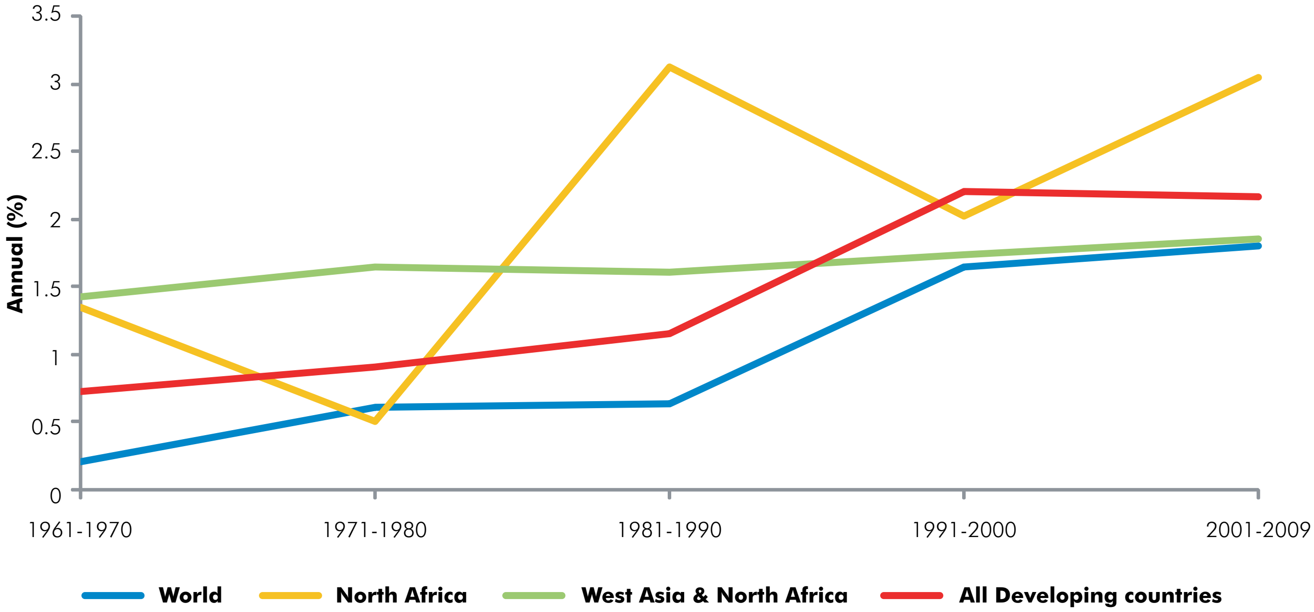


FIGURE 3 **TFP GROWTH, 1961-1970 TO 2001-2009 (PERCENT PER YEAR)**



been reflected in the output growth. Faba bean production deteriorated in the 1990s and 2000s as a result of a decrease in the planted area, which was partially offset by yield growth.

Annual chickpea yield grew by 4 percent during 2001-2012, but this impressive progress was offset by the (-4.4 percent) decline in the planted area, resulting in negative production growth (-0.6 percent). For lentil, both yield and area grew by 1 percent in the last decade, recovering from negative growth in the 1990s. As a result, lentil production grew by 2.1 percent annually between 2001 and 2012.

During the past 50 years the livestock and sheep population and production of sheep meat saw an annual growth rate of 2.1 and 2.9 percent, respectively. Growth rates of the goat population and goat meat were estimated at 1.6 and 2.1 percent respectively, during the 1961-2012 period. For both sheep and goats, the growth rates in the 2000s were lower than those of the previous decade.

This trend information indicates that the growth rates of wheat, food legume and small ruminant commodities achieved in the last two decades are lower than the growth rates obtained between 1961-1970 and 1981-1990. Several factors explain this unstable growth pattern, including weather variability and drought, low adoption rates of improved technologies, diseases and insects, and the lack of enabling policies to provide sufficient incentives to farmers to encourage investment in productivity-enhancing technologies and inputs.

With the current advances in science and availability of improved technologies, current trends of decreased growth can be reversed. Increased investments in agricultural research and development will provide new opportunities to enhance food security in Arab countries.

V. HOW CAN SMALLHOLDER FARMERS IN RAINFED AREAS BE EMPOWERED TO IMPROVE THEIR CONTRIBUTION TO FOOD SECURITY?

To address food, water and nutritional security challenges, there is a need to transform current food production into sustainable systems.

To achieve food and nutritional security targets, the focus should be on developing socially sound and environmentally sustainable food production and consumption systems. Integrated

THE CONSERVATION OF TRADITIONAL CROPS PROJECT IN JORDAN

Erin Addison

Jordan is among the world's ten most water-poor countries and imports 87 percent of its food. Cultivable land in the higher-rainfall zones is being rapidly consumed by urban sprawl, and throughout the region topsoils are degraded. Excessive tillage combined with declining water resources, overgrazing and devegetation have depleted organic matter in topsoils and exposed them to wind and water erosion. Soils' capacity to bank rainwater has diminished, even as precipitation becomes less frequent and more intense.

Resource intensive western agricultural practices introduced in the mid-20th century have increased yields but drained aquifers, salinized soils, and polluted surface water with pesticides. High-yield agriculture has made cheap food widely available, but brought with it the so-called "western diseases": cardiovascular disease, adult-onset diabetes and cancer.

The landscape of the southern highlands of Jordan is still a mosaic of small farms, producing mainly durum wheat and barley from local, drought-resistant varieties. Sites in the southern Jibal al-Sherah, around Petra, are amongst the earliest known for the domestication of wheat and barley during the early Neolithic period. The deep continuity of agricultural tradition is evident in the Jibal al-Sherah, and older generations are mepositories of valuable information about small-scale farming on arid lands. As younger generations turn away from agriculture as a low-status occupation, traditional foodways and farming practices are becoming lost.

Al-Hima, a foundation devoted to the conservation of the natural and cultural environment of Jordan, encourages "multi-functional agriculture" to address soil and water conservation, biodiversity and public health. The Conservation of Traditional Crops Project began in 2012, to promote sustainable smallholder farming of staple crops. The project goals are to:

- Farm staple crops sustainably, without chemical inputs or irrigation;
- Encourage smallholders to continue farming, integrating traditional drylands agriculture with cutting-edge conservation agriculture;
- Conserve local varieties of staple crops to promote biodiversity;
- Address Jordan's diabetes epidemic by bringing reasonably priced whole grains and legumes to the average Jordanian.

Encouraging low-input smallholder farms promotes Jordan's food security by perpetuating a sustainable supply of staple foods. Al-Hima farms are solely rain-fed. Traditional small farms are terraced and punctuated by small islands of biodiversity, which surround the stonepiles made over centuries of field-clearing. These biodiversity islands bank water and inhibit soil erosion. The cause of biodiversity is further served by saving and cultivating local seed varieties. Genetic resources are crucial to addressing both biotic (e.g., pests and disease) and abiotic challenges (e.g., drought) in the face of climate change. Finally, hay and stubble provide animal fodder, which reduces the pressure of grazing on the range, encouraging biodiversity and allowing for soil conservation and rainwater banking.

Al-Hima employs farmers born in the 1930's and 1940's, before hybrid seeds were widely imported, as consultants to approve seed samples for farms. Crops currently sown are durum wheat (Triticum durum, local variety names ملغوطة [also قطعة] صفراء،), two-row barley (Hordeum vulgare ssp. distichum), red lentils (Lens culinaris) and hummous (Cicer arietinum). Partner farms are 2.5 hectares (ha.) or less, prioritizing farms held by women and youth. Al-Hima provides approved seed and supplies all machinery costs for the first year of partnership to encourage farmers to keep fields under cultivation. In return, the farmers agree not to irrigate or apply chemical inputs and to harvest the fields themselves (vs. hiring illegal foreign labor). Al-Hima guarantees purchase of the entire crop. The 2014 yield is estimated at 290 kg/ha, at a cost competitive with conventionally grown wheat. While in global, conventional agricultural terms the yield is low, the crop scarcely "costs" anything – either to the farmer or the environment – and it "pays off" in environmental and nutritional quality.

Low-quality food is a public health concern: the prevalence of adult-onset diabetes in Jordan is one

of the highest in the world. The economic cost of the diabetes epidemic reached JD 654 million in 2008, and continues to increase steeply. Experts attribute much of this increase to the new abundance of cheap, low quality food. Recent research draws a causal connection between the consumption of refined carbohydrates and Type 2 diabetes. Over the past two generations polished white rice and subsidized bread made from refined flour have replaced a cuisine once rich in whole grains and pulses. This year the Traditional Crops Project will deliver to the Amman market cold-milled, whole-grain flour and hulled barley competitive with imported organic products. Grain is cold-milled in Wadi Musa and packaged by local women.

In 2013-14, al-Hima had 100 ha under cultivation in Ma'an Directorate, and will add 100 ha a year. The challenge before us to educate farmers to improve soils and yields by implementing no-till field preparation and applying manure fertilizers.

An IFAD/UNEP study of *Smallholder farms, food security and the environment* (2013) includes helpful maps and schematics to emphasize the importance of sustaining smallholder agriculture. The Arab world is simply not depicted. A wealth of traditional knowledge about drylands agriculture is on the verge of being lost. The Traditional Crops Project revitalizes these thrifty strategies to build soils and bank water, protect biodiversity, redress avoidable chronic disease, revitalize traditional foodways and bring income into households in poverty pockets. In the process of conserving locally-adapted crops we conserve the land, wealth, and health of Arab cultural heritage.

Erin Addison, Director, al-Hima, Amman, Jordan.

TABLE 6 **SOURCES OF OUTPUT GROWTH OF MAJOR COMMODITIES IN ARAB COUNTRIES, 1961-2012**

6-a: Wheat Annual Growth Rates in Arab Countries (percent) 1961-2012

Time Period	Area	Yield	Production
1961-1970	1.8	2.1	4.0
1971-1980	-0.3	3.1	2.8
1981-1990	0.0	3.6	3.6
1991-2000	0.1	-0.2	0.1
2001-2012	0.6	0.4	1.0
1961-2012	**0.6**	**2.4**	**3.1**

6-b: Chickpea Annual Growth Rates in Arab Countries (percent) 1961-2012

Time Period	Area	Yield	Production
1961-1970	1.6	7.8	9.4
1971-1980	2.5	-1.9	0.6
1981-1990	-1.8	2.1	0.2
1991-2000	2.7	-1.5	1.1
2001-2012	-4.4	4.0	-0.6
1961-2012	**-0.1**	**1.9**	**1.9**

6-c: Lentil Annual Growth Rates in Arab Countries (percent) 1961-2012

Time Period	Area	Yield	Production
1961-1970	5.5	-2.5	2.9
1971-1980	-4.2	4.4	0.0
1981-1990	2.9	0.9	3.9
1991-2000	-2.0	-5.0	-6.9
2001-2012	1.0	1.0	2.1
1961-2012	**0.6**	**0.3**	**0.9**

agro-ecosystems approaches need to be applied to improving food production systems.

National, regional and international research-for-development (R-4-D) organizations play a major role in addressing these challenges through their contribution to reducing food insecurity and malnutrition, and eradicating and accelerating the transformation and adoption of 'sustainable food production and consumption systems'.

Practically speaking, how do research and development organizations contribute to addressing and solving these global challenges?

a. These challenges cannot be effectively addressed without partnership platforms that include National Agricultural Research Systems (NARS) and international organizations to facilitate the exchange of experience and knowledge for spillover impact, and to facilitate regional integration among R-4-D organizations.

6-d: Faba Bean Annual Growth Rates in Arab Countries (percent) 1961-2012

Time Period	Area	Yield	Production
1961-1970	1.0	7.1	8.1
1971-1980	0.1	-1.8	-1.7
1981-1990	1.8	2.3	4.1
1991-2000	-2.4	0.9	-1.6
2001-2012	-0.6	0.4	-0.2
1961-2012	**0.2**	**1.5**	**1.8**

6-e: Annual Growth Rates of Sheep Numbers and Meat in Arab Countries (percent) 1961-2011

Time Period	Sheep Numbers	Sheep Meat
1961-1970	3.6	2.1
1971-1980	2.2	2.8
1981-1990	1.6	3.8
1991-2000	2.5	4.5
2001-2011	1.1	1.0
1961-2011	**2.1**	**2.9**

6-f: Annual Growth Rates of Goat Numbers and Meat in Arab Countries (percent) 1961-2011

Time Period	Goat Numbers	Goat Meat
1961-1970	2.1	2.1
1971-1980	1.4	2.0
1981-1990	1.4	0.7
1991-2000	3.2	3.2
2001-2011	1.2	2.3
1961-2011	**1.6**	**2.1**

b. Promotion of tested and proven technologies through scaling-out of improved technologies to reduce (or bridge) the yield gap and increase the use efficiency of on-farm resources and inputs – particularly of water and land resources.

c. Promotion of an integrated agro-ecosystems approach that includes multidisciplinary, multi-partner and community participation to enhance technology innovations. This includes cereal-legume based systems, integrated crop-livestock-rangeland and other food production systems. Such approaches are particularly needed to achieve the eco-efficiency criteria of the sustainable food production systems.

d. Develop and test new technologies and practices to sustainably improve productivity and production. Examples include development of new high-yielding crop varieties that are adapted to biotic and abiotic stresses, combined with improved

ENHANCING MARGINAL LAND PRODUCTIVITY IN THE BADIA OF JORDAN

Odeh Al-Meshan

The Badia is part of the Arab regions (defined as the semi-arid region of Jordan) and constitutes a significant part of Jordan and includes vast hyper-arid areas. As a result, the Badia has been defined based on aridity indices and is classified as a land for communal pastoral use (rangeland). It is situated in the eastern part of Jordan and is considered a home of the Bedu. The Badia stretches from the Jordan' highlands in the west, to the east, bounded in the north by Syria, in the east by Iraq, in the south by Saudi Arabia and the west by the marginal area. The Badia area occupies the majority of the eastern area of Jordan, 85 percent of the total area of Jordan (76,500 km^2), and is dominated by dry weather conditions. Of this area, 11,000 km^2 is classified as a semi-arid area (100-200 mm/year) also considered a marginal area. The marginal area, located around and to the east of the highlands, is a relatively flat land with a gradual slope down towards the east where the Badia area located.

Similar to the Arab arid regions, the Badia of Jordan is currently facing severe natural challenges, specifically water resources depletion and salinization, biodiversity, and rangelands degradation. Many plant species are close to extinction due to overgrazing and frequent droughts, and many wild animals have disappeared. Contributing factors include: excessive groundwater extractions, expansion of extensive agriculture (which limits the amount of rangeland available resulting in overstocking on the remaining area), depletion of soil quality, use of vehicles to move animals to remote pastures for grazing, increases in the number of animals per livestock-holder, rangeland overstocking, shifting land ownership from the tribe or state to individuals, and the absence of a clear land use policy.

Ecologically, the terms "marginal areas", is used interchangeably and frequently within the Jordan Badia, especially when moving gradually from areas with low and fluctuated rainfall to more precipitated areas with agricultural activities and productivity. However, the marginal areas can be identified as the transitional area between the Jordan highlands and the drier areas or steppe in the east.

In general, marginal areas are classified as arable lands for cultivated seasonal crops such as wheat and barley, depending on erratic and sporadic rainfall. Nevertheless, and over the past four decades, things have changed dramatically where huge investment in intensified irrigated farming has taken place such as fruit and vegetables production using groundwater. Despite this, the area still suffers from a big gap between land production outputs and the local communities' consumption requirements.

Groundwater in the marginal areas is one of the biggest environmental challenges the agricultural sector faces, not only in the marginal area but for crop production in the entire country. Investment over the last three decades has been carried out by hundreds of private farmers, most of them from outside the Badia region and from the government, for drinking and industrial uses especially for major cities. This has happened often with no planning or control on the consequences of such work. Land tenure status and tribal areas interfaces are complicating the marginal areas' development in terms of farming practices, particularly through the random use of the state land.

Biophysical constraints such as acute water scarcity, frequent drought, low soil fertility, salinity and desertification are the major restricting factors in the marginal areas. In the future it is expected that the marginal area will face severe deterioration because of climate change impacts and socio-economic factors such as population growth, an increased number of refugees from neighboring countries (uprooted), in addition to the continuation of agricultural investment. Both factors are accompanied by the expansion of poverty pockets, lack of enabling policies contributing to unsustainable resource use, unemployment, and rural out-migration.

Taking these issues into consideration, the land use in these marginal areas increases the difficulties and complexity of land use. For example: the type of crops grown should be selected on the basis of compatibility with the environment in terms of water use at all three stages in crop production: before planting, during planting and after planting in order to minimize the water consumption, reduce the cost and enhance the livelihoods of local communities.

For better achievement of food security in the marginal drylands, emphasis should be placed on diversifying and improving rural livelihoods by improving access of the rural population to available and transferred technology. This could be obtained by addressing the following topics: (1) Achieving sustainable agricultural development in its economic, social and environmental dimensions; (2) Optimum use of natural resources such as water and soil; (3) Making rural financial and marketing services available to farming households; (4) Encouraging farmers to produce organic products and switching a portion of Jordanian production towards this market to increase the yield, either in livestock production or plants or even in processed products where profit margins may be higher; (5) Developing the role of rural women to utilize their skills in order to improve family incomes by addressing the absence of facilities needed to develop skills in the areas of production and marketing; (6) Improving the marketing of agricultural products – which suffer from weak supply-demand links, high post-harvest losses, low prices, and the absence of quality control and standardization – to enhance the profit margins and quality of life for all who live in these areas.

Holistic approach to enhance marginal areas' development:

- Managing run-off water by constructing of earth gabions and terraces to establish water harvesting systems that may irrigate crops and provide water for local domestic consumption and that can contribute to local groundwater recharge.

- Re-vegetating system that combines planting and re-seeding with native species and uses both macro and micro water harvesting techniques and schemes to capture, store and redistribute water for these crops.

- Moving from extensive animal farming to intensive animal farming with produce and providing subsidies to small farmers.

- Encouraging small livestock owners by reducing the number of animals per household.

- Leaving land under the state, stopping the private title, and solving the land tenure issues especially concerning tribal land or land under claims.

- Ecosystem restoration of rangelands with native appropriate shrubs, forbs and trees such as Atriplex species, Acacia species, Salsola species and Juncos species.

- Rehabilitation programs by adopting an atraditional/indigenous alternative system for protecting the rangelands. In this case, Hima concept is the most applicable and useful approach as an option to reverse the degraded ecosystem to the original status, and is also an attractive concept to employ as a possible model for engaging communities in a more focused effort of "self-organization" for sustainable resource management.

- Empowering local communities through the provision of stakeholders with the knowledge and skills to ensure the engagement of all the relevant stakeholders in the management and planning process.

- Using the techniques of traditional irrigation systems; understanding the interaction between animal and vegetable production; making use of old cultivars; relying on farmers' organizations and cooperation and building on existing knowledge.

- Developing a land use plan and database for all areas in the Badia. Land uses are mainly for agricultural production.

- Stakeholder consultation and participatory planning by involving all relevant stakeholders at different levels. This will ensure that at national and governorate levels planning and decision-making for land use and water management will be better informed by local realities, leading to policy frameworks that support decision-making at lower levels. End-users will thus have a better chance to take ownership of, and accountability for the management of local water resources. This is possible by supporting networks of different stakeholders from the community to the national policy level.

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soil and water management technologies and practices – including supplemental irrigation, water harvesting and other water saving technologies. Promotion of food and forage legumes to intensify and sustain cereal-based systems is also needed.

e. Developing risk management, resilient production systems, drought mitigation plans, and adaptive capacity of agriculture to climate change.

f. Develop and communicate to policy makers' alternative policy and institutional options they can apply to put in place a more enabling policy environment to enhance the uptake and adoption of improved technologies.

g. Help countries shift their water strategies to focus on sustainable water use, raising productivity per unit of available water and modifying cropping patterns to fit actual water availability.

h. Capacity development of young agricultural scientists and extension specialists using degree training, non-degree training and other training modalities.

Advances in science and technology are the key strategy to address food security challenges and natural resource limitations in Arab countries. International experience has shown that advances in plant breeding, for example, on major cereal commodities between 1965 and 2004 have saved an estimated 18-27 million ha of new land from being brought into cultivation to meet production targets (Ortiz and Jones, 2014).

VI. UNLOCKING THE POTENTIAL OF RAINFED AGRICULTURE IN DRY ENVIRONMENTS

Some 80 percent of the world's agricultural land is rainfed, contributing to at least two-thirds of global food production. Despite the higher risks in rainfed agriculture, it is widely accepted that the bulk the world's food will continue to come from rainfed agricultural production areas. Although rainfed areas are important in cereal production, insufficient attention has been paid to the potential of production growth in rainfed areas to play a more significant role in meeting future food demand (Rockström et al 2007).

Farmers' yields in rainfed regions in the developing countries are low. Rainfed agriculture has a large untapped potential for increased food production, especially in Asia and Africa, where the bulk of the world's poor live. The primary way to unlock the potential of rainfed agriculture in dry areas is by increasing the effectiveness of rainfall and improving water management to overcome drought spells (Oweis and Hachum 2012).

In the dry areas, moisture stress periods often occur during one or more stages of crop growth causing very low crop yields. Variation in rainfall amounts and distribution from one year to another causes substantial fluctuations in production that can range in the case of wheat for example, from 0.3 to over 2.0 t/ha. This situation creates instability and negative socio-economic impacts.

Rainfed cereal yield globally is about 2.2 metric tons per hectare, which is about 65 percent of the irrigated yield. In developing countries however, it is around 1.5 metric tons per hectare; very low compared to that of the developed countries (Oweis and Hachum 2011).

A. Supplemental Irrigation: the water management response

Shortage of soil moisture in the dry rainfed areas often occurs during the most sensitive growth stages of the crops. As a result, rainfed crop growth is poor and yield is consequently low. Supplemental irrigation (SI) may be defined as "the addition of small amounts of water to essentially rainfed crops during times when rainfall fails to provide sufficient moisture for normal plant growth, in order to improve and stabilize yields". SI can, using a limited amount of water, if applied during the critical crop growth stages, result in substantial improvement in yield and water productivity. Therefore, SI is an effective response to alleviate the adverse impact of soil moisture stress during dry spills on the yield of rainfed crops. In addition to yield increases, SI also stabilizes rainfed crop production from year to the other. (Oweis and Hachum 2012).

Supplemental irrigation in rainfed areas is based on the following three basic aspects: (i) Water is applied to a rainfed crop that would normally produce some yield without irrigation. (ii) Since rainfall is the principal source of water for rainfed crops, SI is only applied when rainfall fails to provide essential moisture for improved and stable production. (iii) The amount and timing of SI is scheduled not to provide moisture-stress-free conditions throughout the growing season, but to ensure a minimum amount of water available during the critical stages of crop growth that would permit optimal instead of maximum yield.

Harvest results from farmer's fields, showed substantial increases in crop yield in response to the application of relatively small amounts of irrigation water. This increase covers areas with low as well as high annual rainfall. The area of wheat under SI in northern and western Syria (where annual rainfall is greater than 300 millimeters) has increased from 74,000 hectares (in 1980) to 418 thousand hectares (in 2000), an increase of 470 percent. The estimated mean annual increase in production cost due to SI as compared to rainfed equals US$150 per hectare. The estimated mean increase in net profit between rainfed and SI for wheat equals US$300 per hectare. The ratio of increase in estimated annual net profit per hectare to estimated difference in annual costs between rainfed and SI is 200 percent.

SI caused rainwater productivity in northwest Syria to increase from 0.84 kilograms of grain per cubic meter to 2.14 kilograms per cubic meter. Similarly, for biomass water productivity, the obtained mean value was 3.9 kilograms per cubic meter for deficit SI. Guidelines for recommending irrigation schedules under normal water availability conditions need to be revised when applied in water-scarce areas.

In Syria, average wheat yields under rainfed conditions are only 1.5 t/ha which is one of the highest in the region. With SI, the average grain yield was up to 3 t/ha. In 1996, over 40 percent of rainfed areas were under SI and over half of the 4 million tons national production was attributed to this practice. Supplemental irrigation does not only increase yield but also stabilizes farmer's production. The coefficient of variation in rainfed production in Syria was

FOOD SECURITY OPTIONS IN SAUDI ARABIA

Ali Al-Tkhais

Saudi Arabia is located in southwestern Asia and is part of the dry desert belt where renewable water resources are rare, running rivers and freshwater lakes are absent, and the rate of annual rainfall is almost 60 millimeters. The kingdom also faces major challenges in terms of providing food for its citizens and immigrants, estimated at 28 million in 2012.

Although renewable water resources are scarce, in 2012 agriculture consumed almost 17.5 billion cubic meters of water, or 84 percent of the kingdom's total consumption. Most of the quantity came from unrenewable resources, and 80 percent of it was used in the production of only three crops: cereals, feed, and dates. Groundwater overdraft in the last four decades has led to negative consequences, especially an ongoing decline in groundwater levels at the main strata – levels in some regions have become too critical to allow economically feasible draft in the future, while underwater quality has often become saltier at larger depths as seawater has crept in, making groundwater treatment for drinking purpose costlier.

There are chances for developing agriculture in Saudi Arabia in tandem with plans to preserve groundwater sources, including more reliance on treated sewage, which amounted to almost 3.6 million cubic meters daily in 2012, with only 17 percent (0.6 million cubic meters daily) having been recycled. Following the drying up of natural springs that nourished Al-Ahsa's oasis for many centuries, the Irrigation and Drainage Authority in Al-Ahsa provides leading experience in exploiting treated sewage. The authority now oversees the daily distribution of 145,000 cubic meters of tertiary treated sewage. This totals to 60 percent of irrigation water supplied by the authority to 8,200 hectares of date farms, producing 120,000 tons of dates annually, alongside lemon crops. The amount is expected to increase to 450,000 cubic meters daily after current projects are completed. The remaining 40 percent of irrigation water provided by the authority now comes from groundwater and agricultural drainage. Certainly, treated sewage quantities will increase in the future due to more urban sewage because of population growth.

By 2012, 420 dams, with a total capacity of 1.9 billion cubic meters, were constructed. They are designed to either refurbish groundwater strata, protect towns, villages and ownerships from floods, or provide drinking or irrigation water supplies to nearby communities. The chance is there for enhancing exploitation of surface water held by the dams if assessment studies are carried out by consultative bureaus specialized in planning rainwater collection projects and carrying out agricultural projects that suit the region's environment and climate. Documented scientific studies on world climate change and its effects on agriculture in the kingdom are not available. In recent years, abnormal climate conditions have been witnessed, including long-lasting dust waves and short-term rainy storms with strong and devastating floods.

A private company carried out a unique experiment 20 years ago by planting salicornia with seawater, and it benefitted from facilities and soft loans. The experience was successful, but the company deviated from its main target and the project collapsed. Yet, this experience can be built upon in developing seawater farming and selecting the crops that grow best in saline water.

Arid desert states face concerns of food security for their peoples, and they develop plans and strategies for providing food commodities, each according to their climate, water and economic conditions. The kingdom works on having a certain level of food security by sustaining strategic stocks of food commodities that can redress consumption needs for at least six months. Saudi Arabia considered several food security options and decided to follow three tracks at the same time: First, producing some food commodities domestically while taking into consideration the limitedness of water supplies and each area's relative advantages; second, the private sector continues to import food commodities from abroad and sells them according to supply and demand mechanisms; and third, adopting King Abdullah's Initiative for Agricultural Investment Abroad.

In terms of domestic production of food products, the kingdom achieved a good self-sufficiency level of domestic food products. The table shows self-sufficiency percentages of domestic food products. In 2012, wheat self-sufficiency reached 26.6 percent, but the percentage is decreasing and is expected to reach zero percent in 2016. This development is a result of a government decree aimed at protecting water supplies since wheat production relies on unrenewable groundwater. Generally, self-sufficiency reached 7.4 percent for

PERCENTAGES OF SELF-SUFFICIENCY OF DOMESTIC FOOD PRODUCTS IN 2012

Cereals		Vegetables				Fruits		Livestock Products	
Crops	**Percent**	**Crops**	**Percent**	**Crops**	**Percent**	**Crops**	**Percent**	**Crops**	**Percent**
Wheat	27.6	Potato	119	Cucumber	103	Dates	106.7	Table Eggs	117.7
Barley	0.2	Tomato	73.3	Melon	97.6	Citruses	16.5	Fresh Milk	112.4
Sorghum Bicolor	88.1	Dried Onion	26.9	Watermelon	107.3	Grapes	78.2	Red Meats	34.1
Millet	55.3	Carrot	70.7	Okra	100.6	Other	34.5	Poultry Meats	44.6
Other Cereals	3	Eggplant	110.3	Other	112.5			Fish	37.9
Cereals Total	**7.4**	**Vegetables Total**			**88**	**Fruits Total**	**57.4**	**Meats Total**	**41.2**

Source: Statistical agricultural figures in Saudi Arabia, Agriculture Ministry, Issue 26-2014.

cereals, 88 percent for vegetables, 57.4 percent for fruits, 117.7 percent for table eggs, 112.4 percent for fresh milk, 34 percent for red meats, 44.6 percent for poultry meat, and 37.9 percent for fish. Serious initiatives are underway to develop agriculture from traditional farming that relies on unrenewable groundwater to the so-called sustainable farming that largely depends on renewable water resources. The initiatives include providing facilities, aid and soft loans. But if measures are not taken for this shift to succeed, and if farmers are not oriented to plant suitable crops, while taking into consideration the economic value of each water unit and focusing on crops with low consumption of water and high economic value, the kingdom is expected to face difficulties in the future in sustaining those percentages while seriously seeking to develop sustainable agriculture.

For decades, the private sector has played a key role in the provision of food commodities through imports from abroad. These commodities include rice, spaghetti, sugar, vegetables, fruits, vegetable oils, red meats, poultry meats, and fish, among others.

Many Saudi businessmen and agricultural companies concluded partnerships with governmental and specialized bodies in water-rich countries to produce certain crops such as cereals, rice, feed and others and to export these crops to the kingdom. These partnerships were very successful despite there being major risks involved.

As a food importer, Saudi Arabia is influenced by world events, especially by political and economic conditions in producers of agricultural commodities and by the effect of climate change on food-producing areas. Droughts, floods, frost and other natural disasters can destroy agricultural products and decrease world stocks, causing higher world food prices similar to what happened in 2008. To protect itself against such upheavals, Saudi Arabia adopted King Abdullah's Initiative for Agricultural Investment Abroad, which has made it possible to provide food commodities to consumers for well-adjusted prices and to create safe strategic stocks of basic food commodities. This could provide the kingdom with food security, guarantee an inflow of commodities into domestic markets, and secure stable prices yearlong.

The food commodities in question include wheat, barley, rice, sugar, vegetable oils, red meats, poultry meats and fish. King Abdullah's Initiative for Agricultural Investment Abroad is an ambitious initiative that seeks to conclude agricultural investment partnerships with governments. Its technical and economic feasibilities were studied after agriculture, trade and finance officials visited many agricultural countries rich in water resources, agricultural soil and trained labor. Many deals were inked with East Asian, African and North European countries, as well as with Argentina, Brazil and others. The Saudi government will provide various facilities, aid and soft loans to agricultural investors abroad. According to available information, the initiative's outcomes will be encouraging and attractive to agricultural investment and will develop food security for the kingdom. For the initiative to succeed and for businessmen to import food commodities, both before and after the initiative's launching, one element is still in need: the creation of strategic stocks to preserve these commodities long enough.

CONCLUSION AND RECOMMENDATIONS

1- Self-sufficiency percentages of food products in Saudi Arabia are too low in light of the quantities unrenewable groundwater pumped out of deep strata. A quantitative and qualitative analysis of water consumed in agriculture and the quality of produced crops shows that cereal, feed and dates alone consume almost 80 percent of irrigation water.

2- Irrigation efficiency is too low (estimated at 50 percent), showing that consumed irrigation water is higher than the actual needs of plants. This is a hindrance to finding a solution to the ongoing decrease in groundwater resources in an arid desert environment.

3- A quick reconsideration of the crop constituents is needed in order to exclude crops with high water requirements and replace them with crops with low water requirements and suitable economic and nutritional values. In addition, highly efficient irrigation systems must be introduced.

4- Our daily lives include severe squandering and waste in terms of eating habits. This leads directly and indirectly to water waste. Hence, eating habits should be reconsidered in terms of quantity and quality.

5- It is time to reconsider agriculture subsidies to encourage farmers who use modern, water-efficient irrigation systems, such as sparkling. In addition, low fuel prices should be reconsidered because they have contributed to unrenewable groundwater overdraft to irrigate open fields of cereals and feed.

6- Benefit per water unit should be enhanced; the return per cubic meter of groundwater should be specified for different crops.

7- Using renewable water resources should be encouraged, including treated sewage and surface water collected behind dams. New water resources should be considered, such as collected rainwater.

8- Enhancing food security by providing facilities and aid where possible to additional poultry and fishing projects, which are part and parcel of agriculture and do not threaten water resources. The kingdom is far from self-sufficiency in poultry and white meats.

9- The relationships between water security, food security and energy security in light of climate change, world economic fluctuations and political instability in many world countries should be studied.

10- Strategic stocking is a key aspect of food security and a security and social stability factor. Hence, strategic stocking projects should be given utmost priority in order to stock various food commodities for as long as possible – in any event, the stocking period should not be less than one full year.

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reduced from 100 percent to 10 percent when SI was applied (Haddad et al 2011).

Average WP of rain in producing wheat in the dry areas of the WANA region ranges from about 0.35 to 1.00 kg grain/m^3. However, water used in SI can be much more efficient. ICARDA found that a cubic meter of water applied at the right time and good management could produce more than 2.5 kg of grain over the rainfed production. This extremely high WUE is mainly attributed to the effectiveness of a small amount of water in alleviating severe moisture stress during the most sensitive stage of crop growth.

Deficit irrigation is an optimizing strategy under which crops are deliberately allowed to sustain some degree of water deficit and yield reduction in order to maximize the productivity per unit of water used. Results on wheat, obtained from farmers' fields trials conducted in a Mediterranean climate in northern Syria reported significant improvement in SI water productivity at lower application rates than at full irrigation. Highest water productivity of applied water was obtained at rates between 1/3 and 2/3 of full SI requirements, in addition to rainfall.

Early planting is another SI strategy. In the high lands of the WANA region, frost conditions occur between December and March and put field crops into dormant. Usually, the first rainfall, sufficient to germinate seeds, comes late resulting in small crop stand when the frost occurs in December. Rainfed yields as a result are much lower than when the crop stand pre frost is good. Ensuring a good crop stand in December can be achieved by early sowing and applying a small amount of SI in October. SI, given at early sowing, dramatically increased wheat yield and water productivity. Applying 50 mm of SI to wheat sown early has increased grain yield by more than 60 percent, adding more than 2 t/ha to the average rainfed yield of 3.2 t/ha (Ilbeyi et al. 2006). Water productivity reached 4.4 kg grain/m^3 of consumed water compared to water productivity values of wheat of 1 to 2 kg/m^3 under traditional practices.

With supplemental irrigation, it is possible to decide on the sowing date of the basically rainfed crops without the need to wait for the onset seasonal rain. This results in a longer growing season and earlier maturity that helps crop to escape terminal drought.

B. Required packages for maximizing SI benefits

SI alone, although it alleviates moisture stress, cannot ensure the highest performance of the rainfed agricultural system. It has to be combined with other good farm management practices including:

Soil fertility, particularly in the Mediterranean region where nitrogen, is usually the main deficiency. Absence of nutrient deficiency greatly improves yield and water use efficiency. Other areas may have different deficiency levels of N or deficiencies in other elements. It is always important to eliminate these deficiencies to get potential yield.

Sowing date: One of the practical cases of SI is that all the fields may need irrigation at the same time in the spring. A multi-sowing date strategy reduced the peak farm water demand rate by more than 20 percent, thus potentially allowing a reduction in the irrigation system size and cost (Oweis and Hachum, 2001). Also, the water demand of a larger area can be met with the same water supply.

Improved cultivars: To get the best out of SI, a concurrent change in both management practice and water-responsive cultivars. The proper varieties need first to manifest a strong response to limited water applications, which means that they should have a relatively high yield potential. At the same time, they should maintain some degree of drought resistance, and hence express a good plasticity. Using both traditional breeding techniques and modern genetic engineering, new crop varieties can be developed that can increase the water-use efficiency while maintaining or even increasing the yield levels. For example, through breeding winter chickpea and drought resistant barley varieties that use substantially less water have been developed. The chickpea crop is traditionally sown in the spring. As a consequence, terminal drought stress occurs causing low yields. This was avoided by early planting with cultivars that are cold tolerant. On-station as well as on-farm trials have demonstrated that increases in yield

and water productivity of 30-70 percent are possible by adopting early sowing. Currently, winter chickpea is spreading fast among the farmers in the WANA region (Oweis and Hacum 2012). Data of farm yield under SI in northern Iraq indicate that SI has more impact on bread wheat varieties as compared to durum varieties. SI has increased yield of bread wheat varieties by more than 100 per cent, whereas the increase of yield for the durum wheat varieties ranged between 58 and 81 percent.

C. Adaptation to climate change

Rainfed agro- ecosystems will be further stressed as a result of increasing temperature, reduced precipitation, and prolonged droughts. Effects are expected on crop productivity, water resources, and ecosystem services.

It is, therefore, necessary that adaptation measures be developed in advance to overcome the consequences to agriculture and the livelihoods of people depending on rainfed farming. SI can play an important role in the adaptation efforts to climate change in rainfed agro-ecosystems.

As rainfall is unpredictable, SI becomes the most viable practice to alleviate the moisture stress caused by increased temperature. Another mitigation option is the possibility of changing planting dates. With SI this can also help adaptation to global warming. With the help of SI, early planting is possible and the growing season can start relatively early.

Crop yields and WP losses are mainly associated with soil moisture stress during such drought spells. Prolonged drought spells during the rainy seasons resulting from global warming will make the crop situation even worse and further drops in yields are expected as a result. Supplemental irrigation, by definition, deals with two situations. It adds some water to compensate for lower rainfall and less moisture storage and it alleviates soil water stress during dry spells. It is however, important to quantify the changes in rainfall characteristics and the durations of potential drought spells in order to design SI schedules to adapt the system to climate change.

Higher intensity rainstorms are also predicted, not only in the dry area, but also in SSA and globally. This naturally will cause more runoff and soil erosion in rainfed areas, especially on sloping lands. Supplemental irrigation combined with water harvesting can provide workable solutions to this problem. Macro- and microcatchment water harvesting are effective strategies for intercepting runoff and storing water either in the soil profile or in surface and groundwater aquifers. Water stored in the soil may support plants directly or it can be used for SI during dry spells if stored in small reservoirs or ground water aquifers. This model is being researched and tested in many places and should provide a good platform for overcoming the effects of climate change on runoff (Oweis et al 2012).

D. Water resources for supplemental irrigation

The question of water availability for SI in rainfed areas is crucial. Groundwater is the most common source of water for SI. In many dry regions, more than 90 percent of the rainfed areas with SI are fed from groundwater. However, there is a problem of overexploitation of this valuable natural resource. Pumping groundwater in excess of the natural recharge endangers sustainability of the development. In river basins, however, where full irrigation is practiced in the summer rainless season, the same water sources and irrigation facilities can be used for SI during the rainy season.

Water harvesting can be very useful in providing the water needed for SI. Runoff water is collected in a surface or sub-surface storage facility for later use in SI. Surface storage could be in small dams, ponds, man-made tanks, or small-scale reservoirs (Oweis et al. 2012). Several issues, both technical and socioeconomic, need to be considered for optimal implementation of such a water harvesting system. Bridging dry spells through the SI of rainfed crops using harvested rainwater can be an interesting option to increase the yield and WP.

Farmers in water scarce areas use marginal-quality water resources for SI. Whether beneficially used or wasted, marginal-quality water needs appropriate treatment and disposal in an environmentally appropriate manner. The protection of public health and the environment are the main concerns associated with such wastewater reuse. The use of brackish water resources is increasing and warrants attention in order to cope with the inevitable increases in salinity that may occur. Agricultural drainage water is becoming an appealing option in many countries. Treating these drainage waters as a 'resource' rather than as a 'waste' can contribute to the alleviation of water scarcity.

Applying supplemental irrigation is often an important element of upgrading rainfed agriculture. With the right incentives and measures to mitigate risks for individual farmers, water management in rainfed agriculture holds large potential to increase food production and reduce poverty, while maintaining ecosystem services. Key steps for tapping rainwater's potential to boost yields and incomes are (Rockstrom et al 2007):

i. Making more rainwater available to crops when it is most needed. This can be done by capturing more rainfall, storing it for use when needed; adding irrigation to rainfed systems, using it more efficiently, and cutting the amount that evaporates unused. Water harvesting, supplemental irrigation, conservation tillage, and small-scale technologies are all proven options.

ii. Building capacity. Water planners and policymakers need to develop and apply rainwater management strategies, and extension services need the skills and commitment to get rainwater-exploitation techniques out to farmers and to work with them to adapt and innovate for their specific context.

iii. Expanding water and agricultural policies and institutions. Rainwater management in upper catchments and on farms should be included in management plans, and supporting water institutions are needed"

VII. CONCLUSION AND RECOMMENDATIONS

A more recent study indicated that crop yields have reached a plateau in East Asia (for rice) and Northwest Europe (for wheat), the world's most important food producing regions (MacMillan and Benton, 2014). To enhance food security, this study asserted that future investments R&D need to be on "farmer-focused innovation" programs resulting in small-scale agricultural innovations to address the particularities of different production systems and farming innovations. This approach calls for decentralized and diversified R&D in which farmers are the essential players in agricultural innovation systems. ICARDA and its partners are well experienced in such decentralized approaches such as participatory plant breeding, community-based seed enterprises, innovation system platforms, and farmers-managed demonstrations. All these approaches have been successfully developed and practiced under different agro ecologies in dry areas including Arab countries.

Science-based solutions to developing countries' agricultural needs and constraints have often followed the introduction of single technology solutions. Facing complexity, such research efforts address single components of the problem, and not all its aspects. We know from history that successful and sustained innovation in agricultural research, seemingly using this approach is possible. In the early 1960s, following the provision semi-dwarf new wheat and rice varieties, the Indian government was able to avert mass starvation, which became known as the Green Revolution. However, upon closer scrutiny, in fact this achievement took a holistic approach and besides improved varieties also included improved agronomy practices and strong policy support from the Indian government.

An integrated agro-ecosystems approach to improving livelihoods will allow emerging synergies between varied technologies and policies to be identified that elevate solutions to a new level of impact. The day-to-day reality for farmers, agro-pastoralists or pastoralists is a complex agro-ecosystem. Such integrated agro-ecosystems thinking is the next step for agricultural research-for-development. The research question can be simply put as "getting the mix right". Addressing agricultural complexity directly as-is provides a new paradigm that will exceed a purely reductionist way. When addressing seemingly "complex" problems, solutions are not necessarily "complicated", but mostly require a change in mindset in scientists.

The integrated agro-ecosystems approach to agricultural research takes all systems' elements into account. It starts by following the impact pathway backwards from the intended impact in agricultural communities, to then establish the needed research, rather than the other way around. This calls for innovative research that includes systems' modeling all the way to on-the-ground verification and feedback to the research community to start a new cycle of systems research. Complex challenges call for integrated solutions.

To introduce just one example, integration of alley-cropping of fodder shrubs (salt-bush and cactus) into barley-based mixed livestock systems in North Africa was shown to deliver sustainable solutions to the involved communities. Such an approach addresses at the same time low erratic rainfall, erosion, reduced soil fertility and shortages of livestock feed. Alley-cropping technology includes growing drought tolerant salt-bush and spineless cactus between rows of barley, for sheep and goats to graze on. Thus a reliable and increased supply of fodder to the livestock could be provided, while at the same time erosion and rainfall run-off was reduced, resulting in greater water availability to the system.

Where rainfall is a bit higher, incomes can be boosted by growing higher-value crops, such as herbal, medicinal and aromatic plants or protected-agriculture crops with deficit irrigation from water-harvesting technologies, allowing produce to fetch premium prices on markets. Such integrated production systems can also bolster the status of women and youth.

We need to look for integrated options beyond subsistence farming, to provide for sustainable livelihoods in dry areas.

Besides integration of bio-physical innovations, enabling policies are fundamental. Examples include policies on land tenure, reduction of land fragmentation, making integrated approaches affordable and easily obtainable, investment in enabling modern extension services, enhancing access to markets, support for farmer cooperatives for inputs and outputs, simplified access to loans, and enhancing sustainable natural resource management.

Vertical "silos" amongst organizations will need to be replaced by horizontal coordination amongst all actors along the impact pathway to make integrated agro-ecosystems agriculture work, which includes involving policy-makers from the very onset.

The long term priority for Arab countries must be a continued and increased investment in science and technology in order to drive sustainable agricultural development and to enhance food security and rural development.

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NOTES

1. The water footprint (WF) is a measure of human appropriation of freshwater resources and has three components: blue, green, and gray. The blue WF refers to consumption of surface and ground water. The green WF is the volume of rainwater, which is particularly relevant in crop production. The gray WF is an indicator of the degree of freshwater pollution (Hoekstra and Mekonnen, 2012).

2. Aggregate total factor productivity (TFP); is a general measure of the average productivity of all inputs that have market value (land, labor, capital and material) that are used in the production of all crop and livestock commodities while ignoring non-market inputs and outputs for example changes in environmental services caused by agricultural activities.

There are two methods of measuring agricultural outputs:

a. Gross output: which subtracts the value of intermediate inputs from gross output
b. Value added: the use of value added method has been found inferior to gross output method. Hence most empirical research on agricultural productivity relies nowadays on the use of gross output as measure for the agricultural output

Developing Food Chains

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The 2012 Global Strategic Framework for Food Security and Nutrition drew attention to the role of food value chains in providing food security and ending world hunger. In the Arab region, conflict and scarce water resources are the most obvious priorities for increased food security. However, the hypothesis of this article is that unless selected deeper, structural issues are addressed, the Region will miss many opportunities for using the food value chain as a means for both food security and increased, equitable growth. Weak food value chains in the Arab region reflect wider gaps in broad-based local and national development patterns as well as limited regional economic integration.

The constraints to food value chain development in the Arab region are numerous. A properly developed regional food market and related value chain - especially for strategic staple commodities - would help spur the competitiveness of the agricultural sector and improve the region's agricultural terms of trade. Intra-Arab trade data show that the annual value of export to Arab countries is estimated at well over US$50 billion, representing a potential stream of revenues for Arab countries were agricultural and food processing chains developed more fully within the region. This value could potentially double or triple were markets of the region better developed and integrated, which would contribute to enhanced job creation, food security and poverty reduction.

This requires that the appropriate policy interventions – liberalizing regional trade, diversifying financing and insurance opportunities, reducing food waste and loss, among others – are made at appropriate links in the chain, including at the production, processing, distribution and retail phases. Increased investments in regional food value chains have the potential to produce significant economic and social benefits for Arab countries not only by ensuring greater food availability but also by improving food access, food stability and food utilization, as well as enhanced quality and safety.

Specific priority actions are recommended in the chapter.

I. INTRODUCTION AND CONCEPTUAL FRAMEWORK

One of the critical achievements of the 2012 Global Strategic Framework for Food Security and Nutrition (GSF) was the inclusion of a value chain perspective into a global agreement on ending hunger and providing food security in our lifetime (Committee on World Food Security, 2012). A key element of consensus was the understanding that any "new order" for food security would ensure that the various actors involved in producing, storing, distributing, processing, retailing, preparing and consuming food (the "farm to fork" path) are well connected and operating efficiently and sustainably.

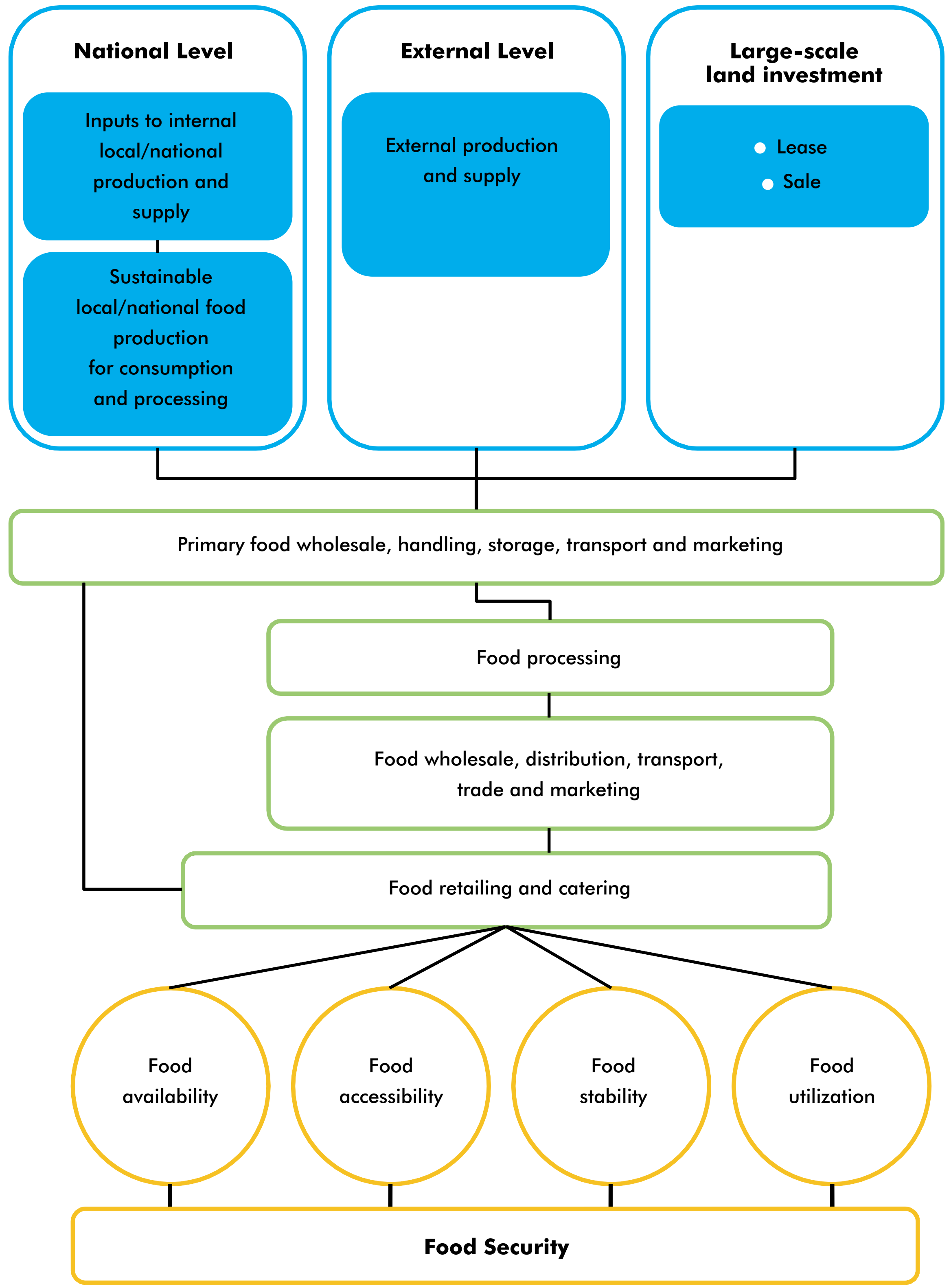
The agricultural and food sectors in the Arab region are changing rapidly as a result of interrelated factors. Chief among these are the rapid rates of population growth and urbanization in most countries, as well as evolving consumer preferences as a result of changes in employment patterns and the growing importance of the information and services sectors. This changing landscape is leading to new methods of food production, processing, and distribution, particularly for selected sectors such as fruits and vegetables. As a result, there is an urgent call to make agricultural and food value chains more efficient and productive, as well as to offer higher quality and safer products.

The lack of strong agricultural and food value chains in the Arab region reflects wider gaps in broad-based local and national development and regional economic integration. It highlights the virtual absence of strong competitive regional advantage in production, processing or distribution through existing value chains in many sectors (UN ESCWA, 2014). This results in the loss of numerous opportunities, which challenge countries' efforts to raise income, create wealth and build capacities for growth and innovation. It also represents untold opportunities, given the significant role that agricultural and food value chains could play in the development of the Arab region, especially for selected commodities such as cotton, sugar, olive oil, dates, livestock, a variety of fruits and vegetables and staples such as wheat.

The constraints to agricultural and food value chain development in the Arab region are numerous. These include, among others, a fragmentation of markets, poor infrastructure, lack of appropriate technology, and weak policy and institutional frameworks governing the agricultural and food sectors. However, the fact that local and national agricultural markets are also not well integrated into regional and international markets, despite the increasing flow of agricultural goods at the regional level, is also a major obstacle in their development. In most cases, agricultural development strategies have been based on specific national priorities, such as ensuring food self-sufficiency or the creation of a strong national agro-processing sector, with little-to-no attempt to build regional scale economies either in production or consumption. In addition, most agricultural and food exports from the region are usually unprocessed, and as a result, the region fails to capitalize on the potential benefit of adding value locally.

Increased investments in regional agricultural and food value chains have the potential to produce significant economic and social benefits for Arab countries not only by ensuring greater food availability, but also by improving food access, food stability and food utilization, as well as enhanced quality and safety. Yet, efforts to-date have still not reached a tipping point that would allow countries to optimize and strengthen their overall agricultural and food value chain capacities (UN-ESCWA, 2014).

FIGURE 1 FOOD VALUE CHAINS IN THE ARAB REGION: A CONCEPTUAL FRAMEWORK



ARAB FERTILIZER SUPPLY CHAIN

Algeria, Egypt and Syria are potential hosts for further phosphate fertilizer manufacturing due to the availability of raw material and reserves, and the fact that they are exporting directly without value-added.

Most Arab exports are in the form of rock phosphate exported for further manufacturing in East Asia (esp. India, China, and Indonesia), Brazil, Turkey, and USA. Manufacturing facilities in Morocco, Jordan and Egypt can be further expanded to produce more phosphate fertilizers. Jordan for example, exports a large percentage of its phosphoric acid production to factories in Saudi Arabia where it is processed into phosphate fertilizers and exported to China for example. Saudi Arabia and other Gulf countries have already good trade relations with East Asia as they export there Nitrogenous fertilizer.

There are no signs of collaboration among phosphate rich countries in the region. Tunisia for example, has ventured with a large Indian Corporation in order to produce phosphoric acid and DAP, enabling it to play a global role in the value chain even though its crude resources are limited.

Trade with Africa could also be enhanced as it is emerging as a strong market that seeks opportunities for low-cost fertilizer solutions. The FAO (2011) forecast that for 2011-2015 the Compound Annual Growth Rate (CAGR) for phosphate fertilizer in Africa should be about 3.4 percent.

Intensified efforts for R&D in waste reduction, capacity utilization byproducts, and recycling of phosphate rock should be built upon in order to guarantee a sustainable life span of this product.

Source: Analysis by UN-ESCWA Technology Centre and based on FAO (2011) available at ftp://ftp.fao.org/agl/agll/docs/cwfto11.pdf.

The central hypothesis in the present chapter is that food security in the Arab region can be improved by strengthening the links in food value chains at the local, national and regional levels. Whether produced or collected on land (crops, livestock, and inland fisheries) or in the sea (fishing), all food will go through a series of steps or links before reaching the consumer (see Figure 1). Most often, at each link value would be added to the produce or food product (e.g., cleaning and freezing of fish, juicing of fruits) while preparing it for the next step (e.g., transport, further processing, retail). The entirety of the chain comprises a diverse range of actors covering varied sectors (agriculture, industry, transport, commerce, health, and environment), institutions (public sector, business, non-governmental) and levels (local, national, regional and global). The Arab region also has additional specificities which are highlighted in Figure 1, including: (i) the acquisition of food from the international markets; and (ii) the purchase or lease of land abroad in order to expand the production base. This chapter focuses on food value chains in Arab countries and highlights priority areas that would lead to improved food security in all of its dimensions – availability, accessibility, stability and utilization.

II. KEY LINKS IN FOOD VALUE CHAINS

The framework used here identifies the "pressure points" where policy signals could be maintained, increased, decreased or changed in order to have maximum impact on food security in a sustainable way in the Arab region.

A. Production

Over the years, countries in the Arab region have endeavored to improve their respective food security through various means, including through import substitution of food products with the overall aim to increase levels of food self-sufficiency. As a result, various types of agricultural support programs were introduced with an emphasis on input support programs. These were further strengthened in the wake of the 2007-08 food price crisis. The most common program has been the provision of free or subsidized fertilizers and seeds, for example, in Sudan, Egypt, Syria and Yemen (Maetz et al, 2011). Other notable support programs have included favorable output purchase price policies, the provision of subsidized loans and the implementation of selected public agricultural investment programs.

Though these support programs are commendable, notably in their ability to enhance productivity, it is generally thought that greater positive impacts could have been achieved through a better integration of the

input market into the agricultural value chain both at national and regional levels in order to enhance the competitiveness and revenue-generating power of locally sourced products (see box *Arab fertilizer supply chain*). As a result, and as has been documented elsewhere in the world, inadequacies in agricultural value chains have hampered the ability of most agricultural stakeholders, and notably input producers, to benefit from recent hikes in worldwide commodity prices.

Nonetheless, these support programs have helped alleviate the burden on producers by ensuring that they would have sufficient means to keep producing in the short to medium term. Although there is no data to quantify the resulting increase in the rate of self-sufficiency caused by these interventions, any increase has not been able to translate into significantly higher food availability through domestic means. Recent data shows that most countries are still heavily relying on imports to meet their food needs (see Table 1). Complete self-sufficiency in staple food is unattainable in the region, whether at overall regional level or at country-level. But there is consensus that an increase in the level of local production has both economic and social importance.

Farmers in the region play a prominent role in responding to the challenge of the food supply deficit. However, they need additional support to enable them to become major actors in the food value chain. There is a need to turn farming from a subsistence and low-yield business into a high performing one able to respond to market demand and needs. In the least developed countries of the region – Yemen or Sudan for example – many parts of the food value chain are still basic. In the middle income countries – Algeria, Egypt, Jordan, Lebanon, Morocco, Tunisia or Syria – the lack of specific support and related services such as adequate technology, appropriate financing instruments or targeted capacity building programs, is a major impediment (see Chapters 2 and 3). In the higher income countries, for example most Gulf Cooperation Council countries, farmers lack adequate natural resources (land and water). As a result, the agricultural sector of the region is caught in a vicious cycle of low productivity and low means, which prevents further investments for higher production.

However, a few sub-sectors – fruit and vegetables; various animal products (meat, eggs, milk); olives and olive oil; and cotton – are

performing relatively well in the region with self-sufficiency ratios well beyond 80 percent (as was seen in Chapter 1). These sectors would require relatively less resources and attention from public sources to perform even better within an integrated agricultural value chain. Private sector involvement in production or processing capabilities should be encouraged in order to add value to the locally sourced agricultural products, which would also lead to greater local employment. Encouraging private sector involvement could be supported and facilitated through various means including capacity building, research and development and product quality enhancement and standards among others.

Selected countries in the region have already put in place national agricultural policies aimed at promoting higher production either for export or for enhancing food security (e.g., Plan Maroc Vert in Morocco; Egypt's smallholder contract farming for high-value and organic agricultural export). Despite the overall direction provided

by regional agricultural development strategies – such as the Arab Organization for Agricultural Development's Strategy for Sustainable Arab Agricultural Development for the Upcoming Two Decades, 2005-2025 – there is still a lack of coherence in region-wide agricultural policies that identify strategic crops for promotion or support at the regional level, and the necessary means for their implementation. A comprehensive regional agricultural policy would go a long way in providing specific guidance for selected staples (e.g., wheat, other grains, tubers) and for selected high value fruits and vegetables, animals, and related byproducts within a general framework of an Arab development strategy.

B. Trade

The share of the Arab region in world agricultural trade is relatively low. Food import is anticipated to increase due to the combined effect of a growing population, increased urbanization, higher income and lower domestic food production. Cereal import has increased over the years to reach a current net deficit of about 70 million tons per year (see Figure 2) with a number of countries from the region, notably Egypt and Saudi Arabia (see Figure 3), among the highest net cereal importers in the world (UN ESCWA, 2013a).

Arab farmers are largely disconnected from regional and global markets due to the inadequacy of supporting infrastructure and related agribusiness system. However, a properly developed regional food market and related value chain – especially for strategic staple commodities – would help spur the competitiveness of the agricultural sector and improve the region's agricultural terms of trade. The region's agricultural and food sectors would also greatly benefit from increased integration which could help turn the region into a price-setter while decreasing transaction costs for improved marketing margins (Conforti and Sarris, 2007).

The trade of food staples currently dominates national and regional agricultural markets (IFPRI, 2010). Intra-Arab trade data show that the value of export to Arab countries is estimated at well over US$50 billion (see Table 1), representing a potential stream of revenues for Arab countries were agricultural and food processing chains developed more fully

TABLE 1 AGRICULTURAL TRADE IN THE ESCWA REGION

Countries	Export to the region (%)	Export to all destinations (US$ millions)	Import from the region (%)	Import from all destinations (US$ millions)
Algeria	19	107	2	6,598
Bahrain	90	54	26	989
Comoros	1	9	3	13
Djibouti	87	3	2	66
Egypt	55	4,568	4	7,738
Iraq	33	5,429	48	4,525
Jordan	81	515	29	2,410
Kuwait	91	44	19	1,470
Lebanon	66	436	17	2,429
Libya	30	119	6	1,100
Mauritania	6	8	6	372
Morocco	9	1,840	6	3,985
Oman	66	103	16	1,562
Palestine	73	189	90	72
Qatar	74	14	34	1,720
Saudi Arabia	88	774	17	10,600
Somalia	98	35	23	444
Sudan	71	540	42	1,271
Syria	95	2,400	14	3,516
Tunisia	30	1,227	5	1,647
United Arab Emirates	60	176	10	2,659
Yemen	74	112	15	2,572

Source: Computed from FAOSTAT (2014).

within the region. This value could potentially double or triple if markets of the region were better developed and integrated, which would contribute to enhanced job creation, food security and poverty reduction.

The evidence suggests that global trade liberalization under the Doha Development Round of trade will lead to higher world agricultural prices as a result of reduced support and other subsidies. Given that Arab countries are almost all net food importers, there is cause for concern regarding the potentially future higher prices of wheat, rice, sugar, cotton and dairy products on the food situation in the region. Estimates show that a 3 to 20 percent increase in global food prices (as recently estimated for some products) would result in an additional US $10.8 billion deficit for Arab countries by 2020 (UN ESCWA, 2014), which was equivalent to about 0.4% of the Arab Gross Domestic Product (GDP) in 2010 (UN ESCWA, 2013b; Minot et al, 2010).

The economic benefits of greater Arab markets integration, in the context of the Pan Arab Free Trade Area (PAFTA), have been limited to date because the agreement underpinning PAFTA has proven to be too flexible and not always for the better. This has allowed for example the issuance of numerous exceptions on the basis of "sensitive goods", particularly in the agriculture and food sectors, and the use of multiple non-tariff measures. These exceptions have had significant negative impacts on the potential gains that could be brought about through trade liberalization. Thus, more stringent rules and standards regarding the use of exceptions and tariff and non-tariff barriers should be agreed upon and enforced.

The creation of the proposed Arab Custom Union (ACU) is another important challenge for the region. In addition to the high dispersion of tariffs on agricultural imports across Arab countries, liberalizing agricultural imports without significant reforms of domestic agricultural policies in the European Union and United States will negatively affect the fragile status of agricultural sectors in most Arab countries. The potential damage is especially acute in countries in which agriculture still plays an important role economically and socially. In this respect, Syria, Egypt, Tunisia, and Morocco would potentially be net losers if agricultural products are integrated in the ACU, prior to an agreement under the Doha Round and a significant harmonization of agricultural policies in Arab countries and their main partners.

The dependency of the region on imported food is clear, both at present and for the future,

URBAN AGRICULTURE IN THE ARAB REGION

Salwa Tohmé Tawk and Shadi K. Hamadeh

The role of agriculture in urban areas is gaining recognition across the globe as a response to increasing urban poverty, food insecurity and scarcity of natural resources. The average world population living in urban areas is estimated to be 51 percent and the number of urban poor is quickly growing. The Middle East and North Africa region (MENA) population is projected to double by 2050 to reach more than 650 million, unemployment is high and increasing, and agricultural production faces severe natural resource constraints (IFPRI, 2010). Moreover, the MENA is the most food import dependent region in the world, importing 50 percent of regional food consumption (FAO, 2008).

Today, the urban setting is under extreme pressure in MENA, as a result of a very rapid urbanization rate over the past 10 years. Out of a population of 380 million, 200 million reside in urban areas and according to UN projections the MENA population will reach 430 million by 2020, of which 280 million are expected to be urban (IFPRI, 2010).The population involved in Urban Agriculture (UA) is 6 percent as compared to an average of 2 percent for other regions (FAO, 2001). UA is a noteworthy source of income and savings and its up and downstream effects in the local economy can be considerable. Agricultural production in and around cities is an ancient activity in the MENA region. Despite the increasing demand for land and water for urban activities, crop and livestock production are common throughout the region's cities (Nasr J., Padilla M., 2004). Unbuilt fertile land is still considerable in and around cities and is remaining vacant for several years before being built, offering an important source of income and job opportunities.

An example of where UA can make an impact is in Amman, Jordan. Amman has a poverty rate of 8.5 percent and an unemployment rate of 12.7 percent (Directorate of Statistics, 2010) About 196,000 people live in poverty, representing 9.43 percent of the total poor in Jordan (World Bank, 2009) while people who are food insecure and vulnerable represent 2.4 percent (WFP, 2012).UA could positively affect the livelihoods of Amman's poor because a significant amount of land is still agricultural (42 percent out of the total available land area was in agricultural use according to the Department of Statistics, 2002). In Sana'a, Yemen, 9,300 hectares of agricultural land was available in the city in 2007 (YASAD, 2007). More than 100 community gardens "maquashim" or mosque gardens exist within the fortified wall of old Sana'a (which is now classified as a UNESCO World Heritage site). Many of these gardens are irrigated by treated greywater produced by the mosques.

Several constraints limit the development of sustainable urban agriculture, in the MENA region. Urban policies and zoning in particular have ignored the potential of urban agriculture as a source of food and livelihood for the urban poor.

In spite of its potential to alleviate poverty, urban agriculture, is still lacking recognition from planners and policy-makers (van Veenhuizen, R. and G. Danso, 2007). Research, extension, resources, enabling policies and strategies concerning existing urban agricultural lands and other urban fertile areas are almost non-existent (Nasr J., Padilla M., 2004). Therefore, reforming policies and institutions will be important to secure food and reduce poverty. The overall strategy for the MENA region as defined by the International Food Policy Research Institute (IFPRI, 2010) is to enhance dialogue, partnerships, and networks between individuals and institutions involved in research, the private sector, civil society, and government. It focuses on governance and policy processes in food, nutrition, and agriculture and on institution building as one of the nine themes in the strategy. Policy development and action planning on urban agriculture should hence involve various sectors and disciplines. Moreover, urban farmers and organizations have to be involved in the strategic urban planning process, in the analysis of the situation and in the definition of priorities (Ruaf, 2014). Such consultative processes will make the outcomes of policy development and action planning comprehensive, accepted and sustainable.

The Environment and Sustainable Development Unit (ESDU), located at the American University of Beirut is the seventh center of the international RUAF network serving the MENA region (RUAF is the Resource Centers network on Urban Agriculture and Food Security).ESDU-RUAF initiated the Participatory and Multi-stakeholder Policy Formulation and Action Planning (MPAP) –a process of collaboration between the urban authorities with citizens, farmers, civil organizations, private sector companies and other governmental entities in the preparation, implementation and evaluation of policies and related action plans. The program supported the integration of urban agriculture in urban policies and planning in the MENA, mainly in Amman (Jordan) and Sana'a (Yemen) since 2007 when it first conducted an exploratory study on UA. ESDU trained teams to conduct the study, develop a city strategic agenda (CSA) and establish a multi-stakeholder forum (MSF) aiming at supporting the sustainable development of UA. The MPAP team in each city was led by a core unit consisting of some municipal departments, in addition to university and farmer representatives.

In both cities, the CSA strategic lines of action were identified: access to reliable and cost effective water resources; human resources which aimed at education, skill building and support through necessary inputs; legislation from local, regional and national governmental institutions; effective marketing; and access to credit as well as support and advice regarding credit. The MSF members agreed on being responsible for the execution of the CSA by mobilizing relevant technical assistance and in kind support and funding.

Their efforts culminated in involving public authorities in supporting UA. In Amman, the Greater Amman Municipality (GAM) took the initiative to establish a specialized UA bureau with dedicated human and financial resources (Tohmé et al, 2011), which gives solid sustainability and institutionalization prospects for the Agenda. The GAM and other interested and influential stakeholders adopted the CSA as part of the city strategy for developing agriculture in 2009. In parallel, pilot projects were implemented: GAM implemented rooftop gardening in poor neighborhoods and ESDU implemented a pilot project with a local women's cooperative to improve the production chain of selected produce such as leafy vegetables. In addition, urban farmers were recognized by agricultural credit institutions, hence opening new microcredit opportunities for small scale urban farmers.. Also, the extension department at the Ministry of Agriculture targeted its services towards urban producers by offering trainings and in-kind subsidies. The institutionalization of UA through the MSF has had further success. The UA bureau at GAM was approached by the Amman Institute (a unit within the GAM) and has worked diligently to include UA as a major component of greening and rezoning initiatives.

In Sana'a-Yemen, the non-governmental organization YASAD (Yemenite Association for Sustainable Agriculture and Development) initiated the MPAP, in cooperation with Sana'a municipality represented by the Public Department of Gardens and the Bureau of Agriculture. They are working on the reformulation of laws and regulations in order to preserve agricultural activities and enhance access to land and more specifically access to land for grazing.

ESDU's multi-stakeholder and value chain approach were effective to promote UA in Amman and Sana'a and the lessons learnt from these two experiences are valuable knowledge for other cities where the potential for UA can be unleashed.

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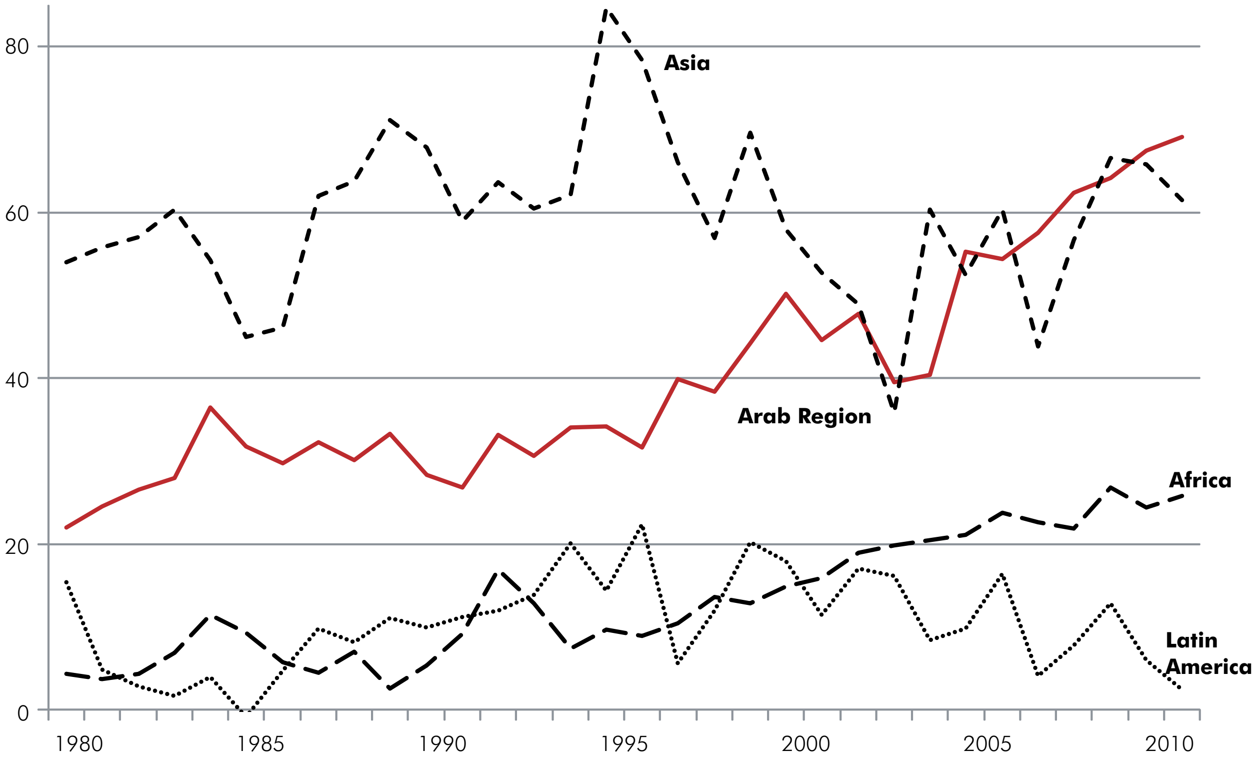
Dr. Salwa Tohmé Tawk and Dr. Shadi Hamadeh, Environment and Sustainable Development Unit, Faculty of Agricultural and Food Sciences, American University of Beirut, Lebanon.

FIGURE 2 NET CEREAL IMPORT 1980-2011 (MILLION TONS)



Source: Computed from FAOSTAT (2013).

though its implication for individual countries is different depending on their fiscal standing. Gulf Cooperation Council (GCC) countries, Iraq, Libya and Algeria all benefit from high oil revenues, making them less impacted than most other countries in terms of the weight of imports bills on public finances and balances of payment. Most other countries are at a higher risk of seeing their financial and social stability shaken (World Bank, 2009). The continued increase in the volume of food imports associated with high world prices and national currency depreciation is negatively impacting public finances in many Arab countries, mostly those where governments are still providing food subsidies (price transmission elasticity almost equal zero). This is the situation in Tunisia, Egypt and Yemen, where food subsidies are increasingly absorbing an important share of public resources. Reform cannot be delayed any longer, and targeted subsidy mechanisms should be crafted to ensure greater equity in the use of public resources.

C. Large-scale land investment

As part of another approach to securing their long-term food requirements, a number of countries in the region are increasingly negotiating, leasing or purchasing prime fertile lands in the region as well as in countries in other regions. Estimates show that almost US$20-30 billion per year is spent on large-scale land leasing in foreign countries (UN ESCWA, 2010). Among countries of the region, Sudan has seen the greatest level of large-scale land investment, but limited land deals were also made in other countries including Egypt, Lebanon, Jordan and Morocco, among others.

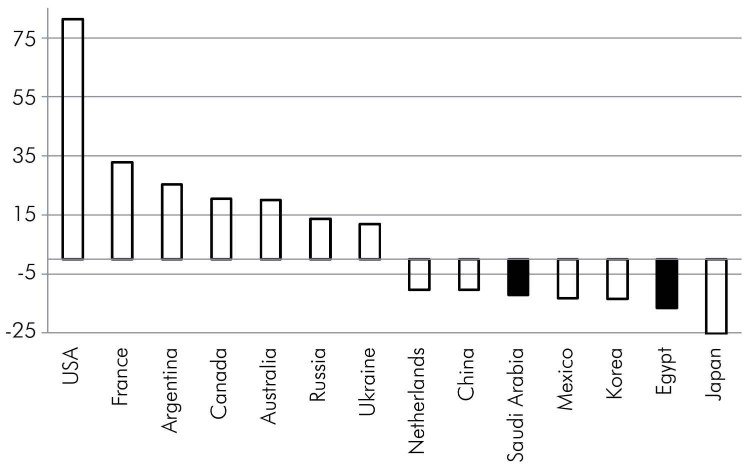
Codes of conduct for foreign land acquisition are critical for ensuring that populations that could benefit from greater agricultural production for local consumption are not disadvantaged by food production which is strictly for export markets. FAO has promoted the need for increased joint ventures between investors and local farmers in host countries as an alternative to land lease or purchase. This approach allows farmers to remain in control of their land, while ensuring that the host country's food security is not endangered. Contract farming and out-grower schemes which involve smallholder farmers may increase their opportunities for benefiting from foreign investment. Schemes such as these usually provide inputs, credit and technical assistance by investors to small farmers in exchange for production, resulting in a potential win-win situation for both parties (UN ESCWA, 2010). The potential financial risks and losses taken by such operations would need to be further assessed to see whether the pre-determination of what products need to be produced would still produce food which is competitive on the global market. In any case, without properly functioning agricultural value chains both host and investing countries will face major obstacles to ensure that the food produced reaches the final consumer in the investing countries.

In 2011, the World Bank released an in-depth study of large-scale acquisitions of land rights for agricultural or natural resource-based use in order to generate empirical evidence on the possible policy frameworks and impacts associated with specific cases (World Bank, 2011b) As part of this work and work with other partners, including FAO, IFAD and UNCTAD, a set of recommended principles on responsible agricultural investment were proposed, with a focus on respecting rights, livelihoods and resources. A global consultation and review process on the set of principles is currently underway and intended for endorsement in 2014 (FAO et al, 2010).

D. Storage and transport

Strategic storage has become an increasing concern – especially for products which are especially important in the region, such as wheat – as a means of minimizing risks associated with import supplies and price shocks (FAO, 2012). For example, after food price increases in 2007-2008, some Arab countries modified their storage strategies by deciding to hold one year's worth of wheat supply. In the case of wheat, the product is an essential part of the Arab countries' diet and demand is mainly inelastic,

FIGURE 3 **MAJOR NET CEREAL TRADERS, 2010 (MILLION TONS)**



Source: Computed from FAOSTAT (2013).

making storage strategies essential for securing alternatives to supply during times of volatility or crisis (FAO, 2012).

Despite being the largest importers of wheat, in 2010 Arab countries only accounted for 10 percent of the world's wheat reserves (FAO, 2012). As concerns have grown, governments are reviewing the strategic reserve and are aiming to increase the current stock of wheat. However, increasing capacity comes at a cost. Investment in building silos, improving infrastructure, training staff in reserve management and building new storage capacity are required to ensure an effective storage system. Strategic reserves are intended to be safety nets; hence government must put in place policies that, for example, will stimulate the involvement of the private sector.

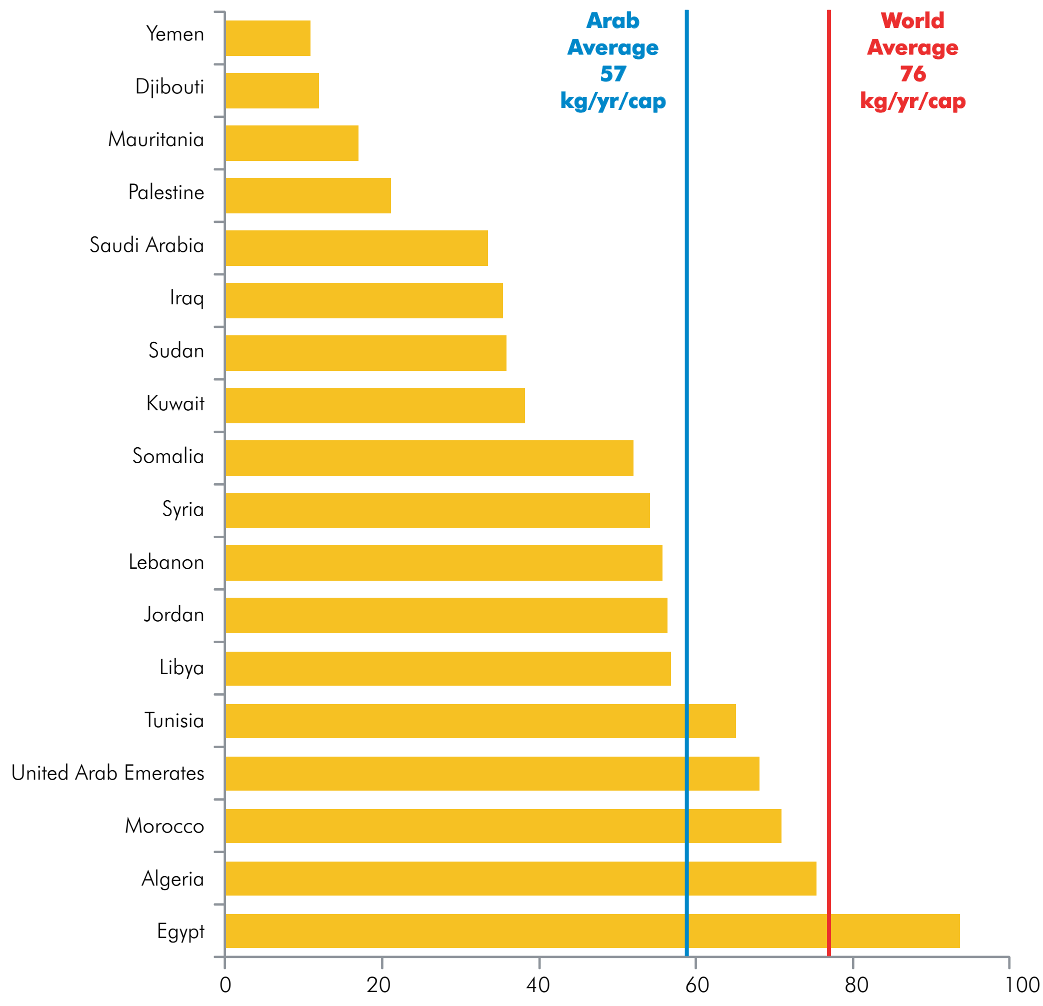
Agricultural and food value chains play their role and improve the overall food situation as long as certain conditions are met. Chief among these is the need for good infrastructure so that the various segments of the chain are well connected, allowing the value chain-generated flows of goods and revenues to function properly. In parts of the region and particularly in rural areas, there are still substantial challenges facing the physical infrastructure supporting agricultural and food value chains.

Transaction costs are usually relatively high for agricultural products due largely to their bulkiness and perishability. Delays and uncertainty lead to spoilage, which require the maintenance of larger operational inventories. Issues such as traceability, health certificates and others add to the delay, thereby increasing overall costs which could further hamper food value chains and the export of certain agricultural goods.

Spoilage is an important – but by no means the only – component of food loss within the food value chain. Most waste in developed countries occurs at retail and consumer levels, while it happens at the post-harvest and processing stages in developing countries as a result of warm and humid climates and gaps in modern transport and storage infrastructure (George Morris Center and Value Chain Management, 2012). In the Arab region, food waste and loss from production to retailing amounts to about 57 kg/year per capita, which is well below the world average of 76 kg/year per capita (Figure 4). However, as seen in Figure 5, there is an overall rising trend in the region, in total food waste/loss across major commodity groups.

Both the public and private sectors should be involved in reducing food loss and waste. It requires a multi-sectoral approach, with governments' efforts focusing on policies that emphasize cooperation on loss and waste

FIGURE 4 **FOOD LOSS AND WASTE, 2011 (KG/YR/CAP)**



Source: Computed from FAOSTAT (2014).

FAO REPORT: SYRIAN CRISIS IMPACT ON FOOD SECURITY

Since the start of the Syrian crisis in 2011, the food security situation has grown worse. Cereal production has decreased by more than 50 percent, while agriculture infrastructure (irrigation canals, dams, roads, electricity) has been significantly damaged in many areas. The conflict has led many farmers to leave their lands, in addition to significant losses in livestock assets, massive uncontrolled movement of cattle, sheep and goats across the Syrian border, and disruptions in agriculture markets.

FAO's yield calculations, based on remote-sensing data and the Agricultural Stress Index (ASI), indicate a yield level at 1.5 tonnes/hectare, much lower than the normal average level of 2.4 tonnes/hectare used in other estimates. Food shortages pushed up import requirements, and prices for cereals and other foods climbed by 108 percent in November 2013, compared with the year before.

FAO-WFP estimates (May 2014) indicate that 6.5 million people inside Syria are food insecure and the situation is likely to further deteriorate because of the prevailing drought conditions.

In the neighboring countries of Lebanon, Jordan, Turkey, and Iraq, the growing influx of refugees and returnees into vulnerable areas at the borders has added pressure to the economic conditions and the precarious food security of already impoverished host communities.

Around 60 percent of the refugees live in rural areas, offering cheap informal labor, thus contributing to a sharp decrease in farm wages that is reaching around 25 and 30 percent in some areas. The increased uncontrolled movement of unvaccinated livestock presents a severe, growing threat to animal and human health. Localized outbreaks of some significant livestock diseases and zoonoses have been reported in all neighboring countries.

Abdessalam Ould Ahmed, FAO Assistant Director General and Regional Representative for the Near East and North Africa pointed out that "behind each family pushed into poverty and hunger, there are whole systems collapsing that need to be protected, restored and strengthened. Agriculture cannot be an afterthought. Affected communities in the sub-region need an effective response to the challenges threatening their food security and livelihoods".

International reports indicated that the drought that has hit Syria since 2007, the worst since the 1950s, was one of the causes that led to the socio-economic crisis that blew up later on. Estimates by the Syrian government and the United Nations assessment mission indicated that more than 800 thousand people affected by drought were living in severe conditions. The drought pushed 40 to 60 thousand rural families to migrate to the outskirts of major cities such as Damascus and Aleppo, after having lost most of their livelihoods. This coincided with the decline in oil revenues, and the ban enforced by Gulf countries on the import of Syrian livestock by land due to the foot and mouth disease outbreak in Jordanian livestock, which was a crushing blow to Syrian breeders already plagued by the drought and the spike in feed prices.

These conditions were detrimental to Syria's food security, especially that its wheat crop had made it one of few self-sufficient countries for over 20 years. In 2008, FAO representative described the situation as a "Perfect Storm" where drought and socio-economic pressures could lead to the undermining of stability.

Dire consequences on Lebanese agriculture

With over 1.5 million Syrian refugees - 34 percent of the pre-crisis country's total population – Lebanon is the country where the Syrian crisis spill overs can have the most destabilizing consequences on food security and agriculture. Concentrated mostly in the poorest areas of Lebanon, the huge numbers of Syrian refugees pouring into poor areas on the borders is putting extra pressure on food and agri-systems of these regions. The refugees high dependence on assistance is causing a major increase in government expenditure on food subsides, weighing heavy on the national deficit.

The agriculture economy and food production capacities of the border areas of Hermel, Baalbek and Akkar, are being deeply affected by the economic repercussion of the protracted crisis. In these areas farmers cannot, to a great extent, even access their agricultural land and keep on struggling to maintain production. Farmers and livestock rearers are increasingly abandoning their animals as they are unable to cope with the escalating feed prices and decreasing prices of their animal products. Agricultural inputs, once bought at low prices from Syria, are now difficult to find on the market and, when found, their prices have dramatically increased.

In this regard, the costs of some vegetables seeds have increased threefold in the past two years. Sulphur, used for pest control, rose from US$4.5 per bag of 25 kg to US$25. Factories are now obliged to find alternative sources for their fresh agriculture products.

The declining contribution of the agriculture sector to the national economy is causing losses in terms of farm produce, wages, profits and investment.

FAO, in collaboration with the Lebanese government, have prepared a national five year plan to support rural livelihoods in the affected areas, strengthen the capacity of local communities to adapt to the crisis and promote the development of the agricultural sector.

Figures and findings are taken from reports on the subject issued by FAO in May 2014.

mitigation among the different actors in the food value chain (Gustavsson et al, 2012). This might also require strategic investments in areas that help to prevent food loss and waste, such as infrastructure for production and storage, as well as upgrading market information systems. The private sector would focus on tangible investment opportunities at different parts of the food supply chain (Gustavsson et al, 2012).

E. Processing and marketing

Globally, and across food types, most of the value in the food chain is added at the point at which food companies process and market food products, with earnings reaching almost 20 percent (similar in value added only to input actors in the food value chain) (Henriksen et al, 2010). This is also true in value chains for staple foods in developing countries (Reardon et al, 2012). In the region, Morocco and Tunisia are identified as countries where agro-processing industries contribute to food security directly (through the provision of food products) and, indirectly, through increased income through labor opportunities (Breisinger et al, 2012). In the case of the Maghreb countries, most of the export of agriculture products is toward Europe. However, region-wide, the majority of agricultural products (including agro-industrial products) are traded within the region. Agro-industry is considered to be the most integrated subsector in the region, and this is a strong basis to justify additional investments (UN-ESCWA 2014). Some level of government intervention at the level of processing in the food chain has been demonstrated to contribute positively to income generation and food security, making this an important priority area for policy makers in the region (Ohrstrom, 2013).

Short-term financial gains can often come at the expense of long-term economic, social and environmental benefits. For example, the over-use of "fossil water" for wheat production and other non-economical purposes is one well-documented historic example and not only in dry Arabian Gulf region, but also worldwide (Pakalolo, 2014). Reliance on global markets for wheat is one step to ensure that policy signals are in line with the conservation of water, but more needs to be done in the food processing link to ensure sustainability. One example is the dairy sector, where efforts for self-sufficiency in dairy products are often based on policies that allow large agro-industries to over-shoot national needs, thereby "milking the desert" for meager export revenues and in turn, further depleting scarce water resources. Lately, this is being addressed by improved food security strategies (Dagestani et al, 2011).

A supply of safe and high-quality food products is promoted through effective risk management at each stage of the food chain, beginning with production and including transport, processing, distribution and retail to consumers (Piñeiro and Díaz Ríos, 2007). At present, in most countries in the Arab region, well-defined standards for food quality are absent or under-resourced and regulatory and enforcement institutions are weak (UN-ESCWA 2013a). Citing Yahia (2005), in recent years some Arab countries have developed new food control systems for both domestic and imported foodstuffs (UN-ESCWA 2013a). In theory, new standards – often brought into national and regional food value chains as a result of potential export opportunities– can benefit local markets as well by improving the safety and quality of food though, in practice, these new standards set by export markets do not always benefit local consumers (Piñeiro and Díaz Ríos, 2007). Moreover, research has shown that there can be negative effects on local small and medium producers who cannot conform to new regulatory standards.

More sustainable strategies include avoidance of direct involvement of the public sector in agro-industries as well as efforts to address problems of inequitable growth, gender bias against women, detrimental environmental impacts, high rates of waste and inefficiency, and the cross-cutting problem of perverse incentives. In Egypt for example, this is being pursued through the UNIDO-supported efforts of Inclusive and Sustainable Industrial Development in the agro-industry sector with progress reported (UNIDO, 2014). In addition to sustainability, policies to be promoted for food security and nutrition in the Arab countries are directed towards improving compliance and certification (quality and safety of the products), reduction of waste, promotion and enforcement of contract farming, innovation and technology development (FAO & UNIDO, 2012).

F. Local markets

There is a global, almost theoretical, debate on whether governments should promote small- or large-scale agriculture production for more effective and efficient global food security. Development policies overwhelmingly call for relying on small-scale agriculture operations and finding ways to link them to national and possibly international food value chains (Rota and Sperandini, 2010). However, as discussed above, processing and other steps in the food value chain often tend to expand due to rational reasons of economies of scale, efficiency gains and other profit-maximization reasons.

This raises two key policy issues: First, to be consistent with the focus on small-scale agriculture, and knowing that the informal, local sector is quite important in many of the Arab non-oil producing countries – estimated to employ 67 percent of the overall labor force in a typical country of the region – should governments do more to encourage formalization of businesses catering to local markets[2] (Angel-Urdinola and Tanabe, 2012 and UN ESCWA, 2013a). Second, what accompanying measures should be taken to ensure that these businesses increase their effectiveness in being part of the overall strategy for food security? Both market-friendly measures would need the light touch of policies to ensure that generally neglected areas of development (small-scale, generally rural focus of development) are given prominence while also insuring that other types of government support do not inhibit local markets.

Local markets face a variety of challenges to improving efficiency and integrating into value chains. For example, they typically suffer from low levels of food safety, poor quality seeds and unsustainable or inefficient use of resources and geographic remoteness (Arias et al, 2013). Incentives for improving the value chain at the local level are important, but should be done ideally in areas where there is a comparative advantage. For example, Maertens et al. (2011) show that a greater integration of local markets into value chains operating at regional or global levels does not necessarily have positive impacts on smallholders' livelihoods or well-being – as large agribusinesses could depress prices by acting in a monopolistic manner – while at the same time, smallholder could benefit through contract-farming, better access to inputs, lower production and marketing risks, higher productivity and ultimately higher income.

Depending on the chain, local markets exposed to global value chains can suffer for a variety of reasons. First, raising production and processing standards can diminish the export opportunities of locally produced products. Second, some have expressed concern that consolidation and foreign direct investment in the agricultural and food sectors could result in unequal bargaining power within supply chains, in which poor farmers have the most to lose (Maertens et al, 2011).

G. Food retail

Concerning the various links in the food value chain, information about end consumers sometimes gets overlooked and their needs are little known. In fact, as consumers do not add or create value, they are distinctive actors within the supply chain even though by expressing their preferences they become arbiters in the functioning of the chain. As noted by Hawkes and Ruel (2011: 15) it should therefore not be surprising that value-chain approaches involving consumers generally classify them simply as end markets but nothing else.

A value chain could be used to help increase or to create demand, as well as to tailor products to fit the preferences of different consumer groups. Here, value chain participants would benefit from better knowledge on the factors influencing demand (e.g., nutritional and health concerns or purchasing power), as it would enable them to design more responsive value chains that could better respond to consumer needs and thus to create or increase demand (Hawkes & Ruel, 2011).

In theory, agricultural value chains could help address inadequacies in the access to food by allowing the participation of at-risk groups through income generation activities and improving the accessibility of these groups to more affordable food. Evidence from agricultural development programs suggests that actions in this area can lead to improved food security status at local levels (Hawkes & Ruel, 2011)[3]. Producing for household consumption and local retail markets remains important in many places while prevailing agricultural policies favor more market-oriented farmers (Hawkes & Ruel, 2011).

Nutrition is an important element of the consumer's link to the food value chain. According to their review of the literature, Gomez and Rickets (2013) found that it is difficult to make generalizations regarding the influence of value chains on nutrition, using their typology of four different value chain types (traditional, modern and two hybrid types). They found that in some cases, more modern chains would promote over-nutrition, while simultaneously reducing micronutrient deficiencies among some segments of a country's population. On the other hand, traditional food value chains seem to be important in the provision of micronutrient-rich food for low income groups, but the "lack of post-harvest and distribution infrastructure may limit the ability of traditional food value chains to assist in micronutrient deficiency reduction year round, and may result in higher intermediation costs that offset the cost advantages in retailing" (Gomez & Ricketts, 2013).

On the basis of limited knowledge, further work needs to be done on the links between value chain development and nutrition (Hawkes & Ruel, 2011). It seems that different types of food value chains, according to some of the analysis that has been done, could have different impacts on different population groups, producing variations even within subsets of population groups (e.g., intensive processed or packaged food distribution through traditional retailing might contribute to over-consumption in urban areas but prevent under-consumption in rural areas) (Gomez & Ricketts, 2013.) Further, nutrition effects might occur as the indirect result of the development of certain types of value chains. For example, the integration of smallholder farmers and traders into modern, supermarket-style retailing chains could benefit certain households through elevating incomes and/or generating non-farm, rural employment opportunities (Gomez & Ricketts, 2013).

H. Risks and mitigation policies

Reducing the risks faced by poor households is essential to improving their food security. Poor households, which are often vulnerable to shocks, tend to be more risk-adverse in their allocation of assets if they are vulnerable to shocks. Given this vulnerability and the exposure of the rural poor to negative effects of natural (e.g., weather events) and man-made events (e.g., conflict) in the region, the development of local markets – specifically targeting the improved livelihoods and well-being of the rural poor and marginalized groups – could help to increase food security in the region (Losacco & Khouri, 2012).

This is possible through a wide range of actions, including microfinance and credit; the creation of non-farm job opportunities for young people; sustainable land and water management and strategies for reducing the negative impacts of climate change. In rural communities where smallholder farming is widespread, vulnerability to shocks could mean farmers forego profitable activities that might entail elements of risk (e.g., the production of higher-value crops). Insurance markets could provide many valuable services to the agricultural sector across the region by promoting increased investment through enhanced predictability. Indeed, insurance schemes are potentially effective substitutes for the input subsidy programs that have been – or are in the process of being – phased out by many governments in the region (UN-ESCWA, 2010).

A similar challenge is the lack of well-developed credit markets for agriculture. The availability of domestic credit available in the private sector is an important indicator for agricultural productivity. For example, the availability of domestic credit correlates strongly and positively with cereal yield and the use of fertilizers (UN ESCWA, 2010).

Small- and medium-size farmers in the region lack the needed assets to use as collateral for the purchase and finance of inputs, machines and other tools that would enable them to develop their farms and bring products to market In addition, the agricultural sector continues to be a high-risk area of the economy, given the variability and unpredictability of natural weather events; volatilities in yields and prices; competition from foreign growers; overproduction of certain crops due to lack of coordination; and low levels of agricultural research and development (UN ESCWA, 2010).

Market penetration of formal microfinance lenders in the Arab region remains low. For example, according to an analysis of the Sudan Microfinance Development Facility Business Plan, in Southern Sudan the penetration is around 8 percent of the total demand and only 1 percent of the potential market (UN-ESCWA, 2010). Farmers can still be seen as high-risk clients. Further, rural areas are sparsely populated, meaning clients are widely dispersed and therefore, more expensive for microfinance lenders to reach.

In recent years, new financial instruments (e.g., forward contracts, futures, options and swaps) are being used to create virtual stockpiles, which can ensure a certain price for cereals without the costs associated with physical stockpiles. These methods avoid the high cost of storage and maintenance of physical stockpiles of perishable materials. One potential tool for stabilizing a country's production capacity which was suggested in a recent UN ESCWA publication (2010) is the establishment of an ad hoc regional guarantee fund. The guarantee scheme brings together different actors to receive the maximum benefit, including governments, investors and lenders. There are some precedents for such schemes in the region, including the guarantee facility provided by the Islamic Development Bank and the Arab Investment and Export Credit Guarantee Corporation (Dhaman).

I. Governance

The governance of food security has been described as the "formal and informal rules and processes through which interests are articulated, and decisions relevant to food security in a country are made, implemented and enforced on behalf of members of a society" (FAO, 2011). Promoting good governance for food systems in order to improve food security is no easy task given the increasingly complex array of global developments and trends which have an impact on the local level – natural disasters and climate change, protracted conflicts and crises, resource scarcity, international trade and financial flows, among others. Unlike in the case of water, the food security governance framework has typically ranged from the global to the local levels, involving global supply and demand, international trade, food safety rules and food aid (Lele et al, 2012).

CONFLICT, REFUGEES AND FOOD INSECURITY IN THE ARAB REGION

Vito Intini

Conflict has a direct and indirect effect on food security, undermining it through various channels. Its direct effects are numerous – the destruction of infrastructure and machinery; death of livestock; razing of farm land,; and blocked access to markets for producers, distributors, and consumers. Indirectly, conflict discourages productive investment in agriculture, thereby reducing the availability of food. It strips government of tax revenues that prevent the establishment of social safety nets which promote food security. The political and economic ramification of conflict beyond its geographic borders is an important indirect effect as well, which is manifested in refugee migration and the deterioration of regional investment climates.

Food insecurity is both a source and a result of conflict. Various drivers of conflict have been identified by researchers, including poverty (Miguel, Satyanath, and Sergenti, 2004; Blattman and Miguel, 2010); underemployment of youth (De Soysa et al. 1999; Collier and Hoeffler, 2004; Taeb, 2004); inequalities in income, access to land and natural resources (Auvinen and Nafziger, 1999; Stewart, 2000; Macours, 2011); population pressures (Ostby et al., 2011), geographic characteristics , the presence of natural resources (Dube and Vargas 2013; Maystadt et al,. 2013), and poor governance (Collier and Hoeffler, 2004; Fearon, 2010). Weak governance systems, in particular, imply that there are few mechanisms through which conflicts can be preempted and managed and there are higher costs associated to collective actions, which in turn, results inhigher risks of violent outcomes.

More recently, food insecurity has been identified as a source of conflict, especially in the presence of certain concurrent economic and social features such as stunted economic development; high horizontal (among groups) inequality; and the presence of a "youth" bulge (Brinkman and Hendrix,2011; Pinstrup-Andersen and Shimokawa, 2008). In particular, increases in food prices have been found to strongly exacerbate the risk of political unrest and conflicts (Arezki and Brückner, 2011; Bellemare, 2011). For example, food riots often occurred as a response to higher food prices in Egypt during the 1970s and in Jordan and Morocco during the 1980s and 1990s (McDermott, 1992; Walton and Seddon, 1994; Adoni and Jillian, 1996). More recently, the 2007–2008 global food crisisreportedly sparked rioting in 48countries. Shortly before the Arab uprisings, Bahrain, Yemen, Jordan, Egypt, and Morocco saw demonstrationsover food in 2008 (The Economist, 2012). Food insecurity might have played a role at the onset of the Darfur crisis.

In practice, however, food insecurity, particularly in the Arab region, acts as a "threat multiplier" by adding pressure to populations already suffering from underdevelopment, marginalization, repression or a history of conflicts. Consequently, while food insecurity has historically not been the central source of conflicts in the region, providing greater food security – as a part of effective poverty reduction programs - could well be a source of conflict mitigation.

In recent years, six Arab countries and territories have faced episodes of armed conflict and political violence that have directly affected food security: Iraq, Lebanon, Palestine, the Sudan, Syria, and Yemen. The situation has proven to be particularly severe at various points in Palestine, the Sudan and Yemen, where food insecurity is at times systemic. As the result of the ongoing conflict, Syria is steadily shifting from acute to systemic food insecurity. Iraq has experiencedsevere problems at various points that presently have been deteriorating further. Lebanon is now confronting an unprecedented humanitarian disaster originating from the Syrian crisis. Other countries in the region such as Jordan are now experiencing increased exposure to food insecurity as a result of the Syrian crisis.

The relationship between conflict, food insecurity and poverty is very strong across the region. In Yemen, Sudan, and Syria farming represents the main livelihood of the majority of rural populations. In Yemen, inflation as measured by CPI rose by 22.7 percent - heavily driven by rising food prices- in 2011 at a time of particularly high political instability compared to 10.5 percent in 2010. An even more extreme pattern became evident with the Syrian crisis in 2012, at 32 percent, and arguably in 2013. Such rises in food prices were exacerbated by transportation and distribution disruptions due to security concerns and decaying physical infrastructures. In Sudan, the 2014 first quarter prices of sorghum and millet increased by over 100 percent from the baseline of the last 5-year average due to significant supply side issues as well as depreciation of the Sudanese pound as well as the recent lift of fuel subsidies.Indeed, in Sudan, almost 30 percent of total food costs were estimated to be spent on checkpoints and in transportation costs. Small traders

are affected disproportionally. Millet and sorghum prices in Darfur are reportedly among the highest in the whole country. Food prices in Iraq are set to rise dramatically due to the severe security deterioration in 2014. Also in some of the countries affected by the Arab uprisings, inflation has picked up as it is the case in Egypt where year on year inflation was above 18 percent in December 2013.

As a result, food insecurity levels in Yemen reached 45 percent of the population in 2011 from 32 percent in 2009, and in 2013 hovered around 42 percent in addition to 47 percent of malnourished under-5 children. In Sudan, the levels of food insecurity are even worse than Yemen and have been deteriorating in the recent past. In addition, preliminary evidence of poverty levels in many countries affected by the uprisings point to a deteriorating trend as evidenced by a WFP report on Egypt according to which 25.2 percent of the population was under the poverty line in 2011 compared to 21.6 percent in 2009.

Internally displaced persons (IDPs) and refugees often face the most extreme food insecurity, as is demonstrated by examples from Palestine, Sudan, and Syria. In some cases, governments and/or insurgents have hindered the deployment of humanitarian operations in conflict zones thereby worsening the situation for local civilian populations and hence increasing the number of IDPs and refugees. According to 2014 UNHCR data, the region is the source and host of over half of the world's officially registered refugees - 8.8 million out of a total of 16.7 million - and about 40 percent of the world IDPs – about 9.7 million out of around 23.9 million worldwide. Almost half of the refugees are children. To date, the Syrian crisis alone has created over 3 million refugees and displaced around 6.5 million people. In just a matter of weeks in June 2014, the Iraqi crisis displaced more than one million people. The outlook for 2014 suggests a further increase of refugees and IDPs in the region. With around 22 percent of the population officially registered at UNHCR as refugees, Lebanon has the highest ratio in the world. If one includes non-registered refugees, mainly Palestinian refugees, in the calculation, the ratio easily exceeds one-fourth of the population. With around 8.7 percent, Jordan is ranked second worldwide based on UNHCR data, not counting the Palestinian refugees that are permanently residing in the country[1].

Humanitarian assistance has increasingly moved towards building resilience in conflict-affected areas. For instance, WFP has introduced vouchers while expanding market-based assistance in Darfur and among the Syrian refugees in Jordan (here through the recent introduction of e-vouchers). This is particularly important given that food aid represents the bulk of total aid received in many humanitarian emergencies in the region, such as Sudan.

In many of these settings, one common pattern seems to be an erosion of governance, at least as it is perceived by the general population. For instance, in Yemen, confidence in most state institutions is below 40 per cent according to a 2011 Gallup survey. The military and religious organizations enjoy higher levels of trust. Weak governance systems may allow communal conflicts to escalate to civil conflicts, as in the case of Darfur and Iraq, particularly when governments are seen to take the side of a specific communal group.

Food security programs need to aim at strengthening resilience of local communities and national institutions. This can be achieved through the following principles for policy and program intervention:

i) Start with a fair, candid assessment of thepolitical economy
ii) Design simple programs with clear and measurable results
iii) Focus on building the capacity of national institutions (including local communities and civil society organizations)
iv) Monitor and analyze direct and indirect impacts of policy and program interventions
v) Focus on programs that have strong inter-sectoral linkages.

In conclusion, the region shares many common threats and future challenges, including climate change, spillovers from conflict, depletion of natural resources, migration, desertification and economic modernization. Hence, the generation of new economic opportunities and of food security must come from within the region. However, the Arab region has one of the lowest levels of regional integration in the world. In addition to conflict, this can be attributed to the absence of investment into regional market development. Physically, it lacks logistic infrastructure in order to connect markets. Institutionally, it lacks the common

policy framework that would reduce transaction costs. Areas for such investments exist in regionally funded supranational development programs that finance agricultural modernization projects, trade integration and new financial instruments. First, regional solutions to regional problems will guarantee that the region has the ownership over the solution. Secondly, the region's voices, concerns and problem-solving ideas are more clearly heard in the development of the solutions. Thirdly, institutional capacity is built in the region. But in order to move on closer regional coordination, key governance reforms based on participation, accountability, transparency, and rule of law will be crucial.

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Fostering export-led growth and targeting transfers to farmers will require substantial improvements in prevailing institutions and legal frameworks. The "governance gap" that exists throughout the region has to be closed by enhancing public administration and accountability. Building on macro-level transformations in state-society relations triggered by recent mobilizations and liberalization initiatives, innovative local level institutional reforms can raise citizen engagement and improve the transparency of public agencies. It is crucial to build efficient institutions in the region that are able to provide, make available, and improve opportunities for Arab entrepreneurs (Breisinger et al, 2012).

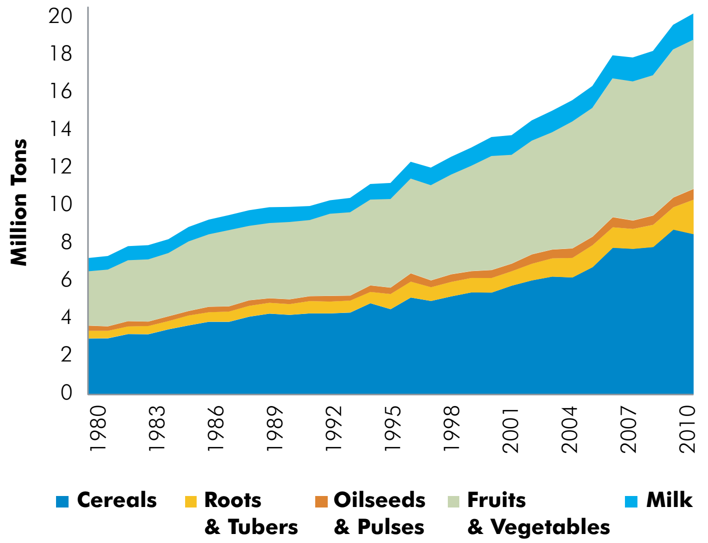
There is a wealth of scholarship on the vital role of institutions on mitigating the occurrence of food storage and famine. As argued by Homer-Dixon (1999), institutional factors ultimately determine the degree to which countries respond effectively to rising scarcities, while diverting social crises and a descent into violence. For example, if the state cannot or will not provide certain minimum thresholds of security for its citizens, investments in infrastructure and public services will have limited impacts (Birner, 2009). In addition, policy instruments and government regulations that foster economic growth must be inclusive, taking into consideration their impacts on the poorest and most disadvantaged groups in society. Participatory mechanisms could be useful for ensuring that the concerns of smallholder farmers and other small-scale actors and firms in the food value chain are taken into consideration.

Governance-related issues are often at the root of unequal access to natural resources, such as land, and basic services, which can in turn trigger instability or conflict, with negative impacts on food security (UN-ESCWA, 2010). As many stakeholders of the food value chain are involved in agriculture production, the governance of natural resources (water, soil, forests) will be necessary in order to ensure the sustainability of strategies for value chain development (Birner, 2009).

III. CONCLUSION AND RECOMMENDATIONS

Improving the performance of agricultural value chains and enhancing their participation in local, regional and global markets has positive social, economic and environmental impacts. They can help to generate employment, raise income, reduce poverty and contribute to slowing unsustainable patterns of production and consumption. Other specialized studies have suggested detailed operational and policy recommendations to improve specific links in the food value chain. While recommendations have been forthcoming, progress on their implementation continues to be limited, and according to a number of criteria, the overall food security in the Arab region has even deteriorated (Breisinger et al., 2012). In the following section, we will highlight selected policy interventions that build on the above discussion and should be pursued immediately.

FIGURE 5 **FOOD LOSS, 1980-2010 (MILLION TONS)**



Source: Computed from FAOSTAT (2014).

Recommendation 1: Make ending severe malnutrition in the region a priority.

- Although outright hunger is believed to be limited to areas of conflict in the region, it is recommended to establish a regionally based "Zero-Hunger" Program (ZHP) in line with the FAO and UN Secretary-General's ZHP launched in 2012 at the UN Conference on Sustainable Development, or Rio+20. The ZHP challenge includes five objectives: (i) 100 percent access to adequate food by all, year-round; (ii) zero stunted children less

than two years old; (iii) sustainable food systems; (iv) two-fold increase in smallholder productivity and income; and (v) no loss or waste of food (UN, n.d.). Specific programs, developed in partnership with the private sector, can ensure that the value chain in food systems contributes to ZHP.

- Building on early lessons learned from the application of ZHP at national and local levels, the first step could be a review and update of the League of Arab States' (LAS) "Emergency Program for Food Security" adopted at the first Social and Economic Summit in Kuwait in 2009. Although the program is ambitious and secured commitments of US$ 15 billion from both private and public sources, progress on actual implementation has been slow. Some possible elements of ZHP, such as direct cash transfers to the poorest and equitable integration of small farmers into regional and global value chains, would need to be further highlighted in a revised Emergency Program, which would lead to further strengthening of local food value chains.

- The upcoming LAS Socio-Economic Summit (planned for January 2015 in Tunis) would be a good opportunity to renew the regional mobilization against hunger. The adoption of a regional ZHP would re-invigorate the practical implementation of programs for the eradication of hunger in the Arab region.

Recommendation 2: Liberalize regional trade

- There is wide agreement that, as a result of increasing world prices, improving food security requires appropriate actions to reduce food price pressures. To some degree, this can be achieved by tackling domestic issues through specific policies aimed at improving procurement, logistics, stockpiling, and planning practices and strategic investments in domestic market infrastructure. In order to support the development of regionally integrated agricultural value chains, the region could build on already existing regional frameworks that call for enhanced and integrated markets at the national, sub regional or regional levels.

- Finally, to enhance Arab food supply chains, it is important to enhance the economic impact of the Pan-Arab Free Trade Area through trade facilitation, which includes measures to reduce the transaction costs, including excessive documentation requirements, authorizations from multiple agencies, unclear or subjective criteria for the application of duties and delays and uncertainties related to customs clearance.

- The "Arab Agricultural Sustainable Development Strategy for the Decades 2005-2025", which stresses the need for a better balance between production and marketing, as well as increasing the effectiveness of institutions and farmers – especially small-scale farmers – could provide a good basis for merging the benefits from trade and sectoral integration. To do this, the region must increase the competitiveness of its agricultural products in the international market and revitalize agricultural trade as an engine for development (UN ESCWA, 2013a).

Recommendation 3: Adopt voluntary guidelines for large-scale foreign investments in land.

- Without proper management, these investments could pose risks as the result of perceived or real inequalities in bargaining power between investing state or non-state actors and local populations – comprised mainly of smallholders – whose land might be part of the transaction. To ensure a sustainable and ethical approach to large-scale foreign investments such as these, agreements should be based on:

a. Transparency and participation in negotiations;

b. Close vertical and horizontal coordination of all national ministries and institutions involved;

c. Assurance of proper due diligence before any deal clarifying land rights, compensation costs and infrastructure requirements;

d. Respect for existing customary rights to land and natural resources;

e. Consideration of distributional issues at the beginning of the process, with clearly measurable benefits for local communities deriving from the investment;

f. Environmental sustainability; and

g. Prioritization of local and national food security vis-à-vis demands from foreign investors, especially in times of acute food crises (FAO et al, 2010 and UN ESCWA, 2010).

Recommendation 4: Integrate value chains into national and local food security plans.

- Plans should ensure that the policy signals and impacts are effective and lead to equity, development and the sustainable use of natural resources. Except for some notable examples (Yemen, Saudi Arabia, Egypt, Qatar) Arab countries do not generally have explicit and politically-supported food security plans. As these plans necessitate policy harmonization across various sectors and ministries, as well as coordination among government tiers, cross-cutting strategies that coherently accommodate the vital priorities of all stakeholders are needed. In particular, inclusive initiatives are needed which embrace the private sector (focusing especially on small-scale producers), as well as civil society groups engaged in advocacy and service provision at the local level. In particular, one key element of value chain development can be identified as a priority in Arab countries: the development of output markets—both local and external (Ministry of Foreign Affairs of the Netherlands, 2011; World Bank, 2011a).

- On subsidies, policy debates tend to result in polarization while it has been shown food and fuel subsidies tend to be costly due to leakage as well as errors of inclusion. Better targeted social protection measures could be more effective and efficient in reducing poverty, although they require capacity-building to dynamically identify eligible groups and appropriate benefits (Breisinger et al., 2012).

- Prioritize and protect local markets, formal or informal and supply assistance to improve production and add value to the products. Informal markets play an important role in food security—especially for the rural poor. Except for issues related to human rights protection, hygiene and health that have clear negative externalities, the role of public authorities should be one of nurturing these informal arrangements, wherever possible. Bridging formal and informal markets can be tackled through improving the prevailing institutional environment and governance structures.

- Provide incentives for private sector involvement through implementation of local development initiatives aimed at promoting a specific value chain activity. The adoption of a cluster approach for a focused food value chain can greatly enhance the competiveness of the entire value chain and that of the individual actors involved. Clustering could happen organically – such as in the Fayoum Oasis in Egypt, where craft-based projects and potteries have developed – or could be induced through appropriate planning and support – such as in many countries of South East Asia or the Silicon Valley in the United States (computers, electronics, software). The food value chains to be targeted are those that could offer the most local development potential due, for example, to the possibility of employment generation, production efficiency, demand conditions, resource endowment or the cost of doing business, to name a few (UN ESCWA, 2011).

- Improve infrastructure for storage and transport. The quality of infrastructure determines the performance of the food value chain including waste reduction and enhancing food security. Large scale infrastructure, such as for transport and storage, water or energy, are the responsibility of governments as they are public goods. However, the private sector should be co-opted in order to reduce more drastically the prevailing infrastructural gaps through the adoption of appropriate technologies, making available investments and seeking partnerships.

Recommendation 5: Diversify financing and insurance opportunities.

- For food value chains to provide the goods and services expected, all actors need to have access to appropriate financial and risk management mechanisms. Most chain actors need adequate working and investment capital. However, while large and more structured operators, including input suppliers, processors, wholesalers and exporters and big retailers, have access to mainstream financial services (e.g., commercial credits and loans), this is not the case for small-scale operators especially farmers and traders and as such innovative ways to provide needed financial services are needed, which could be accomplished by strengthening already existing formal and informal programs.

Recommendation 6: Achieve a 50% reduction in food waste and loss within the region by 2024, in line with the FAO (2014) Regional Conference for the Near East.

- Greater awareness and risk management at all levels of the food supply chain is needed, especially in regard to practices and technologies for preserving food quality and safety. Awareness campaigns could be conducted and disseminated through direct contact with farmers, agro-industry and consumers, with special attention paid to how local producers in food value chains can implement new standards set by export markets and how local consumers can benefit from these.

- Both public and private sector investment is required to reduce food loss and waste. The public sector should focus investment in public goods such as strengthening infrastructure and logistics. The private sector could focus on tangible investment opportunities at different stages of the supply chain which could yield sufficient returns. Focus could be put on exporting, importing, as well as local food supply chains, considering that the Arab region is import-intensive.

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NOTES

1. With thanks for contributions and comments from Gregory Barrett, Mohamed Chemingui, Philippe Chite, Asya El-Meehy and Vito Intini; research assistance was provided by Mounir AbouFadel and Samar Yaafar Jaafar- all from ESCWA.

2. While there is no precise definition of what constitutes a local market, in general it can refer to agricultural production and marketing that occurs within a certain geographic proximity (between farmer and consumer) or that involves certain social or supply chain characteristics in producing food (such as small family farms, urban gardens, or farms using sustainable agriculture practices) (see Johnson et al, 2013).

3. Citing World Bank (2007) and Leroy et al, (2008).

Impact of Climate Change on Food Security[1]

Ayman F. Abou-Hadid

Recent studies, model projections and observations have indicated that climate change will be one of the main drivers for reducing food security levels in the Arab world in the next few decades. The main impacts on food security will result from an expected lower agricultural productivity, increased temperatures, reduced precipitation, increased risk of extreme weather events and heat waves.

IPCC's Fifth Assessment Report (2014) concluded that arid and semi-arid regions are highly vulnerable to climate change. By the end of the twenty-first century, the Arab region will face an increase of 0.9 to 4.1°C in surface temperature. This increase will be coupled with sharp decreases in precipitation and increases in evaporation, which are likely to reduce available water by half by 2100. These projected changes will lead to shorter winters and drier, hotter summers, more frequent heat wave occurrences, and more variability and extreme weather events occurrences.

The majority of Global Circulation Models (GCMs) project a grim outlook for the Arab region in terms of major reduction in precipitation, increase in evaporation, and subsequent reduction in both runoff and soil moisture. Precipitation is projected to decrease by up to 25 percent, which in combination with a 25 percent projected increase in evaporation would translate to a drastic 50 percent drop in runoff by the end of the century. The net effect will be a major reduction in available water resources, exacerbating current water scarcity conditions.

The dominant agricultural system in Arab countries is rainfed agriculture, with the total irrigated area in the Arab world being less than 28 percent (FAO, 2008b). Therefore, annual agricultural productivity and food security are highly correlated to the annual variability of precipitation, which has exhibited major changes in recent decades.

Average surface temperatures in North Africa have increased 1-2°C between 1970 and 2004 (IPCC, 2007). The region is particularly exposed to water shortages. In North Africa, with a 3°C rise in temperature, an additional 155 to 600 million people may suffer increased water stress, while maize yields could fall by between 15 and 25 percent.

Projections also suggest that climate change will cause world food prices to rise, with negative effects on food security. Egypt expects to lose 15 percent of its wheat crops if temperatures rise by 2°C, and 36 percent if the increase is 4°C. Morocco expects crops to remain stable until about 2030, but then to drop quickly afterwards. Most North African countries traditionally import wheat and are therefore highly vulnerable to price shocks and droughts elsewhere. The crop modeling results indicate that climate change will have a negative effect on crop yields in the Middle East and North Africa in 2050. The region will face yield declines of up to 30 percent for rice, about 47 percent for maize and 20 percent for wheat (IFPRI, 2009).

The Arab World can develop a variety of responses to the threat of climate change on food security in the region. Some of these measures are:

- Enhancing knowledge of climate change exposure, sensitivity and vulnerability on food security
- Enhancing knowledge on main climate change determinants on food security
- Mainstreaming climate change vulnerability and adaptation in agricultural sectoral strategies
- Integrating adaptation measures in agriculture/food security with adaptation measures in the water sector, with both linked to energy mitigation options through a comprehensive water-energy-food nexus
- Providing incentives and proper management tools to shift from high water consuming crops to those with a low water footprint.

I. INTRODUCTION

Climate change is reducing water availability and therefore increasing the demand for water needed for irrigation, which will significantly limit crop productivity in affected areas. The FAO predicted that as a result of global warming, the hydrological cycle will accelerate as rising temperatures increase the rate of evaporation from land and sea. Rainfall is thus predicted to rise in the tropics and higher latitudes, but to decrease in the already dry semi-arid to arid mid-latitudes and in the interior of large continents. Water-scarce areas of the world will generally become drier and hotter. Relatively small reductions in rainfall will translate into much larger reductions in runoff – for example, a 5 percent fall precipitation in Morocco is predicted to result in a 25 percent reduction in runoff (FAO, 2011).

Food security in the Arab world has experienced a long history of environmental and socio-economic pressures. The dominant arid conditions, limited water resources, erratic cropping patterns, low knowledge and technology levels, and reliance on imported food commodities are the main factors affecting food production and distribution systems in the Arab region.

Most recent assessments have concluded that arid and semi-arid regions are highly vulnerable to climate change (IPCC, 2014). On the other hand, at a high level conference of the Food and Agriculture Organization (FAO) held in Rome in

June 2008, the delegates asserted that agriculture is not only a fundamental human activity at risk due to climate change, it is also a major driver of environmental and climate change itself. The projected climatic changes will be among the most important challenges for agriculture in the twenty-first century, especially for developing countries and arid regions (IPCC, 2014).

By the end of the twenty-first century, the Arab region will face an increase of 0.9 to 4.1°C in the surface temperature. This increase will be coupled with sharp decreases in precipitation and increases in evaporation, which are likely to reduce water available by half by 2100. These projected changes will lead to shorter winters and drier, hotter summers, more frequent heat wave occurrence, and more variability and extreme weather events occurrence (IPCC, 2013).

II. KEY IMPACTS AND VULNERABILITIES OF THE AGRICULTURE SECTOR IN THE ARAB WORLD

The risks associated with agriculture and climate change arise out of strong and complicated relationships between agriculture and the climate system, in addition to the high reliance of agriculture on finite natural resources (Abou-Hadid, 2009). The inter-annual, monthly, and daily distribution of climate variables (e.g., temperature, radiation, precipitation, water vapour pressure in the air, and wind speed) affects a number of physical, chemical, and biological processes that drive the productivity of agricultural, forestry, and fisheries systems (IPCC, 2014). In the cases of forestry and fisheries systems, vulnerability depends on exposure and sensitivity to climate conditions, and on the capacity to cope with changing conditions.

In the same vein, Marcus Marktanner et al. (2011) indicated that the nexus of climate change and food security is complex. A 2008 FAO report identifies more than 100 links between climate change and food insecurity. Specifically, the FAO examines the climate change impacts of CO_2 fertilization, increase in global mean temperature, precipitation changes, and more extreme weather events on food system assets, food system activities, food security outcomes, and well-being (FAO 2008, p. 14-19). The following is a selection of links between climate change and food security:

SUMMARY OF EXPECTED IMPACTS OF CLIMATE CHANGE ON GLOBAL FOOD SECURITY AS IDENTIFIED IN IPCC 5TH ASSESSMENT REPORT IN 2014

1. Based on many studies covering a wide range of regions and crops, negative impacts of climate change on crop yields have been more common than positive impacts.

2. Climate change has negatively affected wheat and maize yields both regionally and globally.

3. Since the IPCC Fourth Assessment Report, several periods of rapid food and cereal price increases following climate extremes in key producing regions indicate a sensitivity of current markets to climate extremes, among other factors.

4. Risk of food insecurity and the breakdown of food systems linked to warming, drought, flooding, and precipitation variability and extremes, particularly for poorer populations in urban and rural settings. Risk of loss of rural livelihoods and income due to insufficient access to drinking and irrigation water and reduced agricultural productivity, particularly for farmers and pastoralists with minimal capital in semi-arid regions.

5. Projected impacts vary across crops and regions and adaptation scenarios, with about 10 percent of projections for the period 2030-2049 showing yield gains of more than 10 percent, and about 10 percent of projections showing yield losses of more than 25 percent, compared to the late twentieth century. After 2050 the risk of more severe yield impacts increases and depends on the level of warming.

6. All aspects of food security are potentially affected by climate change, including food access, utilization, and price stability.

7. In Africa reduced crop productivity associated with heat and drought stress is expected with strong adverse effects on regional, national and household livelihoods and food security. Another expected impact is increased damage from pests and diseases, and flood impacts on food system infrastructure.

8. Without adaptation, any local temperature increase in excess of about 1°C above pre-industrial is projected to have negative effects on yields for the major crops (wheat, rice, and maize) in both tropical and temperate regions.

9. These impacts will occur in the context of rising crop demand, which is projected to increase by about 14 percent per decade until 2050. Crop production to be consistently and negatively affected by climate change in the future in low latitude countries, while climate change may have positive or negative effects in northern latitudes.

10. Changes in temperature and precipitation, without considering effects of CO_2 will contribute to increased global food prices by 2050, with estimated increases ranging from 3-84 percent.

11. Under scenarios of high levels of warming, leading to local mean temperature increases of 3-4°C or higher, models based on current agricultural systems suggest large negative impacts on agricultural productivity and substantial risks to global food production and security.

12. Projected benefits of adaptation are greater for crops in temperate, rather than tropical or arid regions. Wheat-based systems are more adaptable than other crops.

13. Fluctuations and trends in food production are also widely believed to have played a role in recent price changes, with recent price spikes often following climate extremes in major producers. Moreover, some of these extreme events have become more likely as a result of climate trends (IPCC, 2014).

WITH REGARD TO AVAILABILITY OF FOOD, CLIMATE CHANGE:

- Adversely affects rural livelihood bases through a decline in water availability, soil erosion, desertification and salination (particularly for coastal agricultural lands), droughts, floods, and wildfires.
- Increases pest and disease problems (locusts, yellow rust and the like).
- Likely reduces agricultural output.
- Likely exacerbates the existing inequalities between rich and marginalized populations.
- Affects livestock health and productivity.
- Negatively affects fish supply.
- Decreases drinking water availability and quality (especially in countries like Yemen, Jordan and Libya).

WITH REGARD TO ACCESS TO FOOD, CLIMATE CHANGE:

- Could reduce access to food of people whose livelihoods depend on agriculture, livestock, forestry, and fisheries (especially smallholder, subsistence, rain-fed farmers, and pastoralists).
- Could lead to livelihood losses in urban populations (extreme weather conditions, coastal erosion, and flooding) and, as a result, could reduce food access of vulnerable urban populations.
- Could reduce access to drinking water.
- Leads to an upward trend of food prices and increases their volatility.
- Creates poverty in rural communities.
- Could spur internal and external conflict that disrupts access to markets.

WITH REGARD TO UTILIZATION OF FOOD, CLIMATE CHANGE:

- Undermines the availability and efficient utilization of food through factors like heat stress, disease, malnutrition, and the deterioration of sanitary conditions.
- Increases competition for scarce public health services.
- Increases likelihood of diseases due to epidemics from food and waterborne diseases such as cholera, malaria, dysentery, etc.

WITH REGARD TO STABILITY/CONTINUITY OF FOOD SUPPLY, CLIMATE CHANGE:

- Disrupts continuous availability through trade restrictions in response to climate change-induced catastrophes.
- Leads to the collapse of social safety nets if the creation of fiscal space does not keep up with rising social assistance needs.

FAO (2011) indicated that climate change manifests itself in the Arab region through a) higher temperatures, b) lower precipitation, c) sea level rise, and d) increase in frequency and intensity of extreme weather events such as drought and floods. Average surface temperatures in North Africa have increased 1-2°C between 1970 and 2004 (IPCC, 2007). The region is particularly exposed to water shortages. In North Africa, with a 3°C rise in temperature, an additional 155 to 600 million people may suffer increasedwater stress, while maize yields could fall by between 15 and 25 percent (FAO, March 2008). Climate change impacts at two levels: (i)the emergencies created by increased events of drought and floods, and (ii)the slow but gradual onset of change in mean temperatures and precipitation resulting in lower annual yields which further stresses the already stretched coping mechanisms of subsistence farmers and pastoralists. In addition to encroachment onto fertile lands, rising sea levels will reduce agricultural productivity in delta areas due to increase in water salinity. The Nile delta, an area responsible for 60 percent of agricultural production in Egypt, is highly vulnerable to future sea level rise (IPCC, 2007). Further intensification and expansion efforts by Egypt will be challenged by other factors identified by FAO as limiting the prospects for increasing agricultural productivity (WFP, 2008). Data from the World Meteorological Organization indicate that 80 percent of disasters in the MENA are climate related (IASC, 2009).The change in average temperature and agricultural output in some Arab countries could be summarized in Table 1.

The current total cultivated area in the Arab region makes up about 5 percent of the total global cultivated area, and it represents about 5 percent of the total area of Arab world (FAO, 2008b). Most of the Arab region's lands are classified as hyper-arid, semi-arid, and arid land zones (WRI, 2002). The relationship between the cultivated area and the population is one of the major challenges facing food production in the region. The land share per capita is decreasing annually as a result of rapid population growth rates and urbanization (AOAD, 2008). By 2007, the average agricultural land share in the Arab region was about 0.23 ha per capita, which is slightly lower than the world average of 0.24 ha per capita.

The dominant agricultural system in Arab countries is rain-fed agriculture, with the total irrigated area in the Arab world being less than 28 percent (FAO, 2008b). Therefore, annual

TABLE 1 **CHANGE IN AVERAGE TEMPERATURE AND AGRICULTURAL OUTPUT**

	Change in Average Temperature (°C)			Change in Output 2080 (%)	
	Present	Future	Change		
Country	1961-90	2070-99		Without carbon fertilization	With carbon fertilization
Algeria	22.67	27.81	5.14	–36.0	–26.4
Iran	17.26	22.63	5.37	–28.9	–18.2
Iraq	20.86	26.16	5.30	–41.1	–32.2
Saudi Arabia	24.57	29.3	4.73	–21.9	–10.2
Syria	17.48	22.19	4.71	–27.0	–16.0
Yemen	23.77	27.72	3.95	–28.2	–17.0
Morocco	17.43	21.91	4.48	–39.0	–29.9

Source: Cline (2007).

FOOD SECURITY AND CLIMATE CHANGE: THE UAE EXPERIENCE

Thani Al Zeyoudi

The Arab world faces critical challenges in ensuring its food security. Our region is already the world's largest net importer of essentials such as cereals and sugar, low water supplies in the region mean that expanding agricultural production is difficult, and population growth means that more people must be fed each year. In many ways, the United Arab Emirates (UAE) presents an exemplary case of this challenge. The country has low potential for agricultural production, and can rely on rainfall for less than one percent of its water needs. That means that its food security depends on international markets. For the UAE, food security is fundamentally a foreign policy issue.

The UAE has placed a wide range of policies and measures in recent years to ensure stable, affordable, and long-term food supplies, ranging from increasing domestic agricultural production to acquisition of foreign agricultural land. At the same time, climate change is affecting global food production, and it is projected to worsen in the coming decades. The UAE therefore needs to address these challenges through a balanced, strategic approach and active participation in relevant international negotiations.

Limits of Domestic Production

Currently, the UAE imports around 90 percent of its food products. This is mainly due to the fact that the UAE is located in a highly arid environment that does not favor agricultural production. The lack of surface freshwater resources (the average annual rainfall is less than 100 millimeters), high temperatures in the summer months and the limited availability of land suitable for agriculture limits domestic agricultural production to less than 1 percent of its gross domestic product. Furthermore, ground water, which is the main source of water used for agriculture, is projected to be depleted in the mid-21st century with the current abstraction rate. Significantly increasing other sources of water in agriculture such as desalinated water is not an economically and environmentally viable option. The UAE has taken many important steps to improve domestic agricultural production through better crop selection (e.g., phasing out of water-intensive Rhodes grass for animal feed), increasing water efficiency (e.g., promoting drip irrigation) and introducing new technologies (e.g., introduction of hydroponics). Entities such as Masdar are exploring new options such as renewable energy for desalination to improve economic and environmental footprints associated with the desalination processes. While such efforts are helpful, domestic agricultural production cannot increase to the level of self-sufficiency. The UAE will continue to be heavily reliant on food imports in the foreseeable future, and it needs to take strategic measures to mitigate associated risks.

Global Food Supply and the Impacts of Climate Change

The UAE has a broad and fairly balanced supplier base across all geographic regions. The top five supplying countries account for approximately less than half of the total food import. India, for instance, is one of the major food suppliers for the UAE, and its share is roughly between 15 to 20 per cent of the total, varying from year to year. Land has been acquired or leased, including in countries such as Sudan, Morocco and Pakistan, to provide an assured supply to the UAE. Regardless of where food products are sourced, however, all of the regions will be affected by impacts of climate change, including decreased yields due to drought and flood increases as well as crop damage due to insect outbreaks. For example, a report of the Intergovernmental Panel on Climate Change projects that agricultural production in many of the African countries will be "severely compromised" and yields from rain-fed agriculture in some countries may be halved by 2020 (IPCC, 2007). Similarly, crop yields in Central and South Asia are projected to decrease by up to 30 percent by 2050 (IPCC, 2007). Some regions have already been affected, as seen by the repeated flooding in India and Pakistan in recent years. Some estimates indicate that climate change may account for as much as half of projected food price increases by 2050 for staples such as maize, rice and wheat (Nelson et al., 2010). Coupled with increasing food demand both domestically and internationally due to population growth, as well as increasing global demand for more resource-intensive food products (such as meat), the challenges of food security for the UAE will grow.

Key Factors for Addressing Food Security and Climate Change

There are a number of key factors in ensuring food security against challenges of climate change. First, all

countries must make efforts to limit greenhouse gas emissions and adapt to the impacts of climate change, especially in areas where agricultural production is projected to be affected. An international climate agreement, scheduled for negotiation by 2015 under the United Nations Framework Convention on Climate Change (UNFCCC), must be effective and ambitious. Second, the UAE must invest strategically to build diversified and resilient food supplies, taking into consideration potential impacts of climate change and other factors. Third, the UAE will continue supporting an open, rules-based multilateral trading system, and support agricultural exporting developing countries in having equal access to markets and obtaining necessary technical assistance. Fourth, global goal setting is important in creating a common ground.

Once agreed, the set of universal "Sustainable Development Goals" being developed by the United Nations should help countries to collectively address important issues such as food security and climate change in the coming decades.

Recommendations

The UAE has already done a lot in relation to the above mentioned points. The UAE is active in promoting a climate agreement and sustainable development goals under the United Nations. It plays a major role in clean technology development and deployment through leading actors such as MASDAR. It has taken a wide range of approaches on foreign agricultural investments and supported bilateral and multilateral trade discussions. However, more needs to be done in order for the UAE to safeguard its food security. A strategic national food security policy based on international agreements and investments is essential. The Ministry of Foreign Affairs, in close cooperation with both domestic and international partners, is ready to play a growing role in enhancing the country's food security in the years ahead.

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agricultural productivity and food security are highly correlated to the annual variability of precipitation, which has exhibited major changes in recent decades (Abou-Hadid, 2006). Irrigated agriculture is widely represented in the Arabian Peninsula countries and Egypt, where fully irrigated agriculture makes up 100 percent and 95 percent of the total cultivated area, respectively.

The agricultural productivity of most crops exhibited noticeable increases during recent years. The per capita food production index (PCFPI) shows the food output, excluding animal feed, of a country's agriculture sector relative to the base period 1999-2001 (FAO, 2008b). The PCFPI value of the Arab region increased from 99.8 in 2003 to 112.3 by 2005, an increase of 13 percent, whereas the world values of the PCFPI increased during the same years by 20 percent (AOAD, 2008). The productivities of crops under irrigated agriculture in the Arab region improved due to switching to new cultivars, applying modern technologies, and improving management programs. Some Arab countries such as Egypt now yield some of the highest productivities in the world. Nevertheless, the majority of Arab countries have serious problems in agricultural production as a result of limited economic resources, low levels of technology, limited crop patterns, and environmental limitations and pressures (Agoumi, 2001).

The FAO (2005) expected growth rates in world agricultural production to decline from 2.2 percent/yr during the past 30 years to 1.6 percent/yr between 2000 and 2015, 1.3 percent/yr between 2015 and 2030, and 0.8 percent/yr between 2030 and 2050. This still implies a 55 percent increase in global crop production by 2030 and an 80 percent increase to 2050 (compared with 1999 to 2001). Globally, to facilitate this growth in output, 185 million ha of rain-fed crop land (+19 percent) and 60 million ha of irrigated land (+30 percent) will have to be brought into production. Expanded land use and improved technology are the primary reasons contributing to the expected rise in yields. Cereal yields in developing countries are projected to increase from 2.7 tonnes/ha currently to 3.8 tonnes/ha in 2050 (FAO, 2005). Notwithstanding these overall improvements, important food-security problems remain to be addressed at the local and national levels. Areas with high rates of population growth and natural resource degradation are likely to continue to have high rates of poverty and food insecurity (Alexandratos, 2005). Cassman et al. (2003) emphasize that climate change will add to the dual challenge of meeting food demand while at the same time efforts are in progress for protecting natural resources and improving environmental quality in these regions.

The production and dissemination of seasonal climate forecasts have improved the ability of many resource managers to anticipate and plan for climate variability (Harrison, 2005). However, problems related to infectious diseases, conflicts, and other societal factors may decrease the capacity to respond to climate variability and change at the local level, thereby increasing current vulnerability. Policies and responses made at national and international levels also influence local adaptations (Salinger et al., 2005). National agricultural policies are often developed on the basis of local risks, needs, and capacities, as well as international markets, tariffs, subsidies, and trade agreements (Burton and Lim, 2005).

Water balance and weather extremes are key to many agricultural and forestry impacts. Most Arab countries are characterized by limited water resources and high water demands. The total annual renewable water resources in the Arab world are about 460 km^3, or about 0.9 percent of the global annual renewable water resources. Based on annual water resources per capita, all Arab countries are facing a vulnerable water situation, except Mauritania, Iraq, Comoros and Somalia, which have renewable water resources of more than 1,500 m^3/capita/year. Sudan and Lebanon are currently facing water stress (1,000 to 1,500 m^3/capita/year), while the rest of the Arab countries are facing water scarcity (less than 1,000 m^3/capita/year) (AFED, 2010 and Table 6 of Chapter 1 of AFED 2014 report). The agriculture sector uses about 80 percent of the total water resources of the Arab world. However, the water use efficiency of the agriculture sector in most of the Arab countries is low (Montazar et al., 2007).

The climatic wind system that brings precipitation to North Africa and the Eastern Mediterranean is expected to drift northward, thereby removing

a large portion of already meager precipitation levels. This grim perspective makes it necessary for Arab countries to take active and long-term measures to bridge the widening gap between rising water demands and exhausted and deteriorating water resources. (AFED, 2010)

IPCC projections for this century are for further warming in all seasons, while precipitation shows some distinct sub-regional and seasonally dependent changes, characterized by model scatter. In both winter (October to March) and summer (April to September), precipitation in general is projected to decrease. However, the Mediterranean side still appears likely to become drier, the likely precipitation changes for the interior land masses are less clear and the intensified and northward shifting may imply an increase in precipitation in the most southern part of the Arabian Peninsula. Overall, the projections by the end of the century (2081–2100) indicate little overall change, although with a tendency for reduced precipitation, particularly in the high end scenarios (IPCC, 2013).

The majority of Global Circulation Models (GCMs) project a grim outlook for the Arab region in terms of major reduction in precipitation, increase in evaporation, and subsequent reduction in both runoff and soil moisture. Precipitation is projected to decrease by up to 25 percent which in combination with a 25 percent projected increase in evaporation would translate to a drastic 50 percent drop in runoff by the end of the century. The net effect will be a major reduction in available water resources exacerbating current water scarcity conditions (AFED, 2010).

Many negative impacts of climate change on freshwater systems are observed in recent studies. These impacts are mainly due to the observed and projected increases in temperature, evaporation, sea level, and precipitation variability (IPCC, 2007 and IPCC, 2014).

Changes in annual mean runoff are indicative of the mean water availability for vegetation. Projected changes between now and 2100 show

REVIEW OF THE LIKELY IMPACT OF CLIMATE CHANGE ON AGRICULTURE IN SELECTED ARAB COUNTRIES

Fidele Byiringiro

Climate change is expected to impact agriculture in the region in one way or another. Below is a short review of the anticipated impact of climate change on agricultural in selected Arab countries.

In Egypt, climate change is expected to lead to decreased crop yields for most crops. Wheat yields are projected to be lower by up to 9 percent by 2030 and by close to 20 percent by 2060. Despite this drop in yield levels, overall farm income is projected to be higher as a result of the anticipated higher global commodity prices, which will benefit market-oriented farmers while worsening the situation of subsistence farmers, urban poor and Egypt's overall food security situation (Smith et al., 2013).

In Jordan, higher levels of water consumption are anticipated by 2030 as a result of population growth. However, the county is one of the most water-scarce in the world and as such expansion in irrigation is severely limited unless new sources of water (e.g., water treatment and/or water desalination) are developed. Though crop yields may slightly be bumped up by the positive effects of increased CO_2 concentration due to climate change, severe water restrictions will be the major determinant of agriculture and food production especially that Jordan is already reaching the limit of its technological capacity given that modern pressurized systems are already installed across a large share of its irrigated area (Varela-Ortega et al., 2013; Verner et al., 2013).

In Lebanon, higher temperatures, lower precipitations and reduction in snow cover are anticipated, which might increase the occurrence of drought, heat and fires. These will negatively affect crop yields with some estimates putting, for example, some yield decreases to up to 80 percent notably for the most vulnerable crops such as sugar beets, cherries, grapes but also wheat. Higher temperatures may also lead to the discontinuance in the production of temperate crops, which would be displaced by those with a more tropical nature (Verner et al., 2013).

In Morocco, assessments show that climate change will substantially alter regional production patterns and induce yield shocks (mostly negatively) while driving up commodity prices. Agricultural production is projected to decrease by up to 5 percent in the worst case scenario (Ouraich & Tyner, 2012). The Oum Er Rbia River basin, which houses half of the irrigation potential of Morocco and where 60 percent of sugar beets, 40 percent of olives and 40 percent of milk are produced, is already plagued by lower-than-expected rainfall for a decade or more, which has reduced water for irrigation by half. As a result, groundwater pumping is at all time high, which has dropped the water table by more than 5 meters (World Bank, 2014).

some consistent runoff patterns: increases in high latitudes and the wet tropics, and decreases in mid-latitudes and some parts of the dry tropics. Declines in water availability are therefore projected to affect some of the areas currently suitable for rain-fed crops, for instance in the Mediterranean basin and sub-tropical regions (Christensen et al., 2007).

The AFED report on water (AFED, 2010) used a vulnerability approach analysis on climate change impacts on water resources in Arab countries. Arab countries are situated in climate change hotspots where major reductions in precipitation accompanied with increases in evapotranspiration are projected to result in an even more precarious water balance. Faced

In Saudi Arabia, climate change is expected to have a major impact on agriculture and food production largely as a result of reduced water availability. Climate change impact is expected to manifest through higher temperatures, up to 3°C higher by 2040, greater rainfall variability and sea level rise. These are expected to dramatically impact agriculture and food production, which are already highly affected by the lowering of groundwater tables. When there are low precipitations, wells often dry up causing substantial crop yield variability (Darfaoui & Al Assiri, 2010).

In Sudan, projections point to greater variability in wheat production and yields under various climate change scenarios together with a decrease in harvested area due to the impact of higher temperatures and rising water scarcity. However, the same projections show potential increases in sorghum and millet production. Thus, the impact on overall food security for Sudan will be mixed at best (Taha, Thomas & Waithaka, 2012).

In Syria, it is projected that food prices might increase as a result of climate change, which would benefit the agricultural sector even though these high prices would hamper overall economic growth. In the long run, however, agricultural growth rate should exhibit a declining trend largely because of the combined effect of lower precipitations and higher temperatures, which will negatively affect crop yields even while discounting the impact of the on-going conflict (Al-Riffai et al, 2013).

In Yemen, climate change is a real concern. A decrease in the levels of precipitation will put rainfed agriculture in peril and worsen the already precarious food security situation. Yields are projected to vary because of climate change. Sorghum and millet yields are expected to increase while those of maize and wheat would decrease. However, the overall impact of climate change on agricultural GDP would be positive because of the anticipated higher global prices even though most farmers would likely not benefit from these higher prices as they are not market-oriented (Breisinger et al., 2011).

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with the reality of physical water scarcity, sharp increases in pumping costs driven by high energy prices, and declining water levels in strategic aquifers, many Arab countries have started to reorient their food policies by relying on imports and restricting irrigation to high value crops.

Climate change will increase consumptive water use in key sectors in the future, especially in countries that have limited water resources, high population growth, and high development rates. Magano et al. (2007) point out that irrigation demands will increase and the period of supplementary irrigation will become longer under projected climate changes. For example, the total annual reference irrigation demands of Egypt are projected to increase by 6 to 16 percent by the 2100s, due to the increase in reference evapotranspiration values, which will lead to a general increase in the crop-water demands.

Smallholder agriculture is used here to describe rural producers, who farm using mainly family labour and for whom the farm provides the principal source of income (Cornish, 1998). Pastoralists and people dependent on artisanal fisheries and household aquaculture enterprises (Allison and Ellis, 2001) are also included in this category. Smallholders in most Arab countries are poor and suffer in varying degrees from problems associated both with subsistence production (isolated and marginal location, small farm size, informal land tenure, and low levels of technology) and with uneven and unpredictable exposure to world markets, which have been characterized as 'complex, diverse and risk-prone' (Chambers et al., 1989). Risks are also diverse (drought and flood, crop and animal diseases, and market shocks) and may be felt by individual households or entire communities (Scoones et al., 1996). Subsistence and smallholder livelihood systems currently experience a number of interlocking stressors other than climate change and climate variability (Iglesias, 2002). It is likely that smallholder and subsistence households will decline in numbers, as they are pulled or pushed into other livelihoods, with those that remain suffering increased vulnerability and increased poverty (Lipton, 2004).

The impacts of climate change on subsistence and smallholder agriculture, pastoralism, and artisanal fisheries will include, (i) the direct impacts of changes in temperature, CO_2 and precipitation on yields of specific food and cash crops, productivity of livestock and fisheries systems, and animal health; (ii) other physical impacts of climate change important to smallholders such as decreased water supply for irrigation systems, effects of sea level rise on coastal areas, increased frequency of tropical storms (Adger, 1999), and other forms of environmental impact still being identified, such as increased forest-fire risk (Agrawala et al., 2003) and remobilization of dunes (Thomas et al., 2005); and (iii) impacts on human health, like malaria risk.

III. IMPACT OF CLIMATE CHANGE ON CROP PRODUCTION

Plant response to elevated CO_2 alone, without climate change, is positive and was reviewed extensively in a vast number of studies, which confirmed that the effects of elevated CO_2 on plant growth and yield will depend on photosynthetic pathways, species, growth stage, and management regimes, such as water and nitrogen (N) applications (e.g. Ainsworth and Long, 2005). On average, across several species and under unstressed conditions, recent data analyses find that, compared to current atmospheric CO_2 concentrations, crop yields increase at 550 parts per million (ppm) CO_2 in the range of 10-20 percent for C3[2] crops and 0-10 percent for C4[3] crops (Ainsworth et al., 2004; Long et al., 2004).

Some studies use re-analyses of recent FACE (Free Air Carbon Enrichment) to argue that crop response to elevated CO_2 may be lower than previously thought, with consequences for crop modelling and projections of food supply (Long et al., 2006). Studies found that temperature and precipitation changes in future decades will modify, and often limit, direct CO_2 effects on plants. For instance, high temperatures during flowering may lower CO_2 effects by reducing grain number, size, and quality (Caldwell et al., 2005). Increased temperatures may also reduce CO_2 effects indirectly, by increasing water demand (Xiao et al., 2005).

Future CO_2 levels may favour C3 plants over C4 (Ziska, 2003), yet the opposite is expected under associated temperature increases; the net effects remain uncertain. In particular, since more than 80 percent of total agricultural land and close to 100 percent of pasture land is rain-fed, general circulation model (GCM) dependent changes in precipitation will often shape both the direction and magnitude of the overall impacts (Reilly et al., 2003).

The IPCC (2007a) reported that agricultural production in many African countries is projected to be severely compromised by climate variability and change. Yields from rain-fed agriculture in Africa could be reduced by up to 50 percent by 2020, and the projected sea-level rise will affect low-lying coastal areas with large populations,

which will require a total cost of adaptation that could amount to at least 5-10 percent of GDP.

The IPCC (2014a) moreover indicated that reduced crop productivity is associated with heat and drought stress, with strong adverse effects on regional, national, and household livelihoods and food security in Africa. Also expected are increased occurrences of pests and diseases and flood impacts on food system infrastructure. The same report indicates increased risk of drought-related water and food shortage causing malnutrition in Asia.

For the Arab world, the overall conclusion of most studies indicates a general trend of reduction for most major field crops. El-Shaer et al. (1997) concluded that climate change could do severe damage to agricultural productivity if no adaptation measures were taken.

Figures 1 and 2 show the change in percentage of crop productivity and crop water needs for some main crops in Egypt under climate change conditions compared to current conditions (El-Marsafawy, 2011). The results indicate that climate change could decrease the national production of the main crops in Egypt (except cotton) and increase water needs by up to 16 percent.

There are additional negative impacts of increased climate variability on plant production due to climate change. Understanding links between increased frequency of extreme climate events and ecosystem disturbance (fires, pest outbreaks, etc.) is particularly important to quantify the impacts (Hogg and Bernier, 2005).

Furthermore, CO_2-temperature interactions are recognized as key factors in determining plant damage from pests in future decades, though few quantitative analyses exist to date. CO_2-precipitation interactions will likewise be important (Zvereva and Kozlov, 2006).

The International Food Policy Research Institute (IFPRI) predicted that warming in the MENA region, combined with the high likelihood of overall declines in precipitation, makes the region particularly vulnerable to climate change. Projections also suggest that climate will cause world food prices to rise, with negative effects on food security. Egypt expects to lose 15 percent of its wheat crops if temperatures rise by 2°C,

FIGURE 1 CHANGE PERCENT IN MAJOR CROPS PRODUCTION (EXCESS OR DEFICIT) IN EGYPT BY THE YEAR 2050 DUE TO CLIMATE CHANGE.

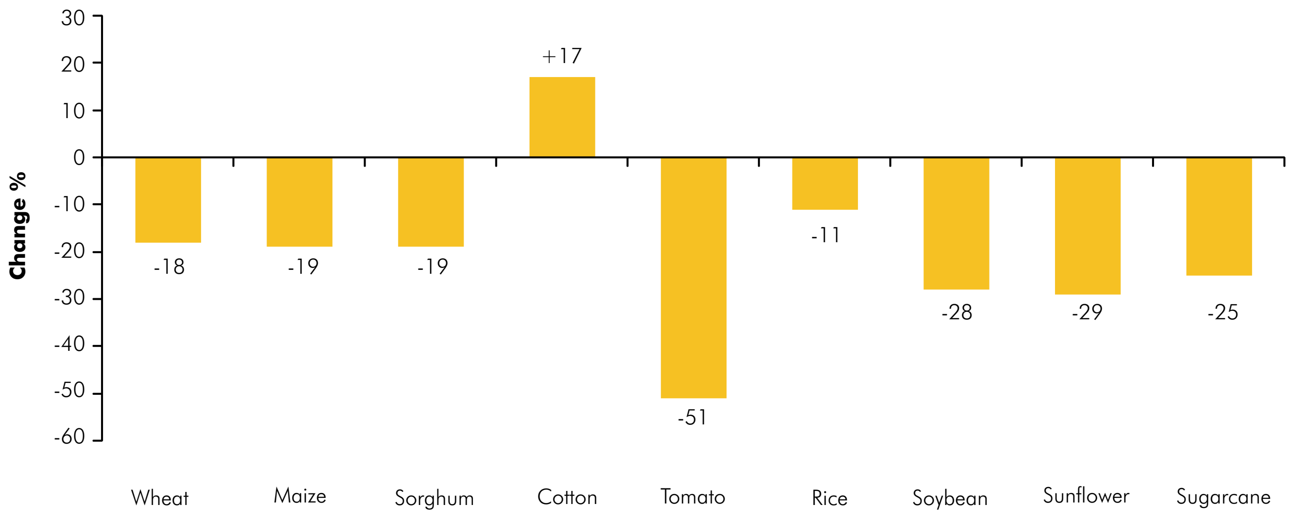
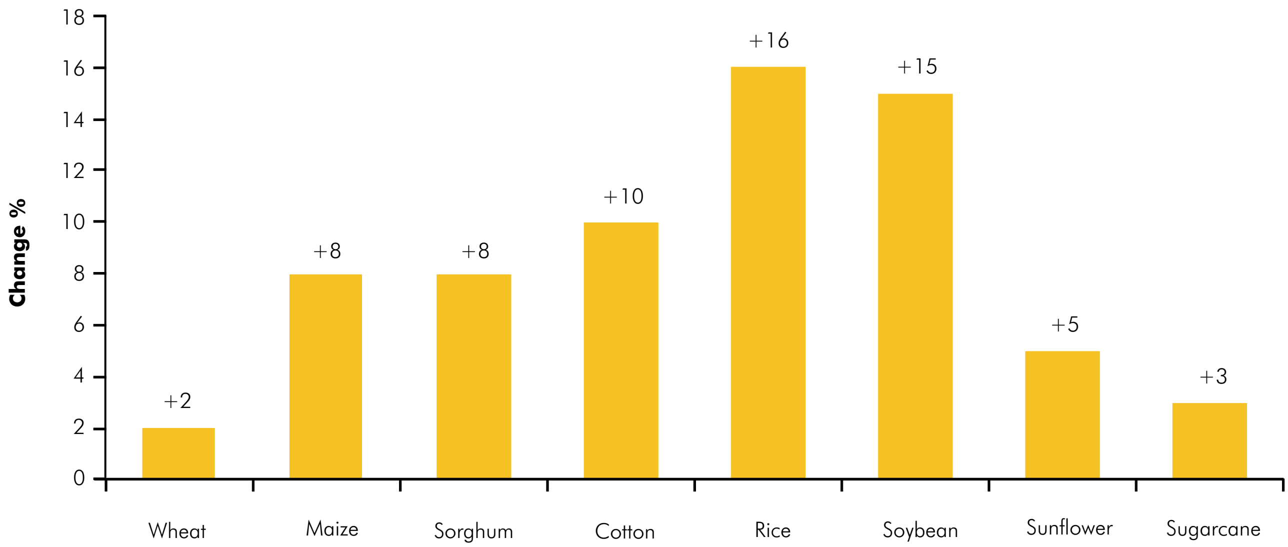


FIGURE 2 CHANGE PERCENT IN CROP EVAPOTRANSPIRATION FOR MAJOR CROPS IN EGYPT BY THE YEAR 2050 DUE TO CLIMATE CHANGE.



and 36 percent if the increase is 4°C. Morocco expects crops to remain stable up to about 2030, but then to drop quickly later. Most North African countries traditionally import wheat and are therefore highly vulnerable to price shocks and droughts elsewhere. The crop modeling results indicate that climate change will have a negative effect on crop yields in the Middle East and North Africa in 2050. The region will face yield declines of up to 30 percent for rice, about 47 percent for maize and 20 percent for wheat (IFPRI, 2009).

The impact of climate change on pests and diseases was studied for some important diseases at the national level, such as pear early blight, potato late blight (Fahim, et al., 2007), and wheat rust diseases (Abo Elmaaty et al., 2007). Importantly, increased climate extremes may promote plant disease and pest outbreaks (Gan, 2004).

IV. IMPACT OF CLIMATE CHANGE ON LIVESTOCK AND GRAZING

Pastures comprise both grassland and rangeland ecosystems. Rangelands are found on every continent, typically in regions where temperature and moisture restrictions limit other vegetation types; they include deserts (cold, hot, and tundra), scrub, chaparral, and savannas. Pastures occupy 33 percent of the total area of the Arab region. However, this area faces risks due to events related to climatic variability (e.g. drought, floods) and desertification (AOAD, 2008).

Pastures and livestock production systems occur in most climates and range from extensive pastoral systems with grazing herbivores to intensive systems based on forage and grain crops, where animals are mostly kept indoors. The combination of increases in CO_2 concentration with changes in rainfall and temperature is likely to have significant impacts on grasslands and rangelands, with production increases in humid temperate grasslands, but decreases in arid and semi-arid regions (IPCC, 2007a).

Animal requirements for crude proteins from pastures range from 7 to 8 percent of ingested dry matter, up to 24 percent for the highest-producing dairy cows. In conditions of very low Nitrogen status in pasture ranges under arid and semi-arid conditions, possible reductions in crude proteins under elevated CO_2 may put a system into a sub-maintenance level for animal performance (Milchunas et al., 2005). The decline under elevated CO_2 levels (Polley et al., 2003) of C4 grasses, which are a less nutritious food resource than C3 (Ehleringer et al., 2002), may also compensate for the reduced protein content under elevated CO_2. Generally, thermal stress reduces productivity and conception rates, and is potentially life-threatening to livestock. Because ingestion of food and feed is directly related to heat production, any decline in feed intake and/or energy density of the diet will reduce the amount of heat that needs to be dissipated by the animal. Mader and Davis (2004) confirm that the onset of a thermal challenge often results in declines in physical activity with associated declines in eating and grazing (for ruminants and other herbivores) activities. New models of animal energetics and nutrition (Parsons et al., 2001) have shown that high temperatures put a ceiling on dairy milk yield irrespective of feed intake. Increases in air temperature and/or humidity have the potential to affect conception rates of domestic animals not adapted to those conditions. This is particularly the case for cattle, in which the primary breeding season occurs in spring and summer months. Amundson et al. (2005) reported declines in conception rates of cattle for temperatures above 23.4°C and at high thermal heat index.

Moreover, impacts on animal productivity due to increased variability in weather patterns will likely be far greater than effects associated with the average change in climatic conditions. Lack of prior conditioning to weather events most often results in catastrophic losses in confined cattle feedlots (Hahn et al., 2001), with economic losses from reduced cattle performance exceeding those associated with cattle death losses several-fold (Mader, 2003). In dry regions, there are risks that severe vegetation degeneration leads to positive feedbacks between soil degradation and reduced vegetation and rainfall, with corresponding losses of pastoral areas and farmlands (Zheng et al., 2002). A number of studies in Africa (Batima, 2003) show a strong relationship between droughts and animal death. Projected temperature increases, combined with reduced precipitation in North Africa would lead to increased loss of domestic herbivores during extreme events in drought-prone areas. With increased heat stress in the future, water requirements for livestock will increase significantly compared to current conditions, so that overgrazing near watering points is likely to expand (Batima et al., 2005).

V. IMPACT OF CLIMATE CHANGE ON FISHING AND AQUACULTURE

Aquaculture resembles terrestrial animal husbandry and therefore shares many of the vulnerabilities and adaptations to climate change with that sector. Similarities between aquaculture and terrestrial animal husbandry include ownership, control of inputs, diseases and predators, and use of land and water. Some

GENETICALLY ENGINEERED CLIMATE-RESILIENT SEEDS AS A POSSIBLE RESPONSE TO CLIMATE CHANGE-INDUCED FOOD SHORTAGES

Anne Saab

Climate change is predicted to have dramatic impacts on agricultural production globally. Although food production in some regions of the world may benefit from increasing average temperatures, most of the world will face severe challenges in adapting agricultural systems to the predicted climatic changes. The Arab region will be among the most affected, with precipitation estimated to drop by 25 percent and evaporation to increase by 25 percent before 2100. In addition to higher average temperatures, incidences of drought and higher soil salinity will influence agriculture and food production. Agriculture is highly dependent on climate and therefore changes in climatic conditions impact crop yields for food production.

The latest IPCC assessment report emphasizes the severe impacts climate change is already having, and will continue to have, on food production. Food security is at risk, and methods of food production will have to adapt to the changing climate in order to maintain adequate levels of food supply. As with all other impacts of climate change, food security is most at risk in those areas of the world that are most vulnerable. Part of the reason is that these vulnerable regions, including sub-Saharan Africa, parts of Asia, and the Arab world, already have warmer and drier climates and already suffer from more droughts and floods than other parts of the world. Another important reason for their increased vulnerability is the regions' lack of adaptive capacity. Unless effective adaptation strategies are developed and implemented, this decrease in crop yields and food production could result in millions more people facing food insecurity. The World Food Programme has estimated that the number of people at risk of hunger and food insecurity will increase by 10-20 percent by the year 2050 as a result of climate change.

Agriculture in the Arab world is particularly vulnerable to climate change. As this AFED report illustrates, Arab countries have mostly arid climates with high temperature and low precipitation levels. Moreover, adaptive capacity is currently inadequate to deal with these challenges. Lack of water is a particular problem for agriculture in the Arab world. Adaptation strategies are being devised in the international sphere that may contribute to adapting agriculture to the impacts of climate change and addressing problems of food insecurity. One of these strategies is the development and use of genetically engineered seeds that are made for resilience to certain climatic conditions.

For thousands of years, farmers have adapted to changes in climate through a process of seed selection. Seeds of crops that can grow with little water, for example, are saved and replanted during periods of drought. This process of natural selection and breeding, however, is a slow process and it can take years or even decades for suitable seeds to consistently yield enough crops. Agricultural biotechnology and particularly genetic engineering has in recent years directed attention to the development of climate-resilient seeds and crops. The use

of genetic engineering techniques is intended to speed up this process of natural selection. It allows the transfer of specific genetic traits from one seed to another, with the objective of developing seeds with resistant traits.

The world's largest seed corporations (including Monsanto, Syngenta, Dupont, Bayer, and BASF) are focusing their efforts on the research and development of drought-resistant seeds, as water is one of the main limiting factors in agriculture. Climate-resilient seeds are presented as a possible adaptation strategy to climate change. Seeds that are genetically engineered to require less water to grow crops, for example, could be useful in maintaining adequate food production in periods of drought. For Arab countries that already have dry climates and whose agriculture suffers from the impacts of climate change, such climate-resilient seeds could prove to be a very useful adaptation tool.

Many governments, policymakers, corporations, and even civil society organizations are increasingly promoting the use of biotechnology, and especially genetic engineering, in agriculture. The impacts of climate change are considered unprecedented and sufficiently severe to require new and more effective adaptation measures that go beyond convention breeding techniques. Despite the promise that genetically engineered climate-resilient seeds may hold, there is also a great deal of criticism directed against these seeds as an adaptation strategy to climate change. Critical voices claim that large seed corporations are abusing the climate and food crises for their own commercial gain. The ETC Group, an influential civil society organization, has called the promotion of 'climate-ready' seeds by corporations 'climate profiteering'.

Critiques of climate-resilient seeds take several forms. Some scientists argue that these seeds have not proven to produce more crop yields than non-genetically engineered seeds. For instance, the Union of Concerned Scientists has noted that drought-resistant corn seeds have not proven to produce more corn than other types of corn seeds. Scientists contend that it is very difficult to develop climate-resilient traits in seeds, considering the complexity of these genetic traits. Additionally, they argue that it is almost impossible to develop resistance against climatic conditions such as drought, most fundamentally because such climatic conditions are unpredictable. Every instance of drought is different from the next instance of drought, and developing resistance against one does not guarantee resistance against another.

Another strong criticism is that seed corporations focus their research on commercially viable crops, such as corn. Commercially viable crops are, however, not necessarily the crops that are needed to feed the developing world. In the Arab region, rice is one of the staple crops. However, the production of rice requires a great deal of water. Instead of genetically engineering rice to be able to grow with less water, it might be more beneficial to switch to production of other crops that naturally require less water. An additional criticism is that genetically engineered climate-resilient seeds are often patented by seed corporations. As their research and development requires substantial investments, patent rights are viewed as an appropriate reward and incentive for these corporations. Patent rights, however, also block access to these seeds by the vulnerable populations, as they cannot afford to pay the fees to obtain them.

Perhaps the most fundamental critique of climate-resilient seeds as a strategy to adapt agriculture to climate change and prevent food insecurity is the question of whether increasing food production is enough. If climate-resilient seeds are capable of increasing food production in the face of climate change, will the people who are most food insecure and who require such seeds most urgently be able to benefit from them? Food security depends not only on adequate availability of food, but also and importantly on adequate access to food. If genetically engineered climate-resilient seeds are successfully developed, the people in the Arab world might still not benefit from this adaptation tool if farmers are not able to afford those seeds.

Genetically engineered climate-resilient seeds hold both great promise and great controversy. They could provide a valuable contribution to adapting the world's agriculture to the impacts of climate change and combat food insecurity. At the same time, the critiques voiced must also be taken seriously. This dilemma is common to all climate change adaptation strategies and presents policymakers with difficult challenges. Climate change impacts on society on so many different levels – environmental, social, political, economic, cultural, etc. – and potential solutions must therefore also take all these dimensions into account. The legal framework must also be considered. International law concerning climate change adaptation, patent rights, and human rights in the form of the right to food are all relevant in discussions about climate-ready seeds. In addition to international law, regional and domestic laws also apply. How these laws can best be employed to achieve the most effective adaptation outcomes is not always evident. Identifying and acknowledging the complexities may be a good place to start.

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IMPACT OF CLIMATE CHANGE ON FOOD PRODUCTION IN EGYPT

Egypt, the most populous Arab country, is most vulnerable to the potential impacts and risks of climate change. The climate change effects examined are alterations in Nile water inflows, irrigation water requirements, crop yields, land loss to sea level rise, livestock performance, and increase in municipal and industrial water use. Results of McCarl et al (2013) indicate that:

- Climate change damages the Egyptian agricultural sector and the damages increase over time (2030-2060).
- Prices for agricultural commodities increase and this has a negative effect on producers.
- Egypt may reduce these damages by adapting through lower demand growth, raised agricultural technological progress, sea rise protection and water conservation strategies.
- The Agricultural Sector Model (ASME) was updated to include the most recent Egyptian agricultural data, a water flow model, and municipal and industrial water use.
- Regarding climate change 2030; agricultural production decreases by 6 percent and prices increase by 19 percent with agricultural revenues rising by 15 percent. Farmers benefit from these increased prices. Consumers experience a 1.7 percent welfare loss as there is a reduction in production and increase in price. Imports rise by 23 percent. Agricultural water use increases by 8 percent. Agricultural employment increases by 4 percent. More desert land is reclaimed for agricultural production.
- For climate change 2060; agricultural production decreases by 6 percent, prices increasing by 19 percent plus an increase in imports of 19 percent. Land dedicated to agriculture decreases by 19 percent with agricultural water use is reduced by 17 percent and agricultural employment by 13 percent. There is an increase in groundwater use of 12 percent. Also the agricultural value of production increases by 15 percent while welfare reduces by 6 percent because consumers are spending more on food.

aquaculture, particularly of plants, depends on naturally occurring nutrients, but the rearing of fish usually requires the addition of suitable food. Capture fisheries depend on the productivity of natural ecosystems and are therefore vulnerable to climate change induced changes affecting production in natural aquatic ecosystems.

The IPCC (2007a) reports a number of key negative impacts of climate change on aquaculture and freshwater fisheries, including (i) stress due to increased temperature and oxygen demand and increased acidity (lower pH); (ii) uncertain future water supply; (iii) extreme weather events; (iv) increased frequency of disease and toxic events; (v) sea level rise and conflict of interest with coastal protection needs; and (vi) uncertain future supply of fishmeal and oils from capture fisheries. Positive impacts include increased growth rates and food conversion efficiencies, increased length of growing season, range expansion, and use of new areas due to decreases in ice cover.

Temperature increases may cause seasonal increases in growth, but may also affect fish populations at the upper end of their thermal tolerance zone. Increasing temperature interacts with other changes, including declining pH and increasing nitrogen and ammonia, to increase metabolic costs. The consequences of these interactions are speculative and complex (Morgan et al., 2001).

Changes in primary production and transfer through the food chain due to climate will have a significant impact on fisheries. Such changes may be either positive or negative and the aggregate impact at the global level is yet unknown (IPCC, 2014). However, climate change has been implicated in mass mortalities of many aquatic species, including plants, fish, corals, and mammals, but a lack of standardized epidemiological data and information on pathogens generally makes it difficult to attribute causes (Harvell et al., 1999).

VI. IMPACT OF CLIMATE CHANGE ON FOREST PRODUCTIVITY

Forests cover almost 928 thousand ha constituting 6.6 percent of the Arab world's physical territory. Approximately one third of this area is located in Sudan. Modelling studies predict increased global timber production. Whereas models suggest that global timber productivity will likely increase with climate change, regional production will exhibit large variability, similar to that discussed for crops. Climate change will also substantially impact other services, such as seeds, nuts, hunting, resins, and plants used in

pharmaceutical and botanical medicine and in the cosmetics industry; these impacts will also be highly diverse and regionalized. Recent studies suggest that direct CO_2 effects on tree growth may be revised to lower values than previously assumed in forest growth models. A number of FACE studies showed average net primary productivity (NPP) increases of 23 percent in young tree stands at 550 ppm CO_2 (Norby et al., 2005). However, in a 100-year old tree stand, Korner et al. (2005) found little overall stimulation in stem growth over a period of four years. Additionally, the initial increase in growth increments may be limited by competition, disturbance, air pollutants, nutrient limitations, and other factors (Karnosky, 2003), and the response is site- and species-specific.

A number of long-term studies on supply and demand of forestry products have been conducted in recent years (IPCC, 2007a). These studies project a shift in harvest from natural forests to plantations (Hagler, 1998). Finally, although climate change will impact the availability of forest resources, the anthropogenic impact, particularly land-use change and deforestation, is likely to be extremely important (Zhao et al., 2005).

VII. ADAPTATION OF AGRICULTURE IN THE ARAB WORLD

In 2001, the IPCC defined "Adaptation" as any adjustment in ecological, social or economic systems in response to actual or expected climatic stimuli and their effects or impacts. This term refers to changes in processes, practices or structures to moderate or offset potential damages or to take advantage of opportunities associated with changes in climate. It involves adjustments to reduce the vulnerability of communities, regions or activities to climatic change and variability (IPCC, 2001).

The high vulnerability of the agricultural sector in developing countries should place it at the top of priority lists of adaptation plans. Although climate change is projected to have serious impacts on the agricultural sector in the Arab world, only modest efforts and steps are currently being taken in the areas of scientific research, mitigation, and adaptation.

Agriculture has historically shown high levels of adaptability to climate variations. For cropping systems, there are many potential ways to alter management to deal with projected climatic and atmospheric changes (Challinor et al., 2007). These adaptations include:

a. Altering inputs such as varieties, species, fertilizer, and amounts and timing of irrigation and other water management practices;

b. Wider use of simple technologies;

c. Water management to prevent water logging, erosion and nutrient leaching in areas with rainfall increases;

d. Altering the timing or location of cropping activities;

e. Diversifying income by integrating other farming activities such as livestock raising;

f. Improving the effectiveness of pest, disease, and weed management practices; and

g. Using seasonal climate forecasting to reduce production risk.

In its 2014 report, IPCC suggested the following Adaptation measures for Africa and Asia (IPCC, 2014):

a. Technological adaptation responses (i.e. stress tolerant crop varieties, irrigation, and enhanced observation systems).

b. Enhancing smallholder access to credit and other critical production resources.

c. Strengthening institutions at local, national and regional levels to support agriculture (including early warning systems) and gender-oriented policies.

d. Agronomic adaptation responses (e.g. agro-forestry and conservation agriculture).

e. More efficient use of water (i.e. improved agricultural practices, irrigation management, and resilient agriculture).

Many options for policy-based adaptation to climate change have been identified for agriculture, forests, and fisheries (Easterling et al., 2004). These can either involve adaptation activities such as developing infrastructure, or building the capacity to adapt in the broader user community and institutions, often by changing the decision making environment under which management-level, adaptation activities occur. Designing and applying national adaptation strategies for the agriculture sector faces a number of barriers, including limitations of the existing scientific base, policy perceptions under current conditions and pressures, poor adaptive capacity of rural communities, lack of financial support, and the absence of an appropriate institutional framework.

AFED (2010) indicated that strategic changes in water policies due to Climate Change have created a positive virtual water balance as water became imbedded in imported agricultural produce. This has prompted several GCC countries to seek acquirement of titles to land resources and even fishing rights in developing countries in Africa and Asia to secure food for their rapidly growing populations.

VIII. CONCLUSION AND RECOMMENDATIONS

Food security is a growing international challenge that is felt especially in the Arab world. The factors affecting food security in the region are ever growing population, the limited water resources, the unfavourable weather conditions, and political and economical instability. Climate change has added to this a major new challenge and uncertainty.

Adaptation to climate change is therefore highly needed. Adaptation strategies should build on a mix of local heritage and modern technologies. The target of adaptation in this region is mainly directed towards improving water use efficiency, heat and stress tolerance, and reducing the energy inputs used for crop production.

Capacity building is a major prerequisite for climate change adaptation action to improve the ability of the community to utilise science, technology, and heritage for planning and implementation plans. Awareness and advocacy are also needed to set the community priorities and establish appropriate policies. Community reaction to adaptation measures is a vital issue. Therefore, training and awareness programs should be carefully designed to improve timely implementation of the adaptation schemes.

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NOTES

1. This chapter is based on Dr. Ayman Abou Hadid's chapter on Food Production, published in AFED 2009 Annual Report on Impact of Climate Change on Arab Countries (AFED, 2009). It has been revised by the author to take into account recent developments, especially the latest IPCC reports.

2. C3 carbon fixation is a metabolic pathway for carbon fixation in photosynthesis. This process converts carbon dioxide and ribulosebisphosphate (RuBP, a 5-carbon sugar) into 2,3-phosphoglycerate through the following reaction:

CO_2 + RuBP → 2,3-phosphoglycerate

This reaction occurs in all plants as the first step of the Calvin cycle.

3. C4 carbon fixation is one of three biochemical mechanisms, along with C3 and CAM photosynthesis, functioning in land plants to "fix" carbon dioxide (binding the gaseous molecules to dissolved compounds inside the plant) for sugar production through photosynthesis. Along with CAM photosynthesis, C4 fixation is considered an advancement over the simpler and more ancient C3 carbon fixation mechanism operating in most plants. Both mechanisms overcome the tendency of RuBisCO (the first enzyme in the Calvin cycle) to photorespire, or waste energy by using oxygen to break down carbon compounds to CO_2. However C4 fixation requires more energy input than C3 in the form of ATP. C4 plants separate RuBisCO from atmospheric oxygen, fixing carbon in the mesophyll cells and using oxaloacetate and malate to ferry the fixed carbon to RuBisCO and the rest of the Calvin cycle enzymes isolated in the bundle-sheath cells. The intermediate compounds both contain four carbon atoms, hence the name C4.

OPINION

THIRSTY ENERGY OR HUNGRY WATER?

Najib Saab

The World Bank chose "Thirsty Energy" as title for its report on the energy-water nexus. If we were to produce such a report for the Arab region, the title could better be "Hungry Water"- as production of water eats the bulk of Arab energy.

In no other part of the world is the link between energy and water as critical as it is in the Arab region. While it is one of the driest areas on earth, the Arab region holds the bulk of the world's oil reserves. The energy sector plays a major role in meeting water and food needs in Arab countries, mainly through seawater desalination, in a region which hosts 50 percent of the world's desalination capacity. Water is also heavily needed to generate energy, in all its types; from fossil fuels to solar PV and Concentrated Solar Power (CSP) to nuclear energy.

Climate change will only worsen the water situation, according to a report produced by the Arab Forum for Environment and Development (AFED) on Impact of Climate Change on Arab Countries. By the end of the 21st century, Arab countries are predicted to experience an alarming 25 percent decrease in precipitation and 25 percent increase in evaporation rates.

Desalination, water distribution, and pumping groundwater consume 50 percent of total energy in some Arab countries. Irrigation efficiency is among the world's lowest, while per capita domestic water consumption in some of the most water-scarce Arab countries is among the world's highest. Half of the wastewater produced is discharged without treatment, while only 20 percent of the treated water is reused.

A 2013 AFED report on Sustainable Energy concluded that Arab energy is not managed better than water. Although energy intensity and per capita carbon emissions are among the highest in the world, over 50 million Arab people are without access to modern energy services. Growth in energy consumption, at 8 percent, has been twice the growth in GDP, at 4 percent. Average energy efficiency in the region stands at less than 50 percent. A combination of water and energy efficiency measures can save up to half of the energy currently used, while maintaining the same production levels.

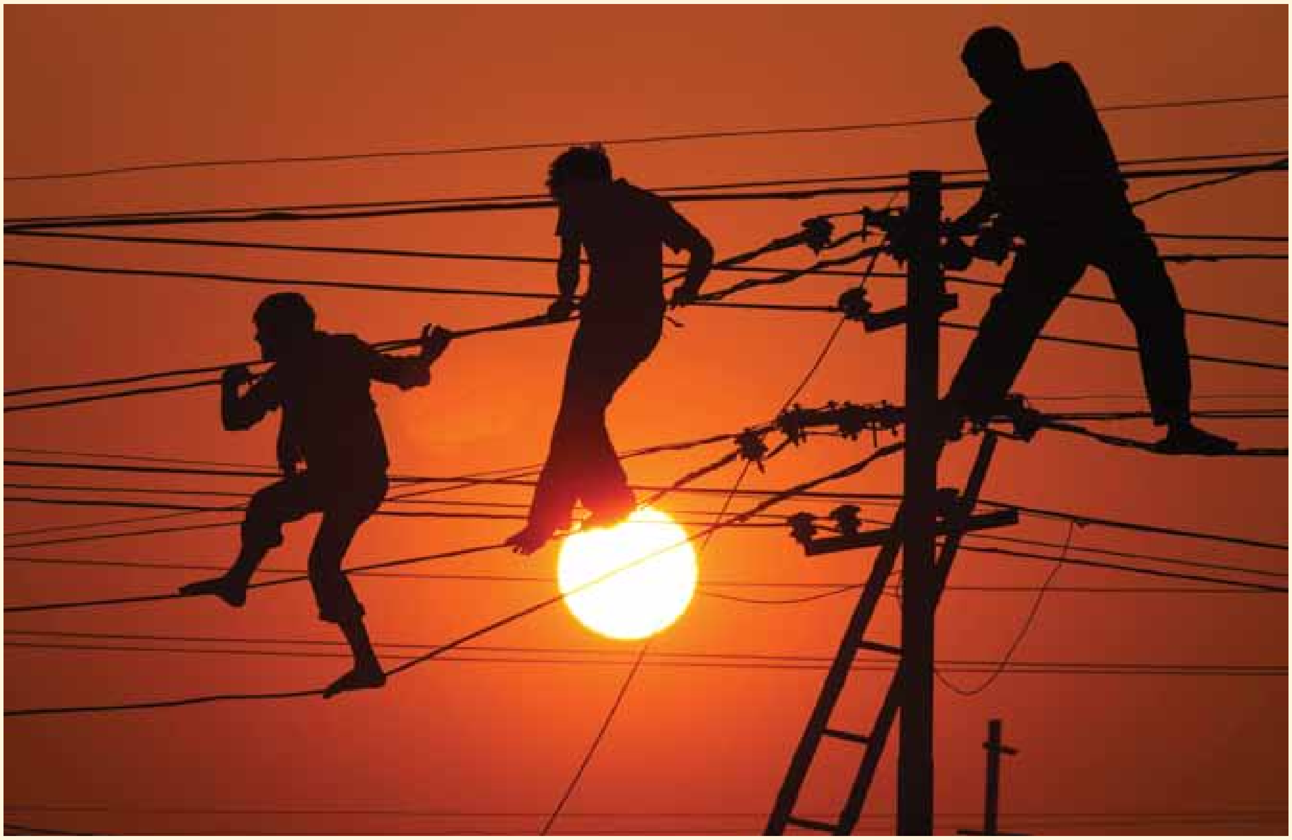
Experience has shown that free water and energy are wasted resources. Artificially low prices and heavy subsidies are at the root of inefficiency, overuse, excessive pollution and environmental degradation in the Arab region. For example, the average price charged for water in the Arab region is about 35 percent of the cost of production, and in the case of desalinated water it is only 10 percent. Unrestrained energy and water subsidies, reaching 95 percent in many cases, are the main obstacle to achieving real results in this regard. This practice only promotes waste, and does not help to ease the burden on the poor, as over 90 percent of the uncontrolled subsidies go to the rich. It is futile to deplete strategic reserves of fossil groundwater, to grow fodder in the desert supporting the production of dairy products for export, while desalinating water to irrigate urban gardens.

Proper management of water and energy supplies requires the introduction of pricing schemes which meet the goals of local acceptability, economic efficiency, cost recovery and equity.

A recent Chatham House report estimated that if consumption levels of water and electricity in the oil exporting GCC countries continue to rise at the same rates, demand would double by 2024. This means more groundwater depletion and growing use of energy for desalination. If no remedial measures are taken, most of the fuel produced will consequently have to be used locally, thus depriving these countries of major export revenues.

Various schemes currently being planned and executed will likely further strain water resources. Some countries (UAE, Jordan) are pursuing nuclear energy, requiring water resources. Other countries, such as Qatar, have ambitious plans to meet food security by cultivating thousands of hectares mainly with desalinated seawater.

This brings us to the root of the problem, which is resource management. A report on Ecological Footprint produced by AFED has found that demand for life supporting goods and services in the Arab countries is twice as much as the potential renewable resources their ecosystems can provide. This imbalance is a threat to future growth opportunities and quality of life.



Pursuing national development strategies is naturally a main priority for Arab countries, but economic growth must take into account ecological limits and the capacity of nature to sustainably support life. Growth targets should respect the regenerative limits of nature. Given the relative low efficiency with which resources are turned into final products, Arab countries must improve their resource productivity by prioritizing energy and water efficiency. Decision makers will need to look beyond GDP as the sole measure of performance, and seek to complement traditional economic analysis with data on resource consumption and availability.

The good news is that serious work has started to stand up to the challenge. Arab ministers of electricity have adopted a comprehensive energy efficiency framework. Abu Dhabi's water strategy was the latest plan to be announced in the region to manage water resources. Saudi Arabia has embarked on an aggressive energy efficiency program. Renewable energy is rapidly expanding: Saudi Arabia plans to meet 33 percent of its local energy needs from renewables by 2032. Abu Dhabi has built Shams-1, a CSP plant with 100 megawatt capacity. Renewable energy projects worth US$11 billion are underway in Morocco, with the aim to build9 gigawatts capacity.

Ultimately, wide-spread reforms in the energy and water sectors require serious institutional and policy measures. Overconsumption cannot be checked, efficiency measures cannot be adequately implemented, and renewable energy cannot spread out if current subsidy regimes are not phased out. Private sector participation in the energy and water sectors requires that policy makers establish the appropriate enablers, including well-defined policies and sound regulatory frameworks.

Arab countries, both oil exporters and importers, are well endowed with renewable sources of energy, primarily solar. For now, these are underutilized. Together with enhanced energy efficiency and cleaner technologies, these renewable sources can help diversify and power a more sustainable future.

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Livestock and Food Security

Shadi Hamadeh

Raising livestock in the Arab world is a traditional activity contributing to the livelihoods of millions of rural communities. Livestock make use of the scarce feed in the predominantly arid lands to convert them into nutritionally and economically valuable products.

Arab countries are heavy consumers of livestock products with most of their needs being met through imports. However, consumption and import patterns are not uniform with higher values noted in the Gulf (livestock products import estimated at US$8.6 billion in the Gulf countries vs. US$7.8 billion in all other Arab countries, in 2011). This consumption is projected to increase in the future driven by three forces: population, wealth and urban growth.

The productivity of the livestock sector is challenged by the scarcity of natural resources in terms of feed and water, lack of supporting infrastructure and services and a history of arbitrary policies that affected the sector negatively. Arab countries face a heavy reliance on feed imports estimated at US$10.4 billion (for only four major feed ingredients in 2012), after attempts to grow feed locally resulted in drainage of non-renewable water reserves. In addition, rangelands, the natural feed resource for mixed and pastoralist systems, have been largely degraded leading to loss of biodiversity, soil erosion and a decrease in their carrying capacity, thus livestock productivity.

However, the picture can be improved by integrating efforts and addressing the problems facing the sector, within each production system. Intensive systems are well established for meeting the ever increasing urban demand, however a regulatory framework is needed to control their negative impact on natural resources, public health and on small producers' livelihoods. Mixed systems constitute the largest portion of the sector where livestock has the potential to play the role of a versatile asset filling the household nutritional or financial gap whenever needed. This system would most benefit from targeted animal health, financial and infrastructure services, along with access to alternative cheap feed resources such as food industry byproducts. Finally, pastoralists and rainfed animal production remain the most resilient in face of high aridity, however policies supporting their movement and access to grazing lands are needed.

Inter-Arab collaboration is of prime importance to improve the use of the collective resources for livestock production and help filling the gaps in each country's needs through mutual and coordinated support.

I. INTRODUCTION

Livestock has traditionally played a role in all aspects of Arab food security: production, stability of supply, access and quality. In addition, it is a significant source of income for small holders and an economic contributor to the GDP. Livestock represents a year-round asset, a readily available source of food or income, and a source of pride, social values and status (Rota and Thieme, 2009; Otte et al., 2012; Hassane, 2013).

Global trends have reshaped the livestock sector with increasing demand and consumption being driven by rising incomes and growth in the population that's becoming more and more urbanized. In response, the increased intensification of the sector, driven by the rising demand, came under fire in association with wide ranging environmental and health negative impacts. On the other hand, small holders in rural and peri-urban areas and pastoralists in drylands are increasingly marginalized and have to face the challenge of climate change and poverty. These global trends aggravated in the natural resource scarce Arab region.

The current chapter presents the past and projected situation of the sector, its potentials and challenges, with a special focus on the particular characteristics of different livestock systems. The paper concludes with system specific recommendations aimed to ensure the sustainability of the sector and provide livestock food security across the Arab world.

The paper will address the following questions:

- What role for Arab livestock production in meeting rising demand? And what price?
- What role for livestock in sustaining the livelihoods of poor Arabs in arid areas?
- What role for livestock in buffering seasonal food gaps and improve nutritional status of households?

II. SECTOR ANALYSIS

A. Supply and Demand

A continuous rise in livestock demand in Arab countries has been observed for the last decade as reflected by the consumption patterns: Kg whole milk equivalent per capita was estimated to increase from 72 to 81 between 2000 and 2014 while the meat consumption (Kg per capita carcass weight equivalent), increased from 21 to 28 (FAO, 2013).

Surveying the dietary habits of Arabs, Musaiger et al. (2011) noted that the caloric intake has increased throughout the last 30 years with animal fat as the major source of calories in wealthy Arab countries while plant sources were the major contributor in low and middle income countries, except for Somalia and Sudan which showed high animal product consumption. The report indicated that based on these dietary habits and changes in lifestyles, the Arabs are facing two opposite challenging health problems, under-nutrition and dietary deficiencies on one end and diet-related chronic diseases such as obesity, diabetes, hypertension, cardiovascular disease and some types of cancer on the other end. The authors indicated that subsidization of red meat and animal fat in some countries might contribute to an increase in the prevalence of coronary heart disease and some types of cancer, if its consumption is high and over a long period. On the other hand, Arab poor seem to have a more plant-based diet and commonly face anemia due to inadequate iron intake.

This brief overview highlights the role that animal products can play in improving the nutritional status in Arab countries. The high level of animal fat consumption in rich countries seems to be questionable for the long run given its negative health impact, while on the other hand the majority of Arab poor are lacking adequate animal protein intake. Given the large population growth and the prevalence of poverty, especially in rural and peri-urban Arab regions, this indicates that the need for animal products will continue to rise.

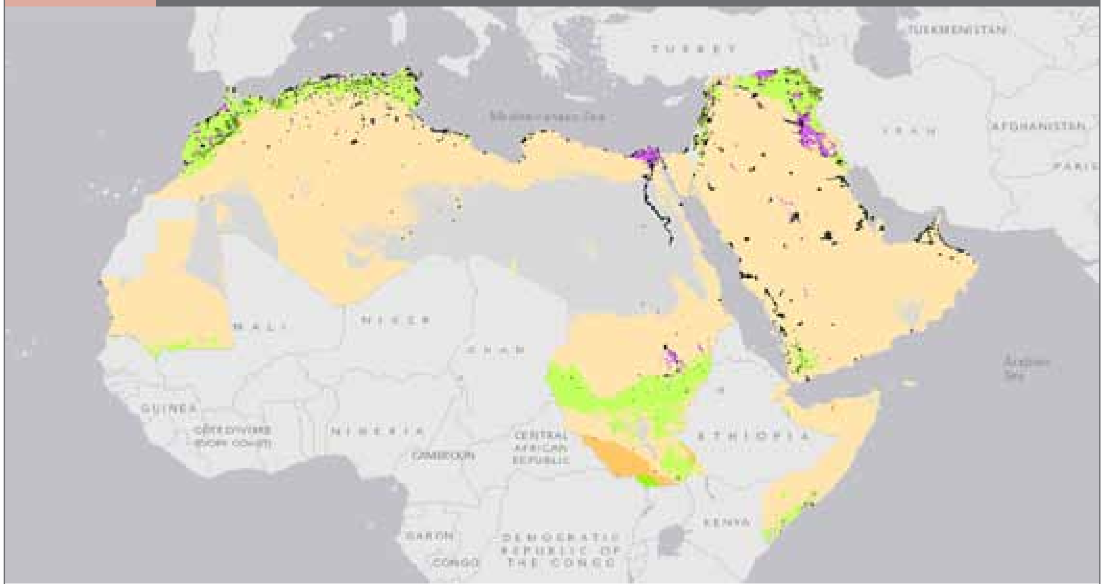
The increased demand is driven by structural factors as described in the report by the World Bank, FAO and IFAD dedicated to "improving food security in Arab countries" (World Bank, FAO and IFAD, 2009).

Arab countries are large net importers of food, with 50 percent of their food calorie needs relying on imports. Population growth rate in Arab countries is estimated at around 1.7 percent, which is above the 1.1 percent world average, along with a rapid increase in income growth rate estimated at 3.4 percent while the world average is 3 percent. At the same time, Arab countries are facing increased urbanization, estimated at 3 percent growth between 1990 and 2006, as compared to the world average of 2.2 percent. The growth of the agriculture sector, including livestock, in response to increased demand, seems to be hindered partly by the slow growth in arable lands estimated at 1.7 percent as compared to 2.3 percent worldwide between 1995-2005, thus affecting cereal production for food and feed. Being largely under arid climates, water scarcity is another obstacle noting a heavy reliance on the exploitation of renewable water resources of 75 percent as compared to the rate of 30 percent in other regions.

On the supply side, the increase in livestock production has not been uniform across the Arab countries and fell short of the demand in spite of important animal inventories.

Livestock production in the Arab countries is also limited by the distribution of production systems (Figure 1) (ARABSPATIAL, 2014). Needless to say,

FIGURE 1 DISTRIBUTION OF THE LIVESTOCK PRODUCTION SYSTEMS IN ARAB COUNTRIES



- LGY - Rangeland-based/hyperarid
- LGA - Rangeland-based/arid-semiarid
- LGH - Rangeland-based/humid-suhumid
- MRY - Mixed rainfed/hyperarid
- MRA - Mixed rainfed/arid-semiarid
- MRH - Mixed rainfed/humid-subhumid
- MRT - Mixed rainfed/temperate-tropical highlands
- MIY - Mixed irrigated/hyperarid
- MIA - Mixed irrigated/arid-semiarid
- Urban areas

Source: ARABSPATIAL, 2014.

the vast majority of the territory, up to 90 percent, falls under rangeland arid or semi-arid regions. These vast arid areas are prone to extensive poverty prevalence, based on the estimates of poverty distribution by production systems presented in the "Farming systems and poverty" report prepared by FAO (FAO, World Bank, 2001), and are therefore among the least food secure. Today 75 percent of all poor in Arab rural areas partially depend on livestock for livelihood, with 60 percent of the income being derived from livestock in pastoral and agro-pastoral systems, while small mixed farming uses livestock for food, manure, draught, buffer seasonal nutritional gaps and provide a source of income for women. Moreover, in peri-urban areas an increasing number of mixed landless farmers feed animals on crop residues and byproducts (Fresco and Steinfield, 1998). On the other hand, demand in urban areas is largely met by intensive non land based systems such as large poultry and dairy farms.

A comparison between four representative Arab countries (Somalia, Syria, Morocco and Saudi Arabia) in numbers of animals and levels of production, showed a marked discrepancy (Table 1). The data clearly indicates high intensification in Saudi Arabia as attested by high productivity from its cattle and chicken stocks, which are predominantly raised under modern input and capital dependent systems. In contrast, the large milk cattle numbers in Somalia showed little productivity and the poultry production remained small, indicating the prevalence of extensive and traditional systems of production. Animal numbers and production were relatively maintained in Syria, while in Morocco the productivity of the animals seemed to increase considerably between 2000 and 2012. This comparison highlights the differences across the Arab countries as well as the effect of the economic status on livestock production.

The rise in demand and relatively slow growth in production have led to heavy reliance on imports of livestock and animal products. Figure 2 shows the discrepancy in the scale of imports versus exports of livestock products in Arab countries, with special note on the differences between the Gulf Cooperation Council (GCC) and other Arab countries. Viewed in combination with the population numbers, the figures show that the demand for livestock products in GCC countries disproportionally exceeds that of other countries, given their relatively small population numbers. Figure 2 was compiled from data available through the FAOSTAT website. This is a reflection of the economic factor and purchase power distribution within the Arab countries, since economic growth reflects directly on livestock products consumption and demand (UNEP, 2012).

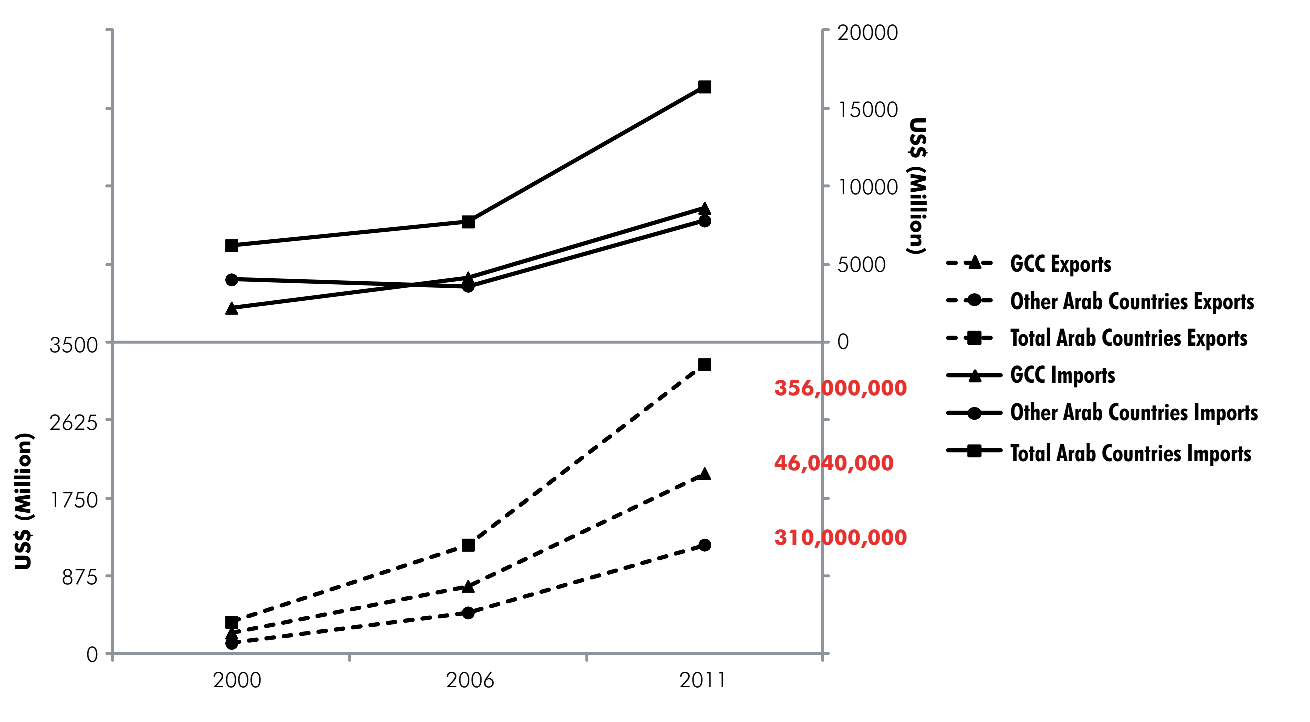
B. Feed Resources

Feed constitutes the major cost of livestock operations, especially in the Arab countries where local feed production is limited and costly. Given the scarcity of arable lands in most of

TABLE 1 CATTLE MILK AND CHICKEN MEAT PRODUCTION IN FOUR REPRESENTATIVE ARAB COUNTRIES AND RELATED NUMBER OF ANIMALS (COMPILED FROM FAOSTAT, 2014)

	Somalia		Syria		Morocco		Saudi Arabia	
Livestock item	**2000**	**2012**	**2000**	**2012**	**2000**	**2012**	**2000**	**2012**
Milk Cattle (heads)	1,150,000	1,235,000	458,947	619,665	1,308,000	1,555,000	84,286	162,000
Milk Production (tonnes)	430,000	480,000	1,156,393	1,604,349	1,184,500	2,500,000	710,000	1,750,000
Chicken meat (x1000 heads)	4,000	4,500	106,602	102,000	310,000	500,000	483,000	567,000
Chicken meat production (tonnes)	3,200	3,600	106,602	138,202	250,000	560,000	483,000	567,000

FIGURE 1 EXPORT AND IMPORT OF LIVESTOCK PRODUCTS IN GCC, OTHER ARAB AND TOTAL ARAB COUNTRIES (IN MILLIONS OF DOLLARS). NUMBERS IN RED REFER TO THE HUMAN POPULATION NUMBERS IN 2011. (DATA EXTRACTED FROM FAOSTAT, 2014).



the Arab countries, there's a challenging choice to be made between using the land for human food production or for animal feed. Feed production in the region is mostly rainfed with low productivity. Attempts to increase local feed production through irrigation have resulted in heavy drainage of the non-renewable water resources thus prompting the termination of such programs in countries were the water reserves have been depleted.

The cases of Saudi Arabia and the UAE are a clear illustration of the impact of feed production on water resources (analysis extracted from the USDA produced "Saudi Arabia, Grain and Feed Annual Report", 2013 and the United Arab Emirates 2012 report "U.S. Hay exports to the UAE on the rise")

Saudi Arabia

In the 1990's Saudi Arabia set a target to achieve self-sufficiency in wheat, leading to the cultivation of large areas of wheat that were 100 percent irrigated. However, with time there was an increasing concern about the depletion of the country's non-renewable water resources. Consequently, the government started by banning the export of domestically grown forage, and then in 2008 it launched a new policy to gradually phase out wheat production by 2016. The same is also being considered for other grains and forage production that's also very water demanding.

United Arab Emirates

The Saudi story was reflected in the UAE. The UAE had some domestic forage production and imported their remaining needs mostly from Saudi Arabia. With the Saudi ban on export, UAE farmers resorted to growing their own forage. However, here again the government of Abu Dhabi realized that non-renewable water resources reached critically low levels and decided to phase out commercial forage production and offer subsidies on imported feed costs for local farmers, mainly in Abu Dhabi.

In many Arab countries, such a scenario is likely to be repeated given the fragility of the water resources. Therefore feed (forage and grain) imports are unavoidable and are expected to

INVESTING IN PASTORAL COMMUNITIES IN THE HORN OF AFRICA'S MARGINAL AND DRYLANDS: ISLAMIC DEVELOPMENT BANK INITIATIVE

Nur Abdi

The Drylands regions in East Africa constitute the arid and semi-arid regions characterized by low (less than average annual of 400 mm) and erratic precipitations. The bulk of the Drylands in the East Africa is a pastoralist habitat and is home to the largest aggregation of traditional livestock producers in the world, estimated at over 40 million pastoralists and agro-pastoralists. Djibouti and Somalia have the greatest proportion of their populations in pasture-based production systems (71 percent and 76 percent of the populations respectively); while Sudan has the largest pastoral and agro-pastoral populations (7.4 percent). The GCC and other Arab countries (e.g. Egypt) are the primary export markets for these three countries' livestock exports.

Livestock production is the primary means of livelihood within the Drylands in the East Africa region. Pastoralists maintain a traditional approach to animals, seeing them as a store of value and a source of protein. For pastoralists across Eastern Africa poverty, famine, and war have become a way of life. These arid,

increase consistently with intensification. In 2013-14 Saudi Arabia was the major importer of barley from the European Union (EU), buying 46 percent of the total EU barley exports estimated at 6.8 million tons; whereas Egypt was the major maize importer from the EU with a share of 19 percent of the total EU exports estimated at 2.5 million tons (EU, 2014). Considering the import value of only four major feed ingredients – Alfalfa meal and pellets, maize, barley and soybeans – the Arab countries imported the equivalent of US$10.4 billion worth of feed in 2012, up from US$2.8 billion in 2000 (FAOSTAT, 2014). In order to alleviate the dependency on foreign imports, policies are being adopted to ensure grain stocks are maintained to leverage against any unforeseen drop in supply. Furthermore, the Saudi government launched the King Abdullah's Initiative for Saudi Agricultural Investment Abroad, encouraging large farmers to invest in foreign countries to secure their supply of forage and grain (Al-Obaid, 2010). Similar initiatives also exist in other wealthy Arab countries.

Under these conditions, industrial animal production in Arab countries becomes financially and ecologically costly in comparison to imported animal products. The ecological cost is mostly represented by the virtual water footprint of these systems where "the virtual water content of a commodity is the volume of water used to produce this commodity". In the case of live animals this means "the water content of their feed and the volumes of drinking and service water consumed during their lifetime" (Chapagain and Hoekstra, 2003). For instance, the estimated global average virtual water content of dairy cows, raised under industrial systems, at slaughter age is 85,955 m^3/ton whereas that of sheep and goats raised under grazing system is 6,435 and 6,692, respectively. Overall, Middle East countries in general are heavy net importers of "virtual water" in relation to livestock trade with an import balance estimated at 13.6 Gm^3/yr; Egypt leads the Arab list of net importers with 2.9 Global m^3/yr (based on 1995-99 data reported by Chapagain and Hoekstra, 2003). Breaking down this water footprint, feed production seems to be the highest contributor to the livestock production's global footprint, as compared to grazing and direct water needs. This is illustrated by table 2 extracted from Mekonnen and Hoekstra.

pastoralist communities face serious challenges: drought, desertification, conflict, inadequate access to potable water, food shortages and insufficient infrastructure including schools, hospitals and roads. When drought strikes in pastoralist communities, food becomes scarce and the number of animals needed to buy food increases. Simultaneously, animals become thin and lose their value or die. Without any other way of saving and without other assets, the impacts of drought can turn into famine and quickly cripple entire communities.

In order to address these challenges, the Islamic Development Bank (IDB) launched in 2012 the East Africa Drylands Program covering three countries – Somalia, Djibouti and Uganda. The overall objective of the program is to reduce the vulnerability and build the resiliency of populations living in the pastoral regions in the program areas. The program is implementing interventions that will strengthen livelihoods and improve community services through community-based health, education, livestock/drylands agriculture production, veterinary services and community-based approaches to natural resource management. They build on traditional law and institutions, so that all local stakeholders can participate in and benefit from the sustainable environmental management.

The total investment of the program is USD 71 million, financing a wide range of interventions including: Livestock and Drylands Agriculture; Environment and Natural Resource Management; Health and Nutrition; Education; Rural Infrastructure, Water and Sanitation; and Community Business Development. The program is impacting the lives of more than one million people, representing 25 percent of the total pastoral population in the three countries. The program, when completed in 2018, will (i) increase in the level, diversity, and stability of household income and assets of target pastoralists; (ii) increase the primary education enrolment rate; (iii) improve community access and use of health services; (iv) improve community understanding and practice of the good use of the natural resources; and (v) improve community business capacities and participation in the market.

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On the other hand, rangelands are a valuable feed resource capable of sustaining animal production if managed wisely. However, repeated policy interventions have led to the degradation of rangelands due to overgrazing as manifested by increased desertification reaching 80 percent in some areas and leading to heavy loss of biodiversity (Kassas, 2008). Neely et al. (2010) summarize the implications of this loss as leading to increased vulnerability to climate change and decreased food security. The following is a brief summary of the implications of biodiversity loss based on Neely et al. (2010) and Kassas (2008):

- Loss of soil cover leading to soil erosion
- Loss of resilient species (up to 1700 species are believed to be endangered due to unsustainable livestock management)
- Loss of habitat and subsequent loss of other animal and/or plant species

TABLE 2 **THE GLOBAL WATER FOOTPRINT OF ANIMAL PRODUCTION FOR THE PERIOD 1996-2005 (GM^3/YR).**

Water footprint of animal production	Green[1]	Blue[2]	Grey[3]	Total
Water footprint of feed crop production	1199	105	159	1463
Water footprint of grazing	913	–	–	913
Direct water footprint of livestock[4]	–	46	–	46

[1] the volume of water withdrawn from the global blue water resources: surface water and ground water.
[2] the volume of water used from the global green water resources: water stored in soil as soil moisture.
[3] the volume of freshwater that is required to assimilate the load of pollutants.
[4] Water footprint of drinking, servicing and feed mixing.

- Loss of plants with pharmaceutical and medicinal properties
- Decrease in productivity and therefore in capacity to support grazing.

C. Policy Impact

The livestock sector was affected by a long history of arbitrary policies that strained the sector and led to the degradation of the scarce natural resources available to support it. The chain of events leading to this situation was fueled by important changes during the second half of the past century most importantly the rapid increase in wealth and population numbers leading to high demand for livestock products. Consequently, Arab countries introduced policies to increase production to meet the rising demand. However, these policies have been centered on the provision of cheap food for the urban population, leading to interventions that were “urban biased”, disregarding the needs and impacts on rural farmers and the natural resources (Dixon et al., 2001). Other policies were further motivated by the concern to alleviate the effect of periodic drought and disease spells on the most vulnerable producers, but have failed to achieve the desired objective. These interventions could be summarized as follows (compiled from Oram (1998)’ Al Ruwaily (1999), and Bourn (2003)):

1. Price support for livestock: this has led to increasing the number of animals irrespective of the available resources to sustain them with heavy reliance on government support. Furthermore the untargeted nature of these subsidies allowed large wealth accumulation of already large farmers while small holders benefited the least.

2. Price support for cereals: leading to production expansion into marginal lands without any soil conservation measure which was further exacerbated by the subsidy of fuel and mechanization allowing agriculture expansion into previously inaccessible rangelands and extended grazing by livestock.

3. Nationalization of grazing lands and attempts to sedentarize nomads: the rangelands were open for use and abuse by livestock owners and grain growers thus leading to decreased soil productivity and loss of biodiversity, and land entitlement disputes.

4. Subsidized vaccines: although at heavy price, some governments opted to intervene for the eradication of certain animal diseases through vaccination. This has helped in maintaining large animal numbers

5. Biodiversity conservation: As a remedy attempt to the degraded state of the lands, there is increased interest in assigning large lands as natural reserves for promoting the regeneration of biodiversity. These areas are off-limits for grazing.

The result of such policies is the current situation the Arab countries are facing namely a large number of low productivity animals with degraded natural resources that are insufficient to support them, thus leading to heavy reliance on government support or shifting to other activities mainly in urban areas. This situation aggravates the vulnerability of the rural livestock farmers to poverty and food insecurity and creates an economically and socially delicate balance with constant threat of strife over water and land resources within and across countries.

D. Forecast 2030

Having overviewed the state of the livestock sector in the Arab world until today, the following section presents the expected forecast for the coming 20-30 years.

The population in the Arab countries is expected to maintain its high growth rate, becoming increasingly urban and consuming more animal products. "Meat consumption will increase by 104 percent and milk consumption will increase by 82 percent. Increases in consumption of animal products will be more pronounced in oil-rich countries—nearly doubling from 2000 to 2030—driven by surging income and population growth", according to the World Bank, FAO and IFAD report (2009).

However, increasing production to meet this demand will be more challenging based on the expected aggravation in desertification and the urban expansion on arable land. In the Middle East and North Africa region, which comprises a large number of the Arab countries, it is estimated that available renewable water will be as low as 500 cubic meters per capita and that arable land will shrink to 0.12 hectares per capita by the year 2050 as reported in the World Bank, FAO and IFAD report (2009).

The area will be also hard hit by the effects of global warming; and the Middle East and North Africa are expected to be the most affected (Brown and Crawford, 2009). Elasha (2010) describes the projected effects of global warming on the Arab countries: Temperatures could increase by 4oC in some countries with a decrease in rainfall of more than 30 percent, thus making the area threatened by desiccation. Naturally this will affect the agricultural yields which are expected to decrease by 21 and up to 40 percent in value in some Arab countries.

III. A NEW LIVESTOCK REVOLUTION

The forecast for the future looks alarming with increasing challenges facing the livestock sector. The demand is driven by structural factors such as increased population rate and urbanization, while production is drastically hindered by desertification and global warming. Within this context, trends for further intensification to meet urban demand are inescapable, while resource-driven extensive systems with limited growth potential could still sustain the subsistence of millions of poor Arabs from arid land for which there is no alternative use. These developments will be presented below with their relative merits and shortcomings, putting a special emphasis on their impact in improving food security and food sovereignty in the Arab countries.

A. Sustainable Intensification

The increase in production to meet the rising demand is and will be mostly driven by large scale intensive production farms, in what has been coined the "Livestock Revolution". These are described by Rota and Thieme (2009) as mostly privately owned with high input, capital and technology dependency. The growth of this system has been largely unregulated and had contributed to the negative outlook of the livestock sector blaming it for environmental damage, greenhouse gases, land and water resource degradation, deforestation, desertification, zoonotic diseases, nutritional disorders, etc. In the Arab countries, the heaviest toll of this system is its impact on water

TABLE 3 **SUMMARY RESULTS OF THE WATER EFFICIENCY PROGRAM AT A DAIRY FACILITY**

Water savings	160,000 m^3/year
Financial savings	US$153,000 /year
Approaches used	Reduction and reuse
Key success factors	Top management support; systemic approach; effective monitoring; employee involvement

resources. This impact may be direct through the freshwater water and service requirements of the animals and more indirectly through the requirements of feed, whether locally produced or imported.

The high water needs of an intensive livestock system draw heavily on the scarce water resources, but also impose heavy expenses on the system. For this reason, large companies are looking for ways to improve their water use efficiency and thus reduce their costs, such as the case of a major intensive dairy farm in Saudi Arabia as presented in the AFED Water efficiency handbook (Table 3). Such approaches are highly needed although they may not be enough.

Chapagain and Hoekstra (2003) observed that the heaviest water impact of the intensive livestock production systems is indirectly through their high dependency on concentrate feeding while the animal production system that puts the least pressure on freshwater resources is based on crop residues, waste and roughages feeding. For instance, the blue and grey water footprint of one ton of bovine meat is estimated at 1001 m^3/ton, whereas that of one ton of sheep/goat meat is 510 m^3/ton (Mekonnen and Hoekstra, 2010), thus making the reliance on bovine meat in arid and semi-arid areas a heavy choice for the non-renewable water resources.

Furthermore, the growth of industrial livestock production, while filling an important gap in the demand of the urban and relatively rich population, has mostly by-passed the small-producers and rural poor. A regulatory framework with a heavy implication of the public sector is needed to address the environmental and public health impacts of this system, as well as the needs of the urban poor consumers (Dijkman, 2009).

Mixed production and pastoral systems which are widely spread in Arab countries are resource driven with dependency on land and feed availability. The vast majority of the agricultural population in the Middle East and North Africa falls under these systems. Mixed systems are characterized by strong interaction between farming and livestock; whereby feed grains and forages are often planted for grazing or harvest whenever the yield is adequate, and livestock benefit from the feed produced and through grazing different crop residues (Gibbon, 2001). Livestock also play a role in enriching the soil with manure for improved productivity and as draught power for working the land. Mixed systems provide the advantage of offering a diversified source of income thus minimizing risk resulting from natural or market related sources, and to improve the use of labor and add value to crops and crop residues (Blackburn, 1998). These systems have been the target of research driven technology projects in the 70s and 80s that have largely failed because of their bias towards big producers as mentioned by Rota and Thieme (2009). Similarly national policies have largely bypassed these systems in favor of satisfying the demand of growing urban population. Improving the sustainability of these systems and maintaining their role in poverty alleviation and food security depends on the establishment of strategies targeting sustainable use of resources, improved productivity through access to appropriate technology and investment, supporting policies and an institutional framework to open access to markets and protect the sector, and access to health and other services (Van de Steeg et al., 2009). The Arab countries have a large margin of potential improvement at this level by focusing new strategies on the comparative advantage of each country in terms of natural, capital and technological resources to develop a sustainable livestock sector as an integral part of a wider Arab Food Security strategy.

B. Tradition for the Future

Mobile pastoral systems are among the most resilient livestock systems to climate change, with a large margin of flexibility in adapting to new constraints through mobility, modifying stock numbers, and diversifying the sources of income (Dick, Ghanem, and Hamadeh, 2008). At the

heart of these systems lie the amazingly adapted local breeds of camel, sheep and goats (Warde and Dawa, 2005; Jaber, Chedid, and Hamadeh, 2013), and to a lesser extent cattle, as well as the indigenous time-tested know-how of the local herders and pastoralists.

Nomadism in the Arab countries is a long standing tradition based on the movement of herds from areas of low water and vegetation to more plentiful regions (Kassas, 2008) based on the sustainable rotational use of the land known as the "Hema" system. Such pastoral systems have traditionally conserved biodiversity because of the direct interest of the pastoralist in maintaining a wide range of products for their animals as well as for their own use such as medicinal plants, gums and resins (Haan et al., 1996). These systems are also the least costly in terms of reliance on non-renewable water resources. Mikonnen and Hoekstra, 2010 noted that the most important water footprints to account for are blue and grey water, given that green water has a lesser impact on freshwater problems in general. Accordingly, the authors conclude that although grazing systems have greater total water footprints, they are still preferable from the water resources point of view, since they rely less on blue and grey water as compared to the industrial production systems.

However, the survival of these systems is being increasingly challenged by environmental constraints, global market forces and inappropriate policies, resulting in the encroachment of rangelands due to population growth and expanding agriculture, increased animal numbers leading to overgrazing of ever shrinking rangelands, and reduced mobility leading to degradation of the limited lands available for grazing (Haan et al., 1996).

On the other hand, Neely et al. (2010) point to the positive role that nomadic livestock systems can play in preserving rangeland biodiversity through species composition and litter accumulation, in addition to helping in carbon sequestration, if provided enough flexibility of movement based on the traditional time-tested methods. Protecting and improving the livestock genetic resources, while preserving the proud tradition of their keepers in sustainable land use management, as exemplified by the Hima system, is of prime importance to transform the biomass of arid and semi-arid regions into highly nutritious products. In addition, national policies aimed at increasing production should also provide secure access to natural resources, climate change mitigation measures, while promoting pastoral mobility and enhancing access to market and veterinary services (Nouala, 2009).

A case in time is that of Mauritania. Ficarelli (2009) briefly describes the transformation of the country from rainfed cereal production to pastoral livestock production including camels, sheep, goats and Fulani cattle, with meat exports now representing 20 percent of the country's GDP. In addition, milk and protein have become the staple food of the poor. The author stresses the importance of considering such success stories in view of global warming with an expected 4oC increase in temperature, which makes crop production almost impossible in the arid and semi-arid areas, while the adapted livestock breeds of the region can sustain production and reproduction using the scarce available vegetation and transforming it into highly nutritious products for consumption and trade. However, this transition "back" to pastoralism, such as in Mauritania, needs a supportive framework and policies as described above.

IV. CONCLUSION AND RECOMMENDATIONS

As outlined in the previous section, the "New Livestock Revolution" relies heavily on a supportive regulatory framework, policies and services that are needed to ensure an equitable growth of the sector aiming to satisfy the increasing demand while at the same time securing the livelihoods and food security of the rural and urban poor. The basis of such a framework has been elaborated through the publications of the FAO "Pro-Poor Livestock Policy Initiative" that was launched in 2001 to "formulate livestock sector and related policies and implementation plans that reduce poverty, whilst managing environmental and public health risks" (FAO, Pro-poor livestock policy initiative, 2014). These publications are a handy tool for practitioners and policy makers providing a wide option of policy considerations that could be adapted to each country's specific situation. Similarly the particular needs of the Middle East and North Africa region in terms of policies and interventions to address the agricultural and livestock issues have been detailed by Gibbon (2001), from the perspective of the different production systems. In the following sections, the recommendations for moving the livestock sector in the Arab countries toward a Food Secure 21st century will be described.

1. *Regulation of the intensive production systems through public policies.* In order to be sustainable, intensive demand-driven production systems need to be responsible for the environmental impact of their activities. These include:

   a. Mitigating environmental pollution through proper waste management.

   b. Water use efficiency to optimize the output for every liter of water used.

   c. Strict health and hygiene control to prevent animal and zoonotic disease outbreaks

   d. Product quality control.

   e. Sustainable use of land resources with special considerations for small holders' fair access to grazing areas.

Public laws and policies are needed to enforce the above.

2. *Support for mixed farmers.* Mixed farmers are constantly challenged by low productivity, competition and variable access to resources and services. Regulatory policies and supportive intervention are needed in order to:

   a. Provide access to market. This could be achieved through initiatives for product collection and transport in refrigerated vehicles, local products labeling and promotion initiatives, and fair pricing.

   b. Improve productivity. This necessitates access to technology and targeted research to serve the needs of the sector. Training and education initiatives are also needed to help the farmers make the best use of their available resources for animal production.

c. Animals' health. Veterinary services are largely lacking for small mixed farmers who either don't have access to specialists or can't afford them. This should be amended through dedicated services by the public sector.

d. Access to capital. Small farmers would greatly benefit from targeted and facilitated investment options that would give them leverage to improve and adapt their situation in view of ever changing constraints.

A special note should be made for the particular case of peri-urban farmers, who are gaining ground given the rise in urbanization. These farmers have the advantage of being closer to the market than their rural counterparts and they often rely on food byproducts as feed for their animals. Policies facilitating their access to industrial food byproducts would be beneficial, in addition to improved veterinary and environmental supervision by the public sector to ensure their safe integration in their urban setting in close proximity to large human dwellings.

3. *Facilitating pastoralism.* Needless to say, pastoralists would benefit from all the above services and support suggested for mixed farmers. In addition, they need special policies to support their mobility and access to grazing areas. Based on their solid know-how, they are well equipped to make the best use of the land if given enough freedom to move their flocks between available grazing sites. National effort should be also made to preserve and improve the local breeds and their genetic resources that are at the heart of this highly adapted production system.

4. *Integrated Arab food security based on comparative advantage.* As previously said, Arab countries are major importers of animal products – the major suppliers seem to be from non-Arab countries. However, inter-Arab trade in live animals is more dynamic, especially between African and non-African Arab states. The GCC countries seem to be the drivers of this trade with live sheep, goats and cattle imports from Yemen, Sudan, Jordan, Syria, Iraq and other non-Arab countries although the actual statistics of the across border animal movements are difficult to verify (Bourn, 2003).

   Many factors render this trade sector vulnerable thus threatening the livelihood and food security of the pastoral and agro-pastoral communities involved. These are described in several reports: "Cross-border Livestock Trade Assessment Report" (FEWS, 2010), "Promoting intra-Africa trade in animals and animal products" (Mankor, 2013), and "The Promotion of the Livestock Industry for Food Security in Africa and Arab countries" by Hassane, 2013. They can be summarized as follows:

- Climatic uncertainty and drought spells leading to lower production.
- Diseases outbreaks and weak veterinary and certification services leading to import/export difficulties.
- Dependency on limited market outlets and lack of market information.
- Lack of processing and diversification of exportable livestock products.
- Constricting policies and political instability.
- Lack of abattoirs and transportation infrastructure.

The reports concur that addressing these hurdles is necessary to improve livestock trade.

This brief overview of the livestock sector in the Arab countries has helped in highlighting large differences in production, demand, import and production systems across the countries. Arab countries collectively have a great potential to ensure their animal food security; harsh climate is often compensated by great wealth while on the other hand economic hardship can be alleviated by vast arable lands and animal numbers. A collaborative approach to address food security is highly needed, preferably through a dedicated governing body. In the context of the livestock sector, such collaboration would facilitate the preferential trade of products between the Arab countries and widen the market access to local producers. Having shared food preferences, Arab countries are at an advantage to serve each other's needs and preserve their traditional animal products market. A well-organized investment in targeted research and services would greatly improve the production and quality to help reduce the high import dependency in most Arab countries. Such collaboration could also help pastoralists' movements in search of grazing areas. Last but not least, Arab collaboration is needed to preserve the rich nomadic heritage where animals played a central part and to promote valued food traditions that have stood the test of time.

Livestock are an essential contributor to food security, particularly in the Arab countries where arid and semi-arid lands are prevalent. The Arab population is growing at a fast rate and getting increasingly urbanized. With these changes demand for animal products and feeds is greatly increasing particularly in relation to increased wealth in the GCC countries. In order to improve food security, it is important to limit the import dependency. This could be achieved by increased production through intensive input and capital-dependent systems and the traditional mixed farming and pastoralist systems. The success in reaching food security will depend on implementing well drafted policies targeting the regulation of the large intensive producers and providing support and services to small holders and pastoralists. Arab collaboration is of prime importance to improve the use of the collective resources for livestock production and help filling the gaps in each country's needs through mutual and coordinated support.

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ANNEXES

ANNEX 1

FOOD PRICE VOLATILITY AND IMPLICATIONS FOR ARAB FOOD SECURITY

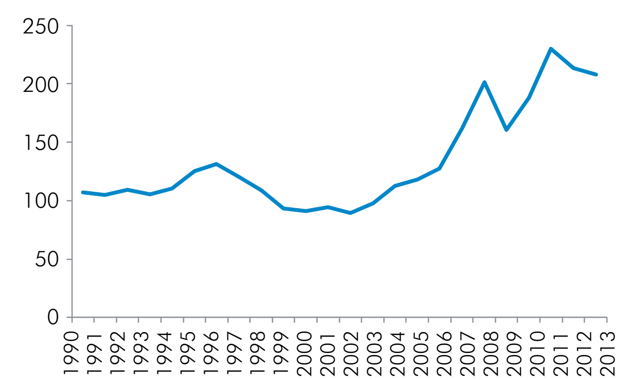
Hafez Ghanem

The period since 2006 has been one of high food price volatility, and most observers expect that the trend of higher and more volatile food prices will continue over the medium term. Arab countries are particularly affected by this volatility because they are major food importers and are highly dependent on world markets for their food and nutrition security. This note describes the implications of price volatility on Arab food security and suggests some policy options to help deal with volatility. Those options include: (1) import and food reserve strategies; (2) increasing domestic food production by supporting smallholders and family farmers; and (3) increasing international investment in agriculture.

Global Food Prices are More Volatile

Figure 1 shows that after a long period of low and relatively stable food prices things began changing from about the beginning of the 21st century as global prices rose and became more volatile. This change reflected a shift in market fundamentals. World food markets became tighter because the rate of increase in agricultural yields slowed down as a result of lower investments. The annual rate of growth of global capital stock in primary agriculture fell from 1.1 percent in the period 1975-90 to 0.5 percent between 1991 and 2007. As a result, productivity growth declined. For example, the rate of growth of cereal yields dropped from 3.2 percent per year in the 1960s and 1970s to 1.5 percent in 2000. At the same time the demand for food increased due to the increase in population and rising incomes which led to a shift toward consuming more meat and hence an increase in the demand for animal feed and the derived demand for cereals.

FIGURE 1 **FAO FOOD PRICE INDEX 1990-2013**



The low level of food stocks being held around the world also contributed to higher price volatility. Many public as well as private market participants reduced the amount of inventories that they hold as a security stock in order to lower costs. This meant that nearly all of the adjustment to production shocks had to be through cuts in consumption, via higher prices, rather than via reductions in stocks as was often the case in the past.

The FAO and the OECD expect that food prices will continue to be high and volatile over the medium term. They provide three main reasons for this. First, the linkage between the food and fuel markets is getting stronger as a result of the development of biofuels. Since world fuel prices tend to be more volatile, this would mean that food prices would also be more volatile. Second, climate change and the greater frequency of extreme weather occurrences would imply more supply shocks and hence higher price volatility. Third, production is moving toward potentially more fragile regions, and world markets are becoming more dependent on supply from such regions (e.g. the Black Sea area). Yields in those regions are less stable and that is causing more world price volatility.

Many observers also argue that increased "financialization" of commodity markets and the rise in speculation is a major cause of higher food price volatility. The returns on commodity futures seem to be negatively correlated to the returns on stocks and bonds. Thus, they are an attractive vehicle for portfolio diversification. Non-commercial actors (i.e. actors who are not involved with the physical product) have doubled their share of open positions in wheat, corn and soybean futures between 2006 and 2011. The tendency of those investors to behave as a "herd" buying or selling large quantities at the same time has been blamed for magnifying changes in food prices and thus contributing to greater volatility.

Moreover, policy measures put in place by a number of governments in times of crises (such as export restrictions or hoarding) increase international price volatility. For example, according to analysis carried out by FAO the sharp increase in rice prices in 2008 can be mainly attributed to government policies. Changes in market fundamentals cannot explain why rice prices doubled in 2008, and there are virtually no forward markets for rice so speculators cannot be blamed for this episode.

The Effects of Food Price Volatility on Arab Countries

Arab countries are particularly affected by those international developments. They are the largest cereal importers in the world and depend on world markets for 50 percent of their caloric intake. Table 1 presents the production and consumption balances for key food commodities for the whole Arab region in 2011. It shows that in addition to cereals, the Arab world has a huge deficit in pulses, sugar, and fats and oils. Moreover, due to an increasing population and land and water constraints on Arab agriculture, this import dependence is likely to increase so that by 2030 nearly two-thirds of the food consumed in Arab countries will be imported.

TABLE 1 ARAB COUNTRIES' BALANCES OF KEY FOOD COMMODITIES, 2011

Food item	Production	Consumption	Self-Sufficiency Ratio (%)
Cereals	54.5	119.6	45.6
Pulses	1.4	2.4	58.3
Vegetables	51.8	48.1	107.7
Fruits	33.2	31.9	104.1
Refined Sugar	3.2	8.7	36.8
Fats & Oils	2.2	4.0	55.0
Meat	8.4	11.0	76.4
Fish	3.9	4.0	97.5
Eggs	1.6	1.7	94.1
Milk & Dairy Products	27.8	37.5	74.1

Source: Arab Organization for Agricultural Development, Statistical Yearbook.

Nearly all Arab countries are highly dependent on imports for their food and nutrition security. This implies particular challenges in periods of high volatility on world markets. Importing countries face two types of risks: the risk of price hikes and the risk of a disruption in physical supply. Arab countries' demand for food imports, particularly cereals, is highly inelastic, which means that they are unable to reduce imports in response to a price increase and therefore have to bear the full impact of the high prices. Moreover, in times of shortages countries sometimes place export bans. Thus, Arab countries could be unable to have access to food imports at any price. Food supplies could also be disrupted by war, civil strife or natural disasters.

In terms of vulnerability to food price volatility Arab countries could be divided into three groups. The first group is the most vulnerable to both price and supply shocks. This is a group of countries that is highly dependent on imports and at the same time faces binding constraints on fiscal and foreign currency resources. This group would include countries like Egypt, Jordan, Lebanon, or Tunisia. The second group is less vulnerable to price shocks because it has sufficient fiscal resources and international reserves, but is vulnerable to supply shocks because it is highly dependent on imported food. This group would include countries like Kuwait, Saudi Arabia, or the United Arab Emirates. The third group is the least vulnerable because it is less dependent on the international market for food security. This group could include Morocco and Syria (in times of civil peace).

Increasing Food Reserves and using Financial Markets for Risk Reduction

Arab countries need to develop strategies to protect their food security in a world of high and volatile prices. Holding larger physical food reserves is a possible option. Countries need to maintain food security emergency reserves to assist the most vulnerable without disrupting normal private sector market development which is needed for long term food security. The size of such emergency reserves depends upon countries' specific circumstances.

Table 2 shows that in spite of being the world's largest importers of wheat no Arab country, except Egypt, appeared among the top 10 holders of wheat reserves in 2010. That is changing as several Arab countries are investing in silos in order to hold larger quantities of emergency stocks. However, holding food stocks can be expensive. FAO and the World Bank estimate that storage of one metric ton of wheat costs US$2.15 per month. Therefore, there is a need to weigh the costs and benefits of holding larger emergency reserves.

Another area that deserves special attention by Arab food importers is the use of financial markets for risk reduction. Countries around the world are increasingly using financial risk hedging instruments to insure against volatility — e.g. Mexico has used these instruments to fix the price of its corn imports and avoid another 'tortilla crisis'. Future contracts

TABLE 2 **THE TOP 10 HOLDERS OF WHEAT STOCKS, 2010**

Countrie	Percent of global wheat stocks	Percent of global wheat imports
China	31	0.7
USA	12	2.0
India	8	0.2
Russia	7	0.1
EU	6	3.5
Canada	3	0.5
Egypt	3	8.1
Iran	3	0.4
Australia	2	0.1
Ukraine	2	0.1

Source: FAO and World Bank, 2012.

TABLE 3 **RELATIVE IMPORTANCE OF HOLDINGS OF LESS THAN 5 HECTARES**

Countrie	Share in Total Holdings (%)	Share in Land Area (%)
Algeria	55.4	11.3
Egypt	98.2	70.7
Jordan	78.9	23.8
Lebanon	96.7	60.1
Morocco	69.8	23.9
Qatar	73.3	3.4
Tunisia	53.5	10.9
Yemen	93.0	43.9
Average	84.2	25.3

Source: FAO, Agriculture Census Data.

are one way of managing commodity price risk. They require the buyer to purchase a fixed quantity at a fixed price at a predetermined future date. Buyers need to obtain credit or guarantees to cover the value of this contract.

Another alternative, which is particularly attractive to countries with less easy access to credit, is to use option contracts. These contracts give the buyer the right, but not the obligation, to purchase a fixed quantity of a commodity at a fixed price at some future date. They act like an insurance against high prices because if prices fall, the buyer can decide not to use the option and thus only lose the premium which is paid up front in cash. A famous example of the use of options comes from Malawi which bought options to purchase maize in 2005. The price of maize increased and Malawi exercised the option, saving about US$5 million.

Increasing Domestic Production by Supporting Smallholders

Vulnerability to international market volatility could also be lowered by reducing dependence on those markets through higher domestic production. But food production in Arab countries is limited by scarce land and water resources. The pressure on land is increasing as populations continue growing so that by 2050 arable land per capita will only be 0.12 hectares, which is a fall of about 60 percent from its levels at the end of the twentieth century. For comparison, arable land per capita today in Europe (where the population is not growing) is 0.4 hectares. From 1950 to the present, per capita renewable water resources have fallen by some 75 percent. They are expected to decline by an additional 40 percent in 2050 (even without factoring in the potential impact of climate change). Today, water per capita in the Arab world is about 850 cubic metres compared to a world average of 6,300 cubic metres.

Nevertheless, improvements in food security could still be achieved by supporting local food production, especially by smallholders and family farmers. Agriculture is an important sector in the Arab world: about 25 percent of the labor force is employed in agriculture and about 40 percent of the population lives in rural areas and their livelihoods are therefore either directly or indirectly affected by agriculture. Agriculture provides a livelihood for poor and food insecure people. Rural poverty rates in Egypt and Morocco are three times higher than urban poverty rates. More than 57 percent of the Sudanese who live in rural areas are poor, as are more than 40 percent of rural Yemenites.

The vast majority of Arab agriculture is carried out by smallholders. Table 3 shows the relative importance of small family farms (less than 5 hectares) in a sample of Arab countries. It shows that about 84 percent of all holdings are under family farming. The importance of family farming appears to be quite uniform across different parts of the Arab world. For example, 73 percent of agricultural land holdings in natural-resource-rich Qatar are under family farming as are nearly 70 percent of holdings in Morocco. Countries with a lower per capita income, such as Egypt or Yemen, tend to have a larger proportion of smallholders. About 98 percent of holdings in Egypt and 93 percent in Yemen are under family farming.

Table 3 also shows that while 84 percent of holdings are under family farming they only control 25 percent of the cultivated area. That means that about three-quarters of agricultural land is under large corporate-type farming. This reflects the

dualistic nature of agriculture in the Arab world, where large numbers of family farms operate alongside big and more modern entities. While family farmers tend to produce for their own consumption (subsistence farming) and to sell to local markets, the large modern farms produce for national and international markets. They tend to have higher productivity and are more profitable than small family farms.

There is a concern that Arab governments have neglected family farming and focused on the development of large-scale modern agriculture. For example, in Egypt the government invested huge sums in the New Valley (or Toshka) project which aims at irrigating about a quarter of a million hectares of desert land by building a 150km long canal from Lake Nasser, south of Aswan. Those large projects often have dubious economic, social and environmental impacts. Developing modern agriculture is a legitimate national objective, but it should not come at the expense of smallholders and family farmers who are key to food security and poverty reduction.

In view of their importance in Arab societies and economies, support to smallholders and family farmers should be central to any policy package that aims at achieving food and nutrition security and poverty reduction. Most observers seem to agree that there is a need to put in place policies and programs that: (1) facilitate farmers' access to credit and investment resources; (2) provide them with insurance against bad weather conditions and other calamities; (3) provide them with secure access to land preferably through titling; (4) help increase farmers' share in value added; and (5) improve the quality of research and extension services and adapt them to the particular conditions of small family farmers. Independent producer organizations and cooperatives ensure that family farmers' voices are heard in policy discussions. Governments alone cannot provide all the necessary services to family farmers; therefore, Arab governments need to support the development of independent producer organizations and cooperatives, and to work in partnership with them, as well as other civil society organizations, to deliver the services that family farmers need.

International Investment

Investing in other countries' agriculture could be an important component of an Arab food security strategy. An obvious impact of such investments is that they would

TABLE 4 **ARAB WORLD'S FOOD IMPORTS IN 2011 (US$ MILLION)**

Total Food Imports	**64,874**
Of which:	
Cereals and flour	23,382
Meat and livestock	9,822
Oil and oil seeds	8,616
Milk products	6,595
Sugar	6,085
Fruits	3,782
Vegetables	1,844

Source: Arab Organization for Agricultural Development, Statistical Yearbook 2011.

increase global food production and therefore the amount of food available on the international market, which would help stabilize prices and ensure continuous supply. Moreover, it is necessary for Arab food security to diversify sources of imports, so that a shock (e.g. drought) in one part of the world does not have an unduly large impact on their market access and the prices they pay. Investment in developing countries' agriculture, which may give them privileged access to imports from those countries, could be one way of achieving such a diversification.

Agriculture investment also offers good business opportunities for the Arab private sector. Table 4 shows that the value of food imports to the Arab world was nearly US$65 billion in 2011. This included about US$23 billion of cereal imports, almost US$10 billion of meat (including red meat and poultry) imports, US$8.6 billion of imports of oil and oil seeds, US$6.6 billion of imports of milk and dairy products, US$6 billion of sugar imports, nearly US$3.8 billion of fruits imports, and US$1.8 billion of vegetables imports. That is, Arab countries represent a huge market for food and other agricultural products with tremendous potential for profits. By investing in developing countries' agriculture and selling to their home markets, the Arab private sector could benefit from a huge demand and a large potential for profits.

To be sustainable, agricultural investments must be designed so that they are win-win-win. In addition to the investors, the host country and the local community must benefit from the project. Experience has shown that any of those three stakeholders can block a project if they feel that their interests have not been adequately taken into account. On the other hand, a strong feeling of project ownership by the government and the local community ensures its success and sustainability. Hence, potential investors need to consider how their projects would benefit their host countries and especially the smallholders who already live and work in the project area.

A key benefit to host countries is the increase in agricultural investment which impacts positively on food security and rural poverty reduction. Public investment in agriculture has started to pick up as a result of the food crises of the last decade and the growing realization that low agriculture investment is a main cause of continued hunger in the world. However, in an era of tight government budgets most of the new investment will need to come from the private sector. That is why many developing countries are opening up their agriculture sectors to foreign private investors.

A major problem with the first wave of agricultural investments is that they did not pay sufficient attention to the needs of local communities, and particularly smallholders in the project area. Governments sold land to investors that they assumed was not being used and for which no one held a title. In reality, land in most developing countries may be underutilized but it is never completely unused. Moreover, in many countries land titling is not sufficiently widespread and people rely on customary laws for land allocation. Thus, those early land acquisitions (either through purchase or long-term leases) by foreign as well as domestic investors has deprived poor rural people from their only source of livelihood and has outraged communities who felt that their customary laws were being violated.

A well-designed investment which respects the local community's rights to its land and its natural resources could bring important benefits to the community, and particularly to the smallholders. Technology transfer is an important potential benefit. Investors can help smallholders increase productivity through better access to new production techniques as well as to the inputs that are required to implement them. The resultant rise in production will improve smallholders' incomes as well as the host country's food security. Investors can also help link smallholders to national and international markets. They do this by helping with quality assurance and marketing, often exporting part of the product to their home countries. Thus, local farmers are able to obtain the best price for their output. Everybody gains from this type of investment.

Conclusion

There appears to be a consensus in the literature that international food prices will remain high and volatile for the foreseeable future. This will certainly affect Arab food security and most governments have taken steps to protect their citizens' food security in the face of greater volatility. In this paper I have presented three possible actions to reduce the impact of volatility on Arab food security: increasing food reserves and making better use of financial markets to hedge price risks; increasing domestic food production by supporting smallholders and family farmers; and increasing international investment in agriculture.

This paper focused on increasing food supply, but food and nutrition security could also be improved by rationalizing consumption and reducing waste. While some Arabs suffer from hunger and food insecurity, others suffer from the over-consumption of unhealthy foods like white bread, sugar and fats and oils. Obesity, high intake of animal fat, and low intake of dietary fibre are risk factors for chronic non-communicable diseases such as coronary disease, diabetes and breast cancer. For example, the obesity rate in Egypt is 45 percent, which is even higher than in the United States (32 percent). Arab governments need to carry out policies to improve nutrition, which will have to include efforts to discourage over-consumption.

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ANNEX 2

DEVELOPING FISH RESOURCES IN THE ARAB WORLD

Tariq Al-Zadjali

Food security with its many aspects is a key question that must be addressed collectively by Arab states by concentrating coordination and enhancing cooperation as part of the Emergency Arab Food Security Program and the Strategy for Sustainable Arab Agricultural Development (2005-2025). The Emergency Program includes a commodity framework consisting of cereals (wheat, barley, rice, maize and sorghum), sugar crops (sugar cane and sugar beet), oil crops (peanut, sesame, sunflower and olive oil), animal and fish products, and dates.

The Arab World is rich with large fish resources providing healthy and cheap proteins to Arab citizens, compared to animal proteins from other sources. Since the Arab World suffers a shortage in grazing and animal feed resources, which limits the capability to expand meat production, it is very important to sustain the contribution of fish resources in providing animal proteins to the Arab food basket; actually, this sector must be developed to sustainably increase its contribu-tion to the Arab food security system.

First: The Current Status of Fish Resources in Arab Countries

1. Fish Production

The Arab fish production is estimated at almost 4.2 million tons, 75 percent of which is produced in three countries (Egypt, Morocco and Mauritania). Production from fish farming amounts to 25 percent of total production in the Arab World. This is less than the global percentage which is estimated at about 43.8 percent. Fish farming is mainly concentrated in Egypt (Table 1).

2. Arab Fish Exports

The fish resources sector in the Arab World achieved a 638.4 million dollar surplus in 2012; and it was estimated at about 862.58 million dollars in 2013. Six Arab countries contributed together 94.8 percent of the value of Arab fish exports in 2013. These countries are Morocco (59.9 percent), Yemen (11.2 percent), Oman (9.8 percent), Tunisia (7.7 percent), Mauritania (4.4 percent) and Saudi Arabia (1.8 percent).

3. Fish Imports

Despite the Arab World's export surplus of fish and fish products, a number of Arab countries rely on imports to meet shortages in their domestic production of fish and their products. Such imports include fresh, refrigerated and frozen fish, in addition to salted, smoked and canned fish. The fish imports of Arab countries in 2013 were estimated at 950,240 tons, costing 2.09 billion dollars (Table 3), with an increase of 3.4 percent compared to the 2012 cost. The topmost Arab fish importers are Egypt (26.5 percent), the United Arab Emirates (19.3 percent) and Saudi Arabia (16.0 percent).

4. Marketing Systems for Fish and Fish Products

Fish and fish products are marketed domestically in Arab countries through several marketing networks, mainly cooperatives, wholesale markets and open markets (unloading spots). Fish products are sold to wholesalers, who resell the products to intermediaries and retailers before reaching final consumers. In some countries, producers sell products directly to consumers.

Many fish markets in Arab countries are primitive and lack infrastructures, basic services and handling and preservation facilities. This has a negative impact on fish quality and value. Marketing systems for fish and fish products in Arab countries face difficulties, problems and restraints, including:

- Marketing systems are weak and not developed enough to cope with pro-duction developments and domestic and foreign market requirements.
- National legislations regulating fish marketing and trade are weak.
- Marketing margins are high because marketing networks and tracks are too many and the domination of some traders.
- Information related to supply and demand in domestic markets is absent.

TABLE 1 **FISH PRODUCTION IN ARAB COUNTRIES (1,000 TONS)**

Country/Region	2013			Percentage of Total Production
	Fisheries	Aquaculture	Total	
Egypt	434.9	1,017.7	1,452.6	33.9
Morocco	1,169.4	0.4	1,169.8	27.3
Mauritania	646.7	0.0	646.7	15.1
Oman	195.5	0.2	195.6	4.6
Yemen	146.1	11.8	157.8	3.7
Tunisia	112.8	4.4	117.2	2.7
Algeria	100.4	1.8	102.2	2.4
Saudi Arabia	66.0	26.4	92.3	2.2
Other Arab Countries	312.5	36.6	349.1	8.1
Arab World	3,183.2	1,100.1	4,283.3	100.0
World	90,500.0	70,500.0	161,000.0	

Sources: The Arab Organization for Agricultural Development, Arab Agricultural Statistics Yearbook, Volume 33 (Arabic); FAO's website.

- Production is irregular, limiting the capabilities of exporters and hindering adherence to trade commitments.
- Infrastructures for handling, preserving and storing products at unloading points, fishing harbors, markets and sale outlets are weak and derelict.
- Qualified labor is limited and training programs targeting productive, promotion, mar-keting and supervisory sectors are weak.
- Interest in marketing studies and information is weak.

5. Fish Processing

Fish processing in Arab countries is of three different kinds depending on the processing technique used:

- The traditional pattern: Fish is processed on the boats or near unloading points; using the salting or drying methods.
- The semi-industrial pattern: It includes units to produce salted, dried and smoked fish, alongside canned and frozen fish and fish products (fish powder and oil). This pattern takes place in suitable sanitary conditions and is most often done in fish smoking ovens or closed drying and salting or equipment for canning or making fish powder.
- The industrial pattern: Industrialized methods and advanced equipment are used under special administrative and technical systems, and advanced quality control systems are in place.

TABLE 2 **FISH EXPORTS OF ARAB COUNTRIES**

	2012		2013	
	Amount (1,000 tons)	Value (million dollars)	Amount (1,000 tons)	Value (million dollars)
Morocco	383.0	1,641.0	361.0	1,769.8
Yemen	115.3	291.9	130.7	331.1
Oman	114.9	237.6	141.1	289.8
Tunisia	25.3	182.7	32.7	226.8
Mauritania	143.0	119.7	159.5	130.2
Saudi Arabia	28.0	62.1	30.0	54.6
Arab Countries Total	851.5	2,662.6	912.4	2,956.4

Source: The Arab Organization for Agricultural Development, Arab Agricultural Statistics Yearbook, Volume 33 (Arabic).

The most important problems and constraints in fish processing in Arab countries include:

- Primitive canning factories and freezing units in many countries.
- Old processing technologies and a shortage in trained labor and technical expertise.

TABLE 3 FISH IMPORTS OF ARAB COUNTRIES IN 2012 AND 2013

	2012		2013	
	Amount (1,000 tons)	Value (million dollars)	Amount (1,000 tons)	Value (million dollars)
Egypt	224.6	512.5	249.3	554.6
UAE	151.8	361.5	169.4	403.4
Saudi Arabia	217.9	363.0	216.0	335.21
Lebanon	27.3	132.5	27.7	142.2
Morocco	49.7	148.3	36.3	122.8
Algeria	36.1	86.9	42.0	107.8
Kuwait	22.8	74.4	30.8	100.6
Arab Countries Total	918.1	2,024.1	950.24	2,093.81

Source: The Arab Organization for Agricultural Development, Arab Agricultural Statistics Yearbook, Volume 33 (Arabic).

- A shortage in raw materials in terms of quantity and quality (fish and marine organisms).
- Failure to implement the Hazard Analysis and Critical Control Points (HACCP) system.
- Quality control laboratories are either weak or absent.
- A shortage in trained technical personnel.
- A shortage or irregularity in financing for factories.

To develop fish processing operations and their requirements, standardized specifications and quality control must be adhered to. There is also a need to develop rural fish processing industries, technical training on fish preservation and processing must be boosted to upgrade traditional patterns, and current processing industries should be modernized.

Second: Fish Resources Sector Challenges

Challenges facing fish development in Arab countries are similar. The most important challenges include:

- Traditional fishing methods and the technological gap.
- Focus on coastline fishing because Arab fishing fleets are not equipped to fish in deep waters.
- Limited or inaccurate information and statistics on fishing and fish stocks.
- Overfishing and degradation of fish stocks.
- Fishing harbors and unloading spots are limited in number.
- The fishing sector lacks harbor infrastructures, such as maintenance workshops, refrigeration rooms, etc.
- Weak institutional and administrative capabilities and a shortage in strategic plans for the fishing resources sector.
- Weak fish processing capabilities.
- Weak capabilities in relation to fish quality and aquaculture and personnel capacity building in the sector.
- Weakness in research, technology transfer and services in all fields related to developing and exploiting fish resources (fishing, aquaculture, transportation and handling, processing, quality control, marketing, etc.).
- Weak financial, technical and organizational capabilities of fishermen societies.
- Limited credit facilities offered to fishermen by financial institutions.
- Limited investments by governments and the private sector in the fish resources sector.

Third: Development and Investment in the Arab World's Fish Resources Sector

Since the chances for developing fishing in the Arab World's natural fisheries are limited, developing fish resources may have to focus on aquaculture in seawater or inland water bodies. Through this, the Arab World has the capability of increasing its fish products by at least two million tons per year by 2030. Saudi Arabia and Oman, for example, have ambitious plans and programs with available funds, seeking to boost their fish production capabilities. Sudan also has large areas of inland water bodies but needs a strategic plan to exploit them for fish production, together with promoting investment in aquaculture to produce one million tons of fish annually.

Developing fish resources and encouraging investment in this sector in the Arab World require the following:

- Developing laws and legislations related to fishing and aquaculture in Arab countries in order to guarantee sustainability.

- Issuing laws on investment in developing fish resources in natural fisheries and aquaculture.
- A significant increase in investments in the fish resources sector, especially in infrastructures, aquaculture and processing.
- Developing fishing in inland water bodies and freshwater aquaculture.
- Creating a suitable investment atmosphere and specifying investment opportunities in order to attract investments to the fish resources sector.
- Establishing an Arab or regional mechanism to finance the development of the Arab World's fish resources sector.
- Enhancing the mechanisms and techniques of investment promotion in the fish resources sector.
- Establishing a reliable database about the sector, including the size of available resources and the degree of their sustainability.
- Providing infrastructures and supporting services, alongside transportation, storing, processing and marketing facilities.
- Capacity building and developing skills in natural fisheries and aquacultures.
- Encouraging the establishment of joint Arab fish resources production, processing and marketing companies.

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ANNEX 3

VIRTUAL WATER TRADE AS A POLICY INSTRUMENT CONTRIBUTING TO THE ACHIEVEMENT OF FOOD SECURITY IN THE GCC COUNTRIES

Waleed Zubari

The concept of 'virtual water' has been introduced by Tony Allan in the early nineties (Allan, 1993; 1994). However, it took nearly a decade to get global recognition for the importance of the concept of achieving regional and global water security. The "virtual water" content of a product, as often defined, is the volume of water used to produce the product, measured at the place where the product was actually produced (i.e., a production site specific definition). The virtual water content of a product can also be defined as the volume of water that would have been required to produce the product in the place where the product is consumed (i.e., consumption site specific definition) (Hoekstra and Chapagain, 2004).

It is often noted that net import of virtual water in a water-scarce nation can relieve the pressure on a nation's own water resources, and that virtual water can be seen as an alternative source of water (Hoekstra, 2003). It is of no doubt that using this additional source can be an instrument in planning and managing water resources. Moreover, virtual water trade between or within nations can be seen as an alternative to real, inter-basin water transfers. Renault (2003) notes that the issue of optimal production is not only a matter of wisely choosing the locations of production, but also a matter of proper timing of production. One can try to overcome periods of water shortage by storing water in its virtual form, e.g. by food storage. This can be a more efficient and more environmentally friendly way to bridge dry periods than, for example building large dams for temporary water storage.

The economic argument behind virtual water trade is that, according to international trade theory, nations should export products in which they possess a relative or comparative advantage in production, while they should import products in which they possess a comparative disadvantage (Wichelns, 2001). Hoekstra and Hung (2003) argue that virtual water trade between nations can be an instrument to increase 'global water use efficiency'. From an economic point of view it makes sense to produce the water-intensive products demanded in this world in those places where water is most abundantly available. In those places water is relatively inexpensive, there are smaller negative externalities to water use, and often less water is needed per unit of product. Virtual water trade from a nation where water productivity is relatively high to a nation where water productivity is relatively low implies that globally real water savings are made.

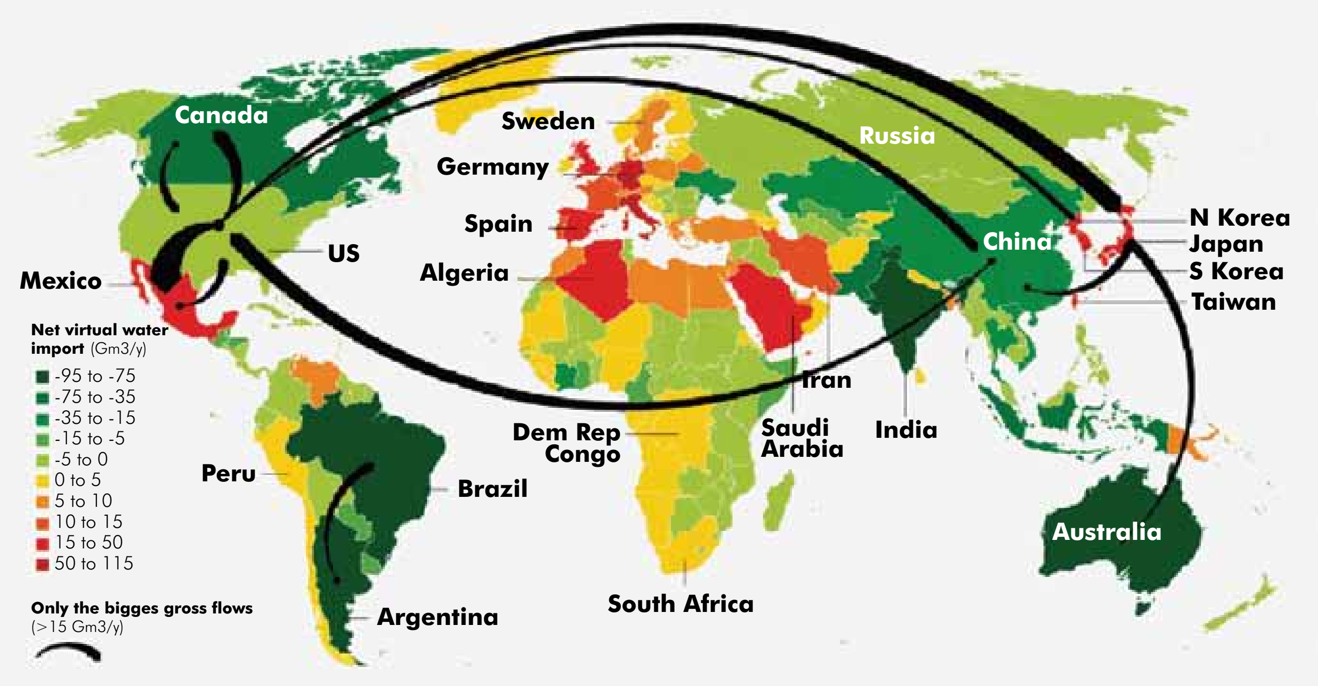
The strength of the virtual water concept is that it embraces the whole water management in a country or basin and allows for a deeper understanding of water use through, for example, diet description or broader optimization of water allocation between different water uses by incorporating access to external water resources through virtual water trade (WWC, 2004). This presents the concept as a practical policy tool that can be extended to detailed analysis of water resources management, as well as environmental, agricultural, and trade policies. Until now many of these policy issues have been solved empirically by common sense food policies and strategies in many GCC and Arab countries. For example, Jordan has made policy choices to reduce or abandon exports of local production of water-intensive crops and replace them by imports or cultivate higher return crops to allow optimization of water use.

Although virtual water is ongoing in the region, whether among the GCC countries, among the GCC and the larger domain of Arab countries, or among the GCC/Arab countries and the world (Figure 1), it is yet to be considered as a policy option in planning and allocating water resources.

While agriculture in the GCC countries accounts for about 85 percent of the total water consumption, drawn mainly from non-renewable groundwater sources, agriculture has not kept pace with the rapidly increasing demand for food, resulting in a widening food gap that is filled by imports. The GCC countries are therefore becoming increasingly dependent on imported food products. Currently, the GCC countries are heavily dependent on food imports (Table 1), which is expected to continue to increase as a result of rapidly growing population, improving living standards, sustained economic and industrial development on one hand, and limited/depleting natural water resources and limited arable lands on the other. Moreover, climate change is expected to have a major impact on the region in terms of agricultural production.

Virtual water trade flow for the GCC countries (1996-2005) was about 33 billion cubic meters/year or about 1,100 cubic meters/capita/year, of which the largest share of this virtual water flows is international trade in agriculture-

FIGURE **VIRTUAL WATER BALANCE PER COUNTRY RELATED TO TRADE IN AGRICULTURAL AND INDUSTRIAL PRODUCTS OVER THE PERIOD 1996-2005. NET EXPORTERS ARE SHOWN IN GREEN AND NET IMPORTERS IN RED. THE ARROWS SHOW THE BIGGEST GROSS INTERNATIONAL VIRTUAL WATER FLOWS (> 15 GM3/YR); THE FATTER THE ARROW, THE BIGGER THE VIRTUAL WATER FLOW.**



Source: Mekonnen and Hoekstra, 2011.

related products (96 percent), while trade in industrial products represents the remaining percentage (Mekonnen and Hoekstra, 2011; Table 2). If the fact that the GCC countries lie well below the severe water scarcity threshold of 500 cubic meters/year/capita (average of 155 cubic meters/year/capita) is taken into account, the importance of virtual water for the region becomes apparent. In contrast, the total virtual water trade volume between the GCC countries is estimated in 2006 at 1.1 billion cubic meters (Al-Otaibi, et al., 2013). This large difference between the two figures obviously indicates that food security in the GCC countries cannot be achieved by their integration in food production alone, for none of these countries has a comparative advantage in agriculture production It also indicates that larger integration circles need to be looked at, namely the Arab world and the Islamic world.

TABLE 1 **GCC FOOD BALANCE, 2008, IN THOUSAND METRIC TONS (MODIFIED AFTER KHOURI, ET AL., 2013)**

Item	SSR (%)	Production	Imports	Exports
Cereals (total)	15.9	2,509.3	13,798.0	547.6
Pulses (total)	1.7	2.2	147.3	21.6
Vegetables (total)	70.3	3,421.7	1,664.5	198.9
Fruits (total)	65.1	2,794.0	1,8521.0	351.3
Meat (total)	44.4	857.8	1,153.0	75.9
Fish	81.7	376.9	202.6	118.4
Eggs	89.6	232.8	59.9	32.9
Milk and Dairy products	25.1	1,229.8	5,052.6	1,382.8

Source: SSR= Self-sufficiency ratio (Domestic Production/(Domestic Production - Exports + Imports)*100.

TABLE 2 **VIRTUAL WATER IN THE GCC COUNTRIES (1996-2005)**

	Agriculture		Industry	total
	crops	livestock		
Water Import (m3/yr/cap)	1,082.3	280.7	127.7	1,490.7
Water Export (m3/yr/cap)	267.1	50.9	80.5	398.5
Balance (m^3/yr/cap)	**815.2**	**229.8**	**47.2**	**1,092.2**

Source: Mekonnen and Hoekstra, 2011.

However, virtual water trade has many constraints and associated risks, the most important of these being price volatility. As a food-importing region, the GCC is vulnerable to spikes in global food commodity prices, such as the one that occurred in 2008[1]. That price increase has had a strong impact on the region's food and agriculture policy, and will continue to have an impact over the next decades. A growing GCC population points towards increased dependence on imported food staples. Food imports are projected to grow from US$18.1 billion in 2007 to US$53.1 billion by 2020, or 8 percent of all imports in value terms. Ensuring that food imports remain available at an affordable price is a key strategic priority for the GCC (EIU, 2010).

In the aftermath of the food price crisis, both GCC governments and private investors in the region have been studying alternative ways of ensuring food imports by controlling the source of supply. The main strategies are buying or long-term leasing land in developing countries to use for export-oriented farming. Gulf-owned farming projects[2] are already being considered, negotiated, or implemented in North Africa, Sub-Saharan Africa, central Asia, southern Asia and eastern Europe, including Sudan, Kenya, Pakistan, Indonesia and others. However, this strategy carries with it many risks[3] and requires careful and continued management and making sure that benefits are shared for both sides[4]. Other but equally important proposed strategies to reduce exposure to market price volatility include the risk management tools of regional strategic food reserves and regional purchasing approach (Khouri, et al., 2013).

However, importing food should not be the only response the water-scarce GCC countries should and can take to achieve food security. Efficient irrigation systems in the GCC countries have a vital role to play in the conservation and sustainability of water resources, as well as the sustainability of food production and agricultural development in the future. A shift to modern irrigation and agricultural methods and demand management tools to increase agricultural productivity and water conservation is imperative. Increasing the efficiency of water use and applying demand management and conservation measures in the agricultural sector, where the largest proportion of water resources are used and where irrigation efficiencies are low, would result in effective and real water savings. Moreover, this has to be paralleled with enhancing agricultural production through a region-based agricultural R&D (Khouri, et al., 2013).

The argument here is that the virtual water strategy should be an integral component in the whole package of integrated water resources management and aligning and integrating agricultural policies with water policies to achieve both water and food securities. Moreover, the energy dimension of the water-food nexus can be seen clearly here – by importing water intensive crops, not only can there be local water savings, there are also energy savings through reduction in withdrawal of irrigation water from deep aquifers (Siddiqi and Anadon, 2011), which could be significant for the GCC countries that have energy intensive groundwater withdrawals.

However, the introduction of virtual water concept as a policy option in the GCC countries and the Arab Region at large is still in need of extensive investigations, in-depth research, and feasibility evaluation Although import of virtual water trade will relieve the pressure on national water resources, including this new concept as a policy option, requires further research and understanding of the impacts on the local social, economic, environmental, cultural, natural, and political situation.

In conclusion, food imports in the GCC countries are necessary to provide what the region is unable to produce due to water resource deficiencies and should be considered as a complementary part of the food security formula. Agricultural policies can benefit from the use of the "virtual water" concept in terms of its potential water saving when used as a practical policy tool. While food import is ongoing in the region, it needs to be used as a policy instrument and embedded within water and food policies. The virtual water concept can help to inform agricultural policymaking about what should be produced internally and what should be imported, putting in consideration political, social, economical and environmental factors.

Finally, food security in the GCC countries can be achieved by adopting a complementary and balanced agricultural policy mix between local agriculture that takes into account the limited water resources in the region, food imports, and agricultural investment abroad in food strategic commodities. Moreover, it is clear that the majority of the Arab countries cannot provide for all of their food needs due to the lack of agricultural capacity in these countries. However, Arab food security could be achieved through regional agricultural integration that combines the relative comparative advantages of the Arab countries, such as land and water resources, human resources, and financial resources. The Arab countries, through appropriate public private participation models, could join together in agricultural projects aimed at achieving food security for the region as a whole using advanced agricultural methods supported by active R&D in agricultural production.

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Notes

1. When food prices soared owing to supply-demand mismatches and speculative investment, the fear of shortages prompted some producing countries to ban food exports.

2. A variety of GCC investment vehicles is being used to finance agricultural investments, including sovereign wealth funds, public funds that have been set up specifically to invest in agriculture, and private equity funds, while state-owned agriculture or food firms may also invest directly.

3. Some of the risks involved are: when GCC investors try to export all of the output of a farming investment at a time when the host country faces a serious food shortage; non-transparent land valuation and transfer process, not ensuring a broader range of stakeholders than just governments, not providing clear and visible benefits for local communities (EIU, 2010).

4. e.g., GCC investing and providing funds in improved agricultural productivity in developing countries, aligning GCC foreign aid spending more closely with food security aims by helping countries to create food surplus to be exported, and consultation and negotiation with local farmers.

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ACRONYMS AND ABBREVIATIONS

AAAID	Arab Authority for Agricultural Investment and Development
ABSP	Agricultural Biotechnology Support Programme
AC	Air-Conditioning
AC	Alternating Current
ACSAD	Arabic Centre for the Studies of Arid Zones and Drylands
ACU	Arab Custom Union
ADA	Arriyadh Development Authority (Riyadh)
ADCO	Abu Dhabi Company for Onshore Oil Operations
ADEREE	The National Agency for Energy Efficiency and the Development of Renewable Energy
ADFD	Abu Dhabi Fund for Development
ADR	Alternative Disputes Resolution
ADWEA	Abu Dhabi Water & Electricity Authority
AED	United Arab Emirates Dirham
AEPC	African Environmental Protection Commission
AEPS	Arctic Environmental Protection Strategy
AEWA	African-Eurasian Waterbird Agreement
AFED	Arab Forum for Environment and Development
AFESD	Arab Fund for Economic and Social Development
AG	Associated Gas
AGDP	Agricultural Gross Domestic Product
AGERI	Agricultural Genetic Engineering Institute
AGP	Arab Gas Pipeline
AGU	Arabian Gulf University
AHD	Aswan High Dam
AHDR	Arab Human Development Report
AIA	Advance Informed Agreement
AIDS	Acquired Immunodeficiency Syndrome
AIECGC	Arab Investment and Export Credit Guarantee Corporation
AKTC	Aga Khan Trust for Culture
Al	Aluminum
ALBA	Aluminium Bahrain
ALECSO	Arab League Educational, Cultural, and Scientific Organization
ALMEE	Lebanese Association for Energy Saving & Environment
ALOA	Association for Lebanese Organic Agriculture
AMCEN	African Ministerial Conference on the Environment
AMF	Arab Monetary Fund
AMU	Arab Maghreb Union
ANME	National Agency for Energy Management
AoA	Agreement on Agriculture (WTO Uruguay Round)
AOAD	Arab Organization for Agricultural Development
AP	Advanced Passive reactor
AP	Additional Protocol

API	Arab Planning Institute
APR	Advanced Power Reactor
APRUE	National Agency for the Promotion and Rationalization of Use of Energy
AREE	Aqaba Residence Energy Efficiency
ARWR	Actual Renewable Water Resources
ASABE	American Society of Agricultural and Biological Engineers
ASDRR	Arab Strategy for Disaster Risk Reduction
ASR	Aquifer Storage and Recovery
AU	African Union
AUB	American University of Beirut
AUM	American University of Madaba (Jordan)
AWA	Arab Water Academy
AWC	Arab Water Council
AWCUA	Arab Water Countries Utilities Association
b/d	Barrels per Day
BADEA	Arab Bank for Economic Development in Africa
BAU	Business as Usual
Bbl	Oil Barrel
BCH	Biosafety Clearing House
Bcm	Billion cubic meters
BCWUA	Branch Canal Water User Association
BDB	Beyond Design Basis
BDL	Central Bank of Lebanon
BGR	German Geological Survey
BMP	Best Management Practices
BMZ	German Federal Ministry of Economic Cooperation and Development
BNEF	Bloomberg New Energy Finance
BOD	Biological Oxygen Demand
boe	Barrels of Oil Equivalent
BOO	Build-Own-Operate
BOOT	Build Own Operate Transfer
BOT	Build Operate Transfer
BP	British Petroleum
BREEAM	Building Research Establishment Environmental Assessment Method
BRO	Brackish Water Reverse Osmosis
BRS	ARZ Building Rating System
BU	Boston University
C&D	Construction and Demolition
C&I	Commercial and Industrial
CA	Conservation Agriculture
CAB	Centre for Agriculture and Biosciences
CAGR	Compound Annual Growth Rate
CAIP	Cairo Air Improvement Project
CAMP	Coastal Area Management Project
CAMRE	Council of Arab Ministers Responsible for the Environment
CAN	Competent National Authority
CBC	Community-Based Conservation
CBD	Convention on Biological Diversity
CBO	Community-Based Organization
CBSE	Center for the Study of the Built Environment (Jordan)
CCA	Climate Change Adaptation
CCGT	Combined Cycle Gas Turbine
CCS	Carbon Capture and Sequestration
CCS	Carbon Capture and Storage
CCS CO_2	Capture and Storage
CD	Compact Disk

CDM	Clean Development Mechanism
CDRs	Certified Emissions Reductions
CEDARE	Centre for Environment and Development for the Arab Region and Europe
CEDRO	Country Energy Efficiency and Renewable Energy Demonstration Project for the Recovery of Lebanon
CEIT	Countries with Economies in Transition
CEO	Chief Executive Officer
CEP	Coefficient of Performance
CERES	Coalition for Environmentally Responsible Economics
CERs	Credits
CFA	Cooperative Framework Agreement
CFC	Chloro-Fluoro-Carbon
CFL	Compact Fluorescent Light
CFL	Compact Fluorescent Lamp
CGIAR	Consultative Group on International Agricultural Research
CH4	Methane
CHN	Centre Hospitalier du Nord -Lebanon
CHP	Combined Heat and Power
CILSS	Permanent Interstate Committee for Drought Control in the Sahel
CIRAD	Agricultural Research for Development
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
CIWM	Chartered Institution of Wastes Management
CIHEAM	International Centre for Advanced Mediterranean Agronomic Studies
CLO	Compost-Like-Output
CLRTAP	Convention on Long-Range Transboundary Air Pollution
CM	Carbon Management
CMI	Community Marketing, Inc.
CMS	Convention on the Conservation of Migratory Species of Wild Animals
CNA	Competent National Authority
CNCA	Public Agricultural Bank
CNG (CNS)	Compressed Natural Gas
CO	Carbon Monoxide
CO_2	Carbon Dioxide
$CO_{2e/eq}$	CO_2 equivalent
COD	Chemical Oxygen Demand
COP	Conference of the Parties
CPB	Cartagena Protocol on Biosafety
CPC	Calcined Petroleum Coke
CRS	Center for Remote Sensing
CSA	City Strategic Agenda
CSD	Commission on Sustainable Development
CSEM	Centre Suisse d›Electronique et de Microtechnique
CSP	Concentrated Solar Power
CSR	Corporate Social Responsibility
CTAB	Technical Center of Organic Agriculture
cum	Cubic meters
CZIMP	Coastal Zone Integrated Management Plan
DALYs	Disability-Adjusted Life Years
DBFO	Design Build Finance Operate
DBO	Design-Build-Operate
DC	Direct current
DED	Dubai Economic Department
DEFRA	Department for Environment, Food and Rural Affairs (UK)
DEM	Digital Elevation Model
DESA	Department of Economic and Social Affairs
DEWA	Dubai Electricity and Water Authority

DFID	UK Department for International Development
DHW	Domestic Hot Water
DII	DESERTEC Industrial Initiative
DMN	Moroccan National Meteorological Office
DNE	Daily News Egypt
DOE	United States Department of Energy
DRM	Disaster Risk Management
DRR	Disaster Risk Reduction
DSIRE	Database of State Incentives for Renewables & Efficiency
DTCM	Dubai Department for Tourism and Commerce Marketing
DTIE	UNEP Division of Technology, Industry, and Economics
DTO	Dublin Transportation Office
DUBAL	Dubai Aluminum Company Limited
E3G	Third Generation Environmentalism
EAD	Environment Agency AbuDhabi
ECA	Economic Commission for Africa
ECAs	Energy Conversion Agreements
ECE	Economic Commission for Europe
ED	Electrodialysis
EDCO	Electricity Distribution Company
EDF	Environmental Defense Fund
EDL	Electricité du Liban
EE	Energy Efficiency
EEAA	Egyptian Environmental Affairs Agency
EEHC	Egyptian Electricity Holding Company
EF	Ecological Footprint
EGBC	Egyptian Green Building Council
EGPC	Egyptian General Petroleum Corporation
EGS	Environmental Goods and Services
EIA	Energy Information Administration
EIA	Environmental Impact Assessment
EITI	Extractive Industries Transparency Initiative
EMA	Europe, the Middle East, and Africa
EMAL	Emirates Aluminium Company Limited
EMAS	Eco-Management and Audit Scheme
EMS	Environmental Management System
ENEC	Emirates Nuclear Energy Corporation
ENPI	European Neighborhood and Partnership Instrument
ENSO	El Niño-Southern Oscillation
EOR	Enhanced Oil Recovery
EPA	US Environmental Protection Agency
EPC	Engineering Procurement and Construction
EPD	European Patent Office
EPDRB	Environmental Program for the Danube River Basin
EPI	Environment Performance Index
EPSA	Exploration and Production Sharing Agreement
ESAUN	Department of Economic and Social Affairs
ESBM	Ecosystem-Based Management
ESCOs	Energy Service Companies
ESCWA	United Nations Economic and Social Commission for Western Asia
ESDU	Environment and Sustainable Development Unit
ESI	Environment Sustainability Index
ESMAP	World Bank Energy Sector Management Assistance Program
ETM	Enhanced Thematic Mapper
EU	European Union
EU ETS	European Union Emission Trading System

EVI	Environmental Vulnerability Index
EWRA	Egyptian Water Regulatory Agency
EWS	Emirates Wildlife Society
FACE	Free Air Carbon Enrichment
FANR	The Federal Authority for Nuclear Regulation (UAE)
FAO	Food and Agriculture Organization of the United Nations
FDI	Foreign Direct Investment
FEMIP	Facility for Euro-Mediterranean Investment and Partnership
FFEM	French Fund for Global Environment
FiBL	Research Institute of Organic Agriculture
FIFA	Fédération Internationale de Football Association
FIT	Feed-in-Tariff
FOEME	Friends of the Earth Middle East
FSU	Former Soviet Union
F-T	Fischer-Tropsch process
FTIAB	Packaging and Newspaper Collection Service (Sweden)
G7	Group of Seven: Canada, France, Germany, Italy, Japan, United Kingdom, United States
G8	Group of Eight: Canada, France, Germany, Italy, Japan, Russian Federation,United Kingdom, United States
GAM	Greater Amman Municipality
GAPs	Good Agricultural Practices
GAS	Guarani Aquifer System
GATT	General Agreement on Tariffs and Trade
GBC	Green Building Council
GBIF	Global Biodiversity Information Facility
GCC	Gulf Cooperation Council
GCM	General Circulation Model
GCOS	Global Climate Observing System
GDP	Gross Domestic Product
GE	General Electric
GECF	Gas Exporting Countries Forum
GEF	Global Environment Facility
GEMS	Global Environment Monitoring System
GEO	Global Environment Outlook
GERD	Gross Domestic Expenditure on Research and Development
GFEI	Global Fuel Economy Initiative
GFU	Global Facilitation Unit for Underutilized Species
Gha	Global hectare
GHGs	Greenhouse Gases
GIPB	Global Partnership Initiative for Plant Breeding Capacity Building
GIS	Geographical Information Systems
GIWA	Global International Waters Assessment
GJ	GigaJoule
GLASOD	Global Assessment of Soil Degradation
GLCA	Global Leadership for Climate Action
GM	Genetically Modified
GME	Gazoduc Maghreb Europe
GMEF	Global Ministerial Environment Forum
GMO	Genetically Modified Organism
GMP	Green Moroccan Plan
GNI	Gross National Income
GNP	Gross National Product
GPC	Green petroleum Coke
GPRS	Green Pyramid Rating System
GRI	Global Reporting Initiative
GRID	Global Resource Information Database

GSDP	General Secretariat for Development planning-Qatar
GSI IISD	Global Subsidies Initiative
GSLAS	General Secretariat of League of Arab States
GSR	Global Status Report
Gt	Gigaton
GTZ	German Technical Cooperation (Gesellschaft für Technische Zusamm)
GVC	Civil Volunteers' Group (Italy)
GW	Gigawatt
GW	Greywater
GW_e	Gigawatt electrical
GWI	Global Water Intelligence
GWP	Global Warming Potential
GWP	Global Water Partnership
GW_{th}	Gigawatt-thermal
ha	Hectares
HACCP	Hazardous Analysis and Critical Control Points
HDI	Human Development Index
HFA	Hyogo Framework for Action
HFCs	Hydrofluorocarbons
HFO	Heavy Fuel Oil
HIV	Human Immunodeficiency Virus
HLW	High Level Waste
HNWI	High Net Worth Individuals
HVAC	Heating, Ventilation, and Air-Conditioning
I/M	Inspection and Maintenance
IAASTD	International Assessment of Agricultural Knowledge Science and Technology for Development
IAEA	International Atomic Energy Agency
IAS	Irrigation Advisory Service
IC	Irrigation Council
ICAM	Integrated Coastal Area Management
ICARDA	International Center for Agricultural Research in Dry Areas
ICBA	International Center for Biosaline Agriculture
ICC	International Chamber of Commerce
ICGEB	International Center for Genetic Engineering and Biotechnology
ICLDC	Imperial College London Diabetes Centre
ICM	Integrated Coastal Management
ICPDR	International Commission for the Protection of the Danube River
ICT	Information and Communication Technology
ICZM	Integrated Coastal Zone Management
IDA	International Desalination Association
IDB	Islamic Development Bank
IDECO	Irbid District Electricity Company
IDRC	International Development Research Center
IDSC	Information and Decision Support Center
IEA	International Energy Agency
IEADSM	International Energy Agency Demand-side Management
IEEE	Institute of Electrical and Electronic Engineers
IFA	International Fertilizer Industry Association
IFAD	International Fund for Agricultural Development
IFOAM	International Federation of Organic Agriculture Movements
IFPRI	International Food Policy Research Institute
IGCC	Integrated Gasifier Combined Cycle
IHP	International Hydrology Program
IIED	International Institute for Environment and Development
IIIEE	Lund University International Institute for Industrial Environmental Economics
IIIP	Integrated Irrigation Improvement Project

IIP	Irrigation Improvement Project
IISD	International Institute for Sustainable Development
ILO	International Labour Organization
ILW	Intermediate Level waste
IMC	Istituto Mediterraneo Di Certificazione
IMF	International Monetary Fund
IMO	International Maritime Organization
InWEnt	Capacity Building International-Germany
IO	Input-Output
IOC	International Oil Companies
IPCC	Intergovernmental Panel on Climate Change
IPF	Intergovernmental Panel on Forests
IPM	Integrated Pest Management
IPP	Independent Power Producer
IPR	Intellectual Property Rights
IPTRID	International Program for Technology and Research in Irrigation and Drainage
IRENA	International Renewable Energy Agency
IRESEN	Institut de Recherche en Energie Solaire et en Energies Nouvelles
IRR	Internal Rate Of Return
ISCC	Integrated Solar Combined Cycle
ISESCO	Islamic Educational, Scientific, and Cultural Organization
ISIC	UN International Standard Industrial Classification
ISO	International Organization for Standardization
ISWM	Integrated Solid Waste Management
ITC	Integrated Tourism Centers
ITC	International Trade Center
ITSAM	Integrated Transport System in the Arab Mashreq
IUCN	International Union for Conservation of Nature
IUCN	World Conservation Union (International Union for the Conservation of Nature and Natural Resources)
IWMI	International Water Management Institute
IWPP	Independent Water And Power Producer
IWRB	International Waterfowl and Wetlands Research Bureau
IWRM	Integrated Water Resources Management
JAEC	Jordan Atomic Energy Commission
JBAW	Jordan Business Alliance on Water
JD	Jordanian Dinar
JEPCO	Jordan Electric Power Company
JI	Joint Implementation
JMWI	Jordan Ministry for Water and Irrigation
JNRC	Jordan Nuclear Regulatory Commission
JVA	Jordan Valley Authority
KA-CARE	King Abdullah City for Atomic and Renewable Energy
KACST	King Abdulaziz City for Science and Technology
KAUST	King Abdullah University of Science and Technology
KEPCO	Korea Electric Power Corporation
KFAED	Kuwait Fund for Arab Economic Development
KFUPM	King Fahd University of Petroleum and Minerals
KfW	German Development Bank
KISR	Kuwait Institute for Scientific Research
KSA	Kingdom of Saudi Arabia
KW	Kilowatt
kWh	Kilowatt-hour
LADA	Land Degradation Assessment of Drylands
LAS	League of Arab States
LATA	Lebanese Appropriate Technology Association

LAU	Lebanese American University
LBNL	Lawrence Berkeley National Laboratory
LCC	Life Cycle Costing
LCEC	Lebanese Center for Energy Conservation
LCOE	Levelized Costs of Electricity
LDCs	Least Developed Countries
LED	Light-Emitted Diode
LEED	Leadership in Environmental Design
LEMA	Suez Lyonnaise des Eaux, Montgomery Watson and Arabtech Jardaneh
LEU	Low-enriched Uranium
LGBC	Lebanon Green Building Council
LLW	Low Level Waste
LMBAs	Land and Marine Based Activities
LMEs	Large Marine Ecosystems
LMG	Like Minded Group
LMO	Living Modified Organism
LNG	Liquefied Natural Gas
LowCVP	Low Carbon Vehicle Partnership
LPG	Liquefied Petroleum Gas
LRA	Litani River Authority
LV	Low Voltage
MAAR	Syrian Ministry of Agriculture and Agrarian Reform
MAD	Moroccan Dirham
MALR	Ministry of Agriculture and Land Reclamation
MAP	UNEP Mediterranean Action Plan
MARPOL	International Convention for the Prevention of Pollution from Ships
MASEN	Moroccan Agency for Solar Electricity
mb/d	million barrels per day
MBT	Mechanical-biological treatment
MCM	Million Cubic Meters
MD	Membrane Distillation
MDGs	Millennium Development Goals
MEA	Multilateral Environmental Agreement
MECTAT	Middle East Centre for the Transfer of Appropriate Technology
MED	Multiple-Effect Distillation
MED WWR WG	Mediterranean Wastewater Reuse Working Group
MED-ENEC	Energy Efficiency in the Construction Sector in the Mediterranean
MEES	Middle East Economic Survey
MEMAC	Marine Emergency Mutual Aid Centre
MENA	Middle East and North Africa
MEPS	Minimum Energy Performance Standards
METAP	UNEP Mediterranean Environmental Technical Assistance Program
MEW	Lebanese Ministry of Energy and Water
MGD	Million Gallon per Day
MHT	Mechanical Heat Treatment
MICE	Meetings, Incentives, Conferences, And Events
MIST	Masdar Institute of Science and Technology
MMBTU	One Million British Thermal Units
MMCP	Making the Most of Commodities Programme
MNA	Multinational Approaches
MOQ	Maersk Oil Qatar
MOU	Memorandum of Understanding
MOX	Mixed-Oxide
MPA	Marine Protected Area
MPAP	Multi-Stakeholder Policy Formulation and Action Planning
MSF	Multi-Stage Flash

MSF	Multi-Stakeholder Forum
MSP	Mediterranean Solar Plan
MSW	Municipal Solid Waste
Mt	Metric tons
MT	Million ton
Mt	Megatons
$MtCO_2$	Million tons of CO_2
Mtoe	Million tons of oil equivalent
MTPY	Metric Tons Per Year
MV	Medium Voltage
MW	Megawatt
MW_h	Megawatt-hour
MW_p	Megawatt-peak
MWRI	Ministry of Water Resources and Irrigation
MW_{th}	Megawatt-thermal
N_2O	Nitrous Oxide
NAMA	Nationally Appropriate Mitigation Actions
NARI	National Agricultural Research Institutes
NARS	National Agricultural Research Systems
NASA	National Aeronautics and Space Administration
NBC	National Biosafety Committee
NBDF	Nile Basin Discourse Forum
NBF	National Biosafety Framework
NBI	Nile Basin Initiative
NBM	Nile Basin Management
NC	National Communication
NCSR	Lebanese National Council of Scientific Research
ND	Neighborhood Development
NDW	Moroccan National Drought Watch
NEA	Nuclear Energy Agency
NEAP	National Environmental Action Plan
NEEAP	National Energy Efficiency Action Plan
NEEP	National Energy Efficiency Program
NEEREA	National Energy Efficiency and Renewable Energy Action (Lebanon)
NERC	National Energy Research Centre
NF	Nano-Filtration
NFC	Nile Forecast Center
NFP	National Focal Point
NGCCs	Natural-Gas-Fired Combined Cycles
NGO	Non-Governmental Organization
NGV	Natural Gas Vehicles
NGWA	Northern Governorates Water Authority (Jordan)
NIF	Neighborhood Investment Facility
NOAA	National Oceanic and Atmospheric Administration
NOC	National Oil Company
NOEC	Net Oil Exporting Countries
NOGA	National Oil and Gas Authority (Bahrain)
NOIC	Net Oil Importing Countries
NORDEN	Nordic Council of Ministers
NOx	Nitrogen Oxides
NPK	Nitrogen, Phosphates and Potash
NPP	Nuclear Power Plant
NPP	Net Primary Productivity
NPPA	Nuclear Power Plant Authority
NPT	Non-Proliferation treaty of nuclear weapons
NRC	National Research Council

NREL	National Renewable Energy Laboratory
NRW	Non-Revenue Water
NSAS	Nubian Sandstone Aquifer System
NSR	North-South Railway project
NUS	Neglected and underutilized species
NWRC	National Water Research Center (Egypt)
NWSAS	North Western Sahara Aquifer System
O&M	Operation and Maintenance
OAPEC	Organization of Arab Petroleum Exporting Countries
OAU	Organization for African Unity
ODA	Official Development Assistance
ODS	Ozone-Depleting Substance
OECD	Organization for Economic Co-operation and Development
OFID	OPEC Fund for International Development
OIES	Oxford Institute for Energy Studies
OME	Observatoire Méditerranéen de l'Energie
OMW	Olive Mills Wastewater
ONA	Omnium Nord-Africain
ONE	National Electricity Office
ONEP	National Office of Potable Water
OPEC	Organization of Petroleum Exporting Countries
OSS	Sahara and Sahel Observatory (Observatoire du Sahara et du Sahel)
PACD	Plan of Action to Combat Desertification
PC	Personal Computer
PCB	Polychlorinated Biphenyls
PCFPI	Per Capita Food Production Index
PCFV	Partnership for Clean Fuels and Vehicles
PEA	Palestinian Energy and Natural Resources Authority
PERG	Global Rural Electrification Program
PERSGA	Protection of the Environment of the Red Sea and Gulf of Aden
PFCs	Perfluorocarbons
PICs	Pacific Island Countries
PIM	Participatory Irrigation Management
PM	Particulate Matter
PMU	Program Management Unit
PNA	Palestinian National Authority
PNEEI	Tunisian National Program of Irrigation Water Conservation
POPs	Persistent Organic Pollutants
PPA	Power Purchase Agreement
PPIAF	Public-Private Infrastructure Advisory Facility
PPM	Parts Per Million
PPM	Process and Production Methods
PPP	Public-Private Partnership
PPP	Purchasing Power Parity
PPP	Public-Private Partnership
PRM	Persons with Reduced Mobility
PRY	Potential Researcher Year
PTSs	Persistent Toxic Substances
PV	Photovoltaic
PWA	Palestinian Water Authority
QNFSP	Qatar National Food Security Programme
QP	Qatar Petroleum
QSAS	Qatar Sustainable Assessment System
R&D	Research and Development
RA	Risk Assessment
RADEEMA	Régie autonome de distribution de l'eau et de l'électricité de Marrakech

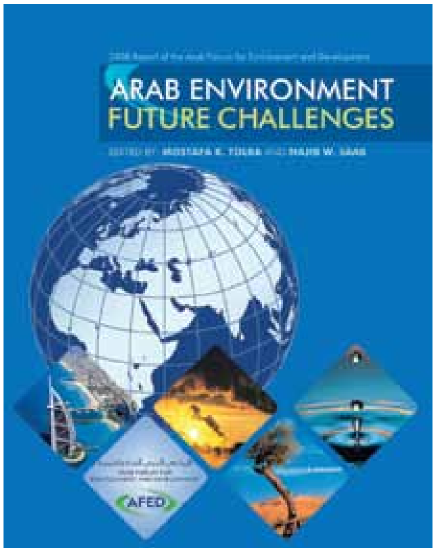
RBO	River Basin Organization
RBP	Restrictive Business Practices
RCM	Regional Circulation Model
RCREEE	Regional Center for Renewable Energy and Energy Efficiency
RDF	Refuse Derived Fuel
RE	Renewable Energy
REC	Renewable Energy Credits
REMPEC	Regional Marine Pollution Emergency Response Centre for the Mediterranean Sea
REN21	Renewable Energy Policy Network for the 21st Century
Rep	Republic
RM	Risk Management
RO	Reverse Osmosis
ROPME	Regional Organization for the Protection of the Marine Environment of the sea area surrounded by Bahrain, I.R. Iran, Iraq, Kuwait, Oman, Qatar, Saudi Arabia and the United Arab Emirates
RPS	Renewable Portfolio Standard
RSA	ROPME Sea Area
RSC	Royal Society of Chemistry (UK)
RSCN	Royal Society for the Conservation of Nature
RSGA	Red Sea and Gulf of Aden
RUAF	Resource Centers Network on Urban Agriculture and Food Security
S&T	Science and Technology
SAIC	Science Applications International Corporation
SAP	Strategic Action Program
SCP	Sustainable Consumption and Production
SCPI	Sustainable Crop Production Intensification
SD	Sustainable Development
SEA	Strategic Environmental Assessment
SFD	Saudi Fund for Development
SHS	Solar Home System
SIR	Shuttle Imaging Radar
SIWI	Stockholm International Water Institute
SL	Syrian Pound
SLR	Sea Level Rise
SME	Small and Medium-Size Enterprises
SMS	Short Messaging Service
SoE	State of the Environment
SONEDE	Société Nationale d'Exploitation et de Distribution des Eaux
SOx	Sulfur Oxides
SPD	Sozialdemokratische Partei Deutschlands
SPM	Suspended Particulate Matter
SRES	Special Report on Emission Scenarios
SRTM	Shuttle Radar Topography Mission
SSA	Sub-Saharan Africa
SSR	Self-Sufficiency Ratio
SWCC	Saline Water Conversion Corporation
SWH	Solar Water Heating
SWRO	Seawater Reverse Osmosis
T&D	Transmission and Distribution
TAC	Technical Advisory Committee
TAR	Third Assessment Report
Tcm	Trillion cubic meters
TDM	Transportation Demand Management
TDS	Total Dissolved Solids
TES	Thermal Energy Storage
TFP	Total Factor Productivity
TIES	The International Ecotourism Society

TII	Thermal Insulation Implementation
Toe	Tons of Oil Equivalent
TPES	Total Primary Energy Supply
TRAFFIC	Trade Records Analysis for Flora and Fauna in International Commerce
TRI	Toxics Release Inventory
TRIPs	Trade-Related Aspects of International Property Rights
TRMM	Tropical Rainfall Measuring Mission
tU	tones of Uranium
TWh	Terawatt-hour
UA	Urban Agriculture
UAE	United Arab Emirates
UCLA	University of California at Los Angeles
UCS	Union of Concerned Scientists
UF	Ultrafiltration
UfM	Union for the Mediterranean
UHCPV	Ultra-High Concentration Photovoltaic
UHI	Urban Heat Island
UIS	UNESCO Institute for Statistics
UK	United Kingdom
UMA	Union du Maghreb Arabe (Arab Maghreb Union)
UN	United Nations
UNCBD	United Nations Convention on Biological Diversity
UNCCD	United Nations Convention to Combat Desertification
UNCED	United Nations Conference on Environment and Development
UNCHS	United Nations Centre for Human Settlements (now UN-Habitat)
UNCLOS	United Nations Convention on the Law of the Sea
UNCOD	United Nations Conference on Desertification
UNCTAD	United Nations Conference on Trade and Development
UNDAF	United Nations Development Assistance Framework
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNESCO-ROSTAS	UNESCO Regional Office for Science and Technology for the Arab States
UNFCCC	United Nations Framework Convention on Climate Change
UNFPA	United Nations Population Fund
UNHCR	United Nations High Commission for Refugees
UNICE	United Nations Children's Fund
UNIDO	United Nations Industrial Development Organization
UNISDR	United Nations International Strategy for Disaster Reduction
UNWTO	United Nations World Tourism Organization
UPC	Abu Dhabi Urban Planning Council
UPI	United Press International
USA	United States of America
USAID	United States Agency for International Development
USCCSP	United States Climate Change Science Program
USEK	Université Saint-Esprit De Kaslik
USEPA	United States Environmental Protection Agency
USJ	Saint Joseph University
USPTO	United States Patent and Trademark Office
UV	Ultraviolet (A and B)
VAT	Value-Added Tax
VC	Vapor Compression
VCM	Volatile Combustible Matter
VMT	Vehicle Miles Traveled
VOC	Volatile Organic Compound
VRS	Vapor Recovery System

WACC	Weighted Average Cost of Capital
WaDImena	Water Demand Initiative for the Middle East and North Africa
WAJ	Water Authority of Jordan
WALIR	Water Law and Indigenous Rights
WANA	West Asia and North Africa Region
WB	West Bank
WBCSD	World Business Council for Sustainable Development
WBGU	German Advisory Council on Global Change
WCD	World Commission on Dams
WCED	World Commission on Environment and Development
WCMC	UNEP World Conservation Monitoring Center
WCP	World Climate Programme
WCS	World Conservation Strategy
WDM	Water Demand Management
WDPA	World Database on Protected Areas
WEEE	Waste of Electronic and Electrical Equipment
WEF	World Economic Forum
WEI	Water Exploitation Index
WETC	Wind Energy Technology Centre
WF	Water Footprint
WFN	Water Footprint Network
WFP	World Food Programme
WGP-AS	Water Governance Program in the Arab States
WHO	World Health Organization
WIPP	Waste Isolation Pilot Plant
WMO	World Meteorological Organization
WNA	World Nuclear Association
Wp	Watt-peak
WRI	World Resources Institute
WSSCC	Water Supply and Sanitation Collaborative Council
WSSD	World Summit on Sustainable Development
WTO	World Trade Organization
WTTC	World Travel and Tourism Council
WUA	Water User Association
WUE	WUE Water Use Efficiency
WWAP	World Water Assessment Program
WWC	World Water Council
WWF	World Wide Fund for Nature
WWF	World Water Forum
WWI	First World War
WWII	Second World War
YASAD	Yemenite Association for Sustainable Agriculture and Development
YR	Year

Arab Environment: Future Challenges

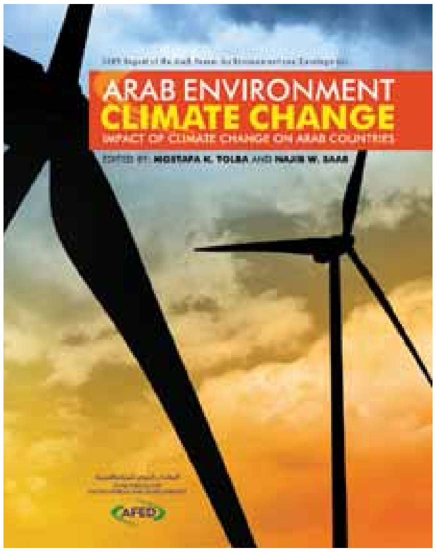
2008 Report
of the Arab Forum for Environment and Development



For the first time, a comprehensive independent expert report on Arab environment is released for public debate. Entitled *Arab Environment: Future Challenges*, this ground-breaking report has been commissioned by Arab Forum for Environment and Development (AFED), and written by some of the most prominent Arab experts, including authors, researchers and reviewers. Beyond appraising the state of the environment, based on the most recent data, the policy-oriented report also evaluates the progress towards the realization of sustainable development targets, assesses current policies and examines Arab contribution to global environmental endeavors. Ultimately, the report proposes alternative policies and remedial action.

Arab Environment: Climate Change

2009 Report
of the Arab Forum for Environment and Development

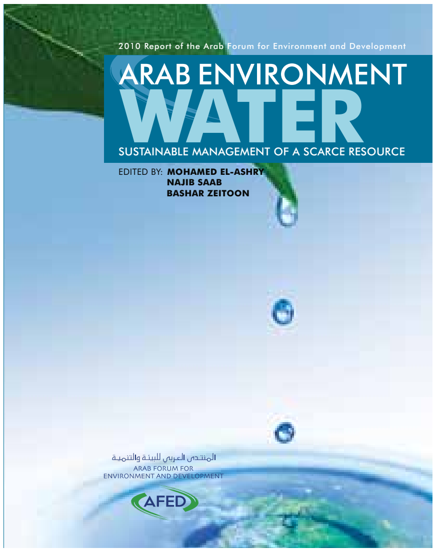


Impact of Climate Change on the Arab Countries is the second of a series of annual reports produced by the Arab Forum for Environment and Development (AFED). The report has been designed to provide information to governments, business, academia and the public about the impact of climate change on the Arab countries, and encourage concrete action to face the challenge.

The report analyzes the Arab response to the urgent need for adaptation measures, and uses the latest research findings to describe the vulnerabilities of natural and human systems in the Arab world to climate change and the impacts on different sectors. In an attempt to help shape adequate policies, the report discusses options for a post-Kyoto regime and outlines the state of international negotiations in this regard.

Arab Environment: Water

2010 Report
of the Arab Forum for Environment and Development



Water: Sustainable Management of a Scarce Resource is the third of a series of annual reports produced by the Arab Forum for Environment and Development (AFED). It follows the publication of two reports, Arab Environment: Future Challenges in 2008 and Impact of Climate Change on Arab countries in 2009.

The 2010 report is designed to contribute to the discourse on the sustainable management of water resources in the arab world and provides critical understanding of water in the region without being overly technical or academic in nature.

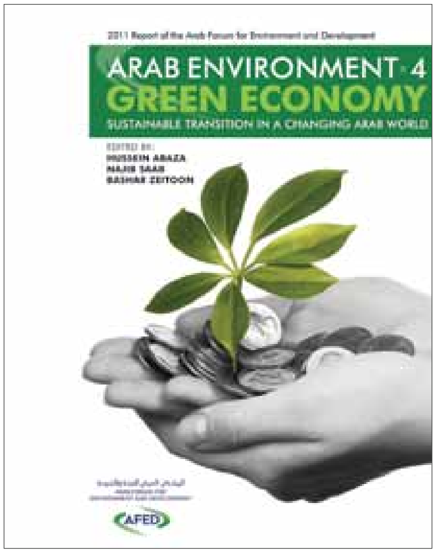
The unifying theme is presenting reforms in policies and management to develop a sustainable water sector in Arab countries. Case studies, with stories of successes and failures, are highlighted to disseminate learning.

This report contributes to the ongoing dialogue on the future of water and catalyzes institutional reforms, leading to determined action for sustainable water policies in Arab countries.

Arab Environment: Green Economy

2011 Report

of the Arab Forum for Environment and Development



Green Economy: Sustainable Transition in a Changing Arab World is the fourth of a series of annual reports on the state of Arab environment, produced by the Arab Forum for Environment and Development (AFED).

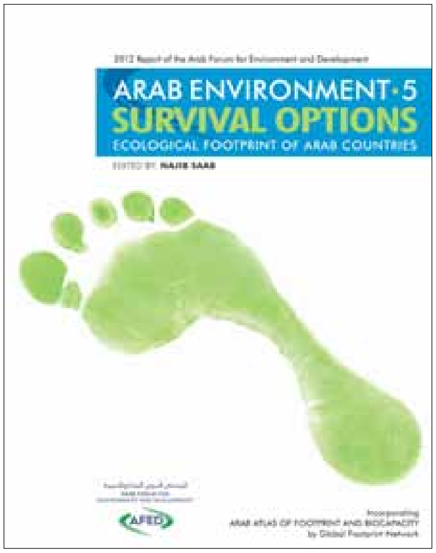
This report on options of green economy in Arab countries represents the first phase of the AFED green economy initiative. Over one hundred experts have contributed to the report, and discussed its drafts in a series of consultation meetings.

The report is intended to motivate and assist governments and businesses in making a transition to the green economy. It articulates enabling public policies, business models, green investment opportunities, innovative approaches, and case studies, and addresses eight sectors: agriculture, water, energy, industry, cities and buildings, transportation, tourism, and waste management.

Arab Environment: Survival Options

2012 Report

of the Arab Forum for Environment and Development



Survival Options - Ecological Footprint of Arab Countries is the fifth in the series of annual reports produced by the Arab Forum for Environment and Development (AFED) on the state of the Arab environment. It examines sustainability choices in Arab countries, based on a survey of people's demand of natural capital and available supply.

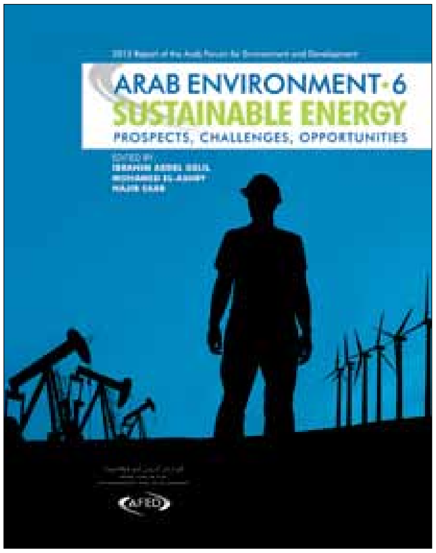
The report discusses potential paths to sustainability based on ecological constraints. As a basis for the analysis, AFED has commissioned the Global Footprint Network, the world leader in this field, to produce an Arab Ecological Footprint and Biocapacity Atlas using the most recent data available. The Atlas covers the 22 members of the League of Arab States, as region, sub-regions and individual countries.

The analysis focuses on the challenges posed by the state of food security, water and energy, while considering main drivers such as population and patterns of production and consumption. Ultimately, it prescribes regional cooperation and sound management of resources as the main options for survival in a region characterized by stark variations in ecological footprint, natural resources and income.

Arab Environment: Sustainable Energy

2013 Report

of the Arab Forum for Environment and Development



Sustainable Energy is the sixth in the series of annual reports produced by the Arab Forum for Environment and Development (AFED) on the state of Arab environment. The report highlights the need for more efficient management of the energy sector, in view of enhancing its contribution to sustainable development in the Arab region.

The AFED 2013 report aims at: presenting a situational analysis of the current state of energy in the Arab region, shedding light on major challenges, discussing different policy options and, ultimately, recommending alternative courses of action to help facilitate the transition to a sustainable energy future.

To achieve its goals, the AFED 2013 report addresses the following issues: oil and beyond, natural gas as a transition fuel to cleaner energy, renewable energy prospects, the nuclear option, energy efficiency, the energy-water-food nexus, mitigation options of climate change, resilience of the energy sector to climate risk, and the role of the private sector in financing sustainable energy.

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Notes

ARAB ENVIRONMENT • 7 FOOD SECURITY

2014 Report of the Arab Forum for Environment and Development

AFED

Food Security is the seventh in the series of annual reports on the state of Arab environment, produced by the Arab Forum for Environment and Development (AFED). The report highlights the need for more efficient management of the agriculture and water sectors, in view of enhancing the prospects of food security.

This report comes after Arab Environment - Future Challenges (2008), Impact of Climate Change on Arab Countries (2009), Water - Sustainable Management of a Scarce Resource (2010), Green Economy in a Changing Arab World (2011), Survival Options- Ecological Footprint in Arab Countries (2012), and Sustainable Energy (2013).

Food security is of great concern to Arab countries. They have been pursuing a target of higher food self-sufficiency rate, but achieving this goal remained beyond reach. While they have limited cultivable land and scarce water resources, they did not use their agricultural endowments in an effective and efficient manner. Lack of appropriate agricultural policies and practices led to diminishing the bio-capacity of the resources to regenerate their services and threatened agricultural sustainability.

The advent of the food crisis in recent years and the unprecedented spike in food prices, coupled with export restrictions imposed by some food producing countries, reignited the call for ensuring reliable food sources for food import dependent countries like the Arab countries. The question is to what extent can the available agricultural resources at country and regional levels meet demand for food in the Arab world? What are the prospects for food self-sufficiency, taking into consideration the growing population and the impact of climate change on land and water resources? And what other options do the Arab countries have to ensure food security?

The result of collaborative work, this AFED report has been produced by a group of leading experts, in cooperation with regional and international organizations, universities and research centers. Over 200 researchers and specialists contributed to the work. Various consultation meetings were held to discuss the drafts, culminating in a regional meeting hosted by the Kuwait Fund for Arab Economic Development (KFAED), where 40 experts from 14 countries and 21 institutions reviewed the drafts with the authors.

A novel feature of the report are the maps showing water and land resources in the Arab region, produced in cooperation with the International Center for Agricultural Research in Dry Areas (ICARDA) based on the most recent data. Beyond identifying the availability of resources per country, they point out obvious routes of regional cooperation, based on the variation in natural endowment.

AFED hopes that its report on Food Security will help Arab countries adopt the right policies and commit to long-term investments, allowing them to secure a sustainable supply of food to meet ever-growing needs.

Arab Forum for Environment and Development (AFED) is an international not-for-profit, non-governmental, membership-based organization headquartered in Beirut, Lebanon. Members include corporations, universities, research centers, media networks, and civil society alongside government entities as observers. Since 2007, AFED has been a public forum for influential eco-advocates. During eight years, it has become a major dynamic player in the global environmental arena.

The flagship contribution of AFED is an annual report written and edited by experts on the state of Arab environment, tracking developments and proposing policy measures. Other initiatives include a regional Corporate Environmental Responsibility (CER) program, capacity building, public awareness, and environmental education.

AFED enjoys an observer member status with the United Nations Environment Program (UNEP), the League of Arab States (LAS), and many other regional and international organizations and conventions. As an Arab think tank, it has played a major role in international negotiations on environment and development, including advising governments and regional organizations on matters such as climate change, green economy and sustainable development.

AFED
البيئة 2014
ARAB ENVIRONMENT 2014

Cooperating Organizations
Kuwait Fund for Arab Economic Development
ICARDA
الإسكوا ESCWA

هيئة البيئة - أبوظبي Environment Agency - ABU DHABI
جامعة البترا
Arab Fund for Economic and Social Development
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ISBN 978-9953437521
9 789953 437521

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